Maiden Creek Watershed

Water Quality Report

Berks County, Pennsylvania

December2018

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The water quality report was compiled by the Berks County Conservation District (BCCD) for PDE, and with the assistance of Schuylkill Action Network (SAN) Agricultural Workgroup.

Special thanks to the following organizations that provided water quality data for the report:

- Berks County Conservation District (BCCD)
- Reading Area Water Authority (RAWA)
- The Academy of Natural Sciences of Drexel University (ANS)
- Stroud Water Research Center (SWRC)
- SSM Group, Inc. (SSM)

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EXECUTIVE SUMMARY

Located in southeast Pennsylvania, the Maiden Creek is the 2nd largest tributary watershed to the Schuylkill River, and a water body in the greater Delaware River Basin. The Maiden Creek drainage area lies in northeastern Berks County and western Lehigh County. Small portions of Schuylkill County also lie within the watershed along the Kittatinny Ridge. The Maiden Creek watershed covers approximately 216-square miles with more than 100 miles of perennial streams including Maiden Creek and ten named tributaries. Nineteen townships and five boroughs are also encompassed in the watershed[1]. The Maiden Creek and its source waters, are collected in a large 1000-acre reservoir, designated as Lake Ontelaunee. The reservoir is managed by the Reading Area Water Authority (RAWA), and is the primary drinking water supply for the approximate 90,000 residents who live in the City of Reading. Likewise, the Schuylkill River is also the drinking water supply for several Boroughs and the City of Philadelphia, which utilizes the river to provide service to an estimated 1.5 million residents.

Approximately 58% of the Maiden Creek watershed land is used for agricultural purposes, both crops and pastures. The most suitable land for agriculture is in the *Great Valley* section of the watershed. The southern portion is comprised of limestone-based soils that is prime agriculture land. Forest is the next largest land use type, covering 39% of the watershed. A substantial amount of wooded land is distributed throughout the watershed in small fragmented farm woodlots, riparian corridors and steep slopes. The remaining land use includes development, industry, and roads or highway and make up about 3% of the watershed. The Maiden Creek watershed is able to sustain high water quality standards, including portions of four tributaries classified either Exception Value (EV) or High Quality – Cold Water Fishery (HQ-CWF), the highest designations for the most pristine water in the Pennsylvania. Likewise, the Upper Maiden Creek and a majority of its tributaries are designated Trout Stocked Fishery (TSF). In the Lower Maiden watershed, Lake Ontelaunee Reservoir supports a strong Warm Water Fishery (WWF) community, and is a favored destination for angling enthusiast[1].

Nevertheless, Lake Ontelaunee, and its network of upstream tributaries are susceptible to impairments due to intensive agricultural, municipal, and industrial land uses, and are impaired by sedimentation, nutrients, and pathogens. It is because of the watersheds geographic significance and importance, that it is included in the Middle Schuylkill Cluster delineated by the Delaware River Watershed Initiative (DRWI), sponsored and collaborated by the William Penn Foundation (WPF), National Fish and Wildlife Foundation (NFWF), Open Space Institute (OSI), Academy of Natural Science (ANS), Institute for Conservation Leadership (ICL). The initiative connects local and downstream partners, and includes the Schuylkill Action Network (SAN). The SAN Agricultural Workgroup prioritized the Maiden Creek watershed for implementation of restoration best management practices (BMPs) on farms along impaired tributaries designated as *focus areas*, through funding sources such as the DRWI or federal initiatives like the Regional Conservation Partnership Program (RCPP) and National Water Quality Initiative (NWQI). Over the past decade, there has been a significant amount of watershed restoration and protection work within the Maiden Creek through these available programs and initiatives[2].

Substantial resources have also been dedicated to assessing the health of the waters, and monitoring measurable water quality improvements. SAN Ag Workgroup partners include RAWA, Berks County Conservation District (BCCD), Stroud Water Research Center (SWRC), Academy of Natural Science (ANS), Partnership for the Delaware Estuary (PDE), Berks Nature, and SSM Group have all participated and contributed to the collection of water quality data.

It is through this long-term and continuous collection of monitoring data, that the Maiden Creek Watershed Water Quality Report has been compiled. The purpose of completing the water quality report is to provide an account to the SAN partners on the long-term or current water quality trends within the Maiden Creek watershed. In addition, to determine if measurable improvements have occurred through targeted funding of restorative BMPs in the *focus area* tributaries. Through the assessment of the available data, SAN partners can evaluate the effectiveness of implementing concentrated BMP's in smaller subwatersheds or *focus areas* of the Middle Schuylkill Cluster. Based on the evaluation, recommendations can be made for continued implementation, monitoring, or the development of more efficient watershed restoration strategies.

EVALUATION CRITERIA

Watershed grades and water quality trends were determined by evaluating the following chemical or biological parameters collected by the data contributors [RAWA, ANS, SSM, SRWC, & BCCD]:

- Total Nitrates (NO_3) mg/L
- Total Phosphate (PO_4) mg/L
- Dissolved Oxygen (0_2) mg/L
- Temperature (^0C)
- Total Suspended Solids (TSS) mg/L
- Turbidity (NTUs)
- Macroinvertebrates
  - Index for Biological Integrity (IBI)
  - Macroinvertebrate Aggregated Index for Streams (MAIS)

These parameters were selected due to the consistent collection by all data contributors. In addition, Agricultural BMP's sponsored by regulator agencies and the DRWI intend to reduce sediment, nutrient, and pathogen pollution to ground and surface waters. The purpose of these pollutant reductions is to improve water quality for public water supply (PWS), aquatic life, and recreation. Bacteria was not evaluated as collection and procedures varied between each data contributor.

Water Quality Standards and Evaluation Range

Total Nitrates (NO_3) mg/L [3]	**Temperature (^0C) designated use maximum[4]**
≤ 1 – 2 mg/L Good 2 – 6 mg/L Fair 6 - 10 ≤ mg/L Poor	CWF- 20 ^0C TSF – 26 ^0C WWF- 30 ^0C
Total Phosphate (PO_4) mg/L [3]	**Total Suspended Solids (TSS) mg/L [7]**
≤ 0.1 – 0.3 mg/L Good 0.3 – 0.5 mg/L Fair 0.5 ≤ mg/L Poor	• *No specific state or federal standard* • *Some state regulations suggest that WTP or WWTP treatment should occur if the 30-day TSS average exceeds 30 mg/L.*
Dissolved Oxygen (0_2) mg/L[4]	**Turbidity (NTUs) [8]**
0.0– 4.0 mg/L Poor 4.0 - 7.0 mg/L Fair 7.0 – 10 ≤ mg/L Good	• Unfiltered Surface Water - ≤ 5 NTUs • Filter Surface Water - ≤ 1 NTUs • Aquatic Stress – 10 ≤ NTUs
Index for Biological Integrity (IBI)[5 & 6]	**Macroinvertebrate Aggregated Index for Streams (MAIS)[9]**
0 – 30 Severe Impairment 30 - 50 Moderate Impairment 50 – 63 Approaching Attainment 63 - 100 Attaining Aquatic Life Use	0 - 6 Poor 6 – 13 Fair 13 ≤ Good

WATERSHED HEALTH

MAIDEN CREEK WATERSHED: [GRADE B-]

Overall, the Maiden Creek Watershed receives a B minus grade. Many of the watershed headwaters remain pristine or maintain good water quality, however historical impairments of siltation, nutrients, and pathogen are still present. Water quality trends, specifically Total Suspended Solids (TSS) or Turbidity, and Total Phosphorus (Phosphate) appear to be stable or decreasing in the entire watershed. Biological ecosystems like macroinvertebrates [IBI or MIAS], fish, and algae are increasing towards healthy communities. The watershed wide increase in biodiversity can be slow, but in some instances, particular downstream from agricultural BMP projects, rapid changes can be observed [Appendix F, Exhibit 5, Younker 017]. With precipitation variation from year to year, some water quality trends can mirror wet and dry seasons [Appendix C]. This is particularly true for Nitrogen (N) due to its high solubility. Generally, with increased precipitation, increase nitrate and sediment concentrations can be observed in collected samples. With recent wetter precipitation patterns, the Lake Ontelaunee reservoir should be closely monitored to determine how the waterbody is processing potential increases in sediment and nutrient runoff.

LOWER MAIDEN: [GRADE C]

The Lower Maiden Watershed's overall grade is a C. The greatest decreases in phosphates in the entire watershed can be observed on the Willow Creek, which has several municipal and industrial permitted point discharges. Lake Ontelaunee reservoir has also maintained relatively low and steady levels of turbidity (avg. 5 NTU's) over the past 8 years. Adversely, the Lower Maiden watershed tributaries, in particular, Moselem Creek, show increasing nitrate trends outside of the influences of precipitation or increased stormwater runoff [Appendix D, Exhibit 5]. Some tributaries approach or exceed the Public Water Supply (PWS) levels of 10 mg/L. The Lower Maiden tributaries also demonstrate significantly lower IBI and MAIS scores than the upper reaches of Maiden watershed, reflecting the consistent impairment of siltation and submarginal habitat.

UPPER MAIDEN: [GRADE B+]

The Upper Maiden Watershed's overall grade is a B Plus. The Upper Maiden by land use percentage has the most forest cover compared to the other watershed sections, and it is the in headwaters where the most ecological diversity and pristine waters can be found. Some of highest IBI and MAIS scores are found in the headwaters of the Upper Maiden. Several sub watersheds with intensive agricultural use that grade either poor to fair, are trending towards better water quality [Upper Maiden Watershed WQ Map]. Some nitrogen and phosphorus spikes can be observed however, and field observation and reconnaissance may be necessary to determine point discharges [Christman Lake 003 – Appendix F].

SAUCONY: [GRADE B-]

The Saucony Watershed's overall grade is a B minus. Nitrates in the Saucony tributaries are either decreasing or holding steady, but are in mid-upper end of the PWS level (avg. 5 – 7 mg/L). Biological communities in the headwaters are healthy, although IBI and MAIS scores in the lower reaches of the watershed indicate the system suffers from impairments. These biological communities are improving specifically on agricultural operations were BMP's have been installed. Impairments are still observed, but water quality trends are improving [Saucony Watershed WQ Map], this can be specifically observed in the Saucony Creek Watershed Restoration, Groundwater Evaluation (January 2017) [Appendix G].

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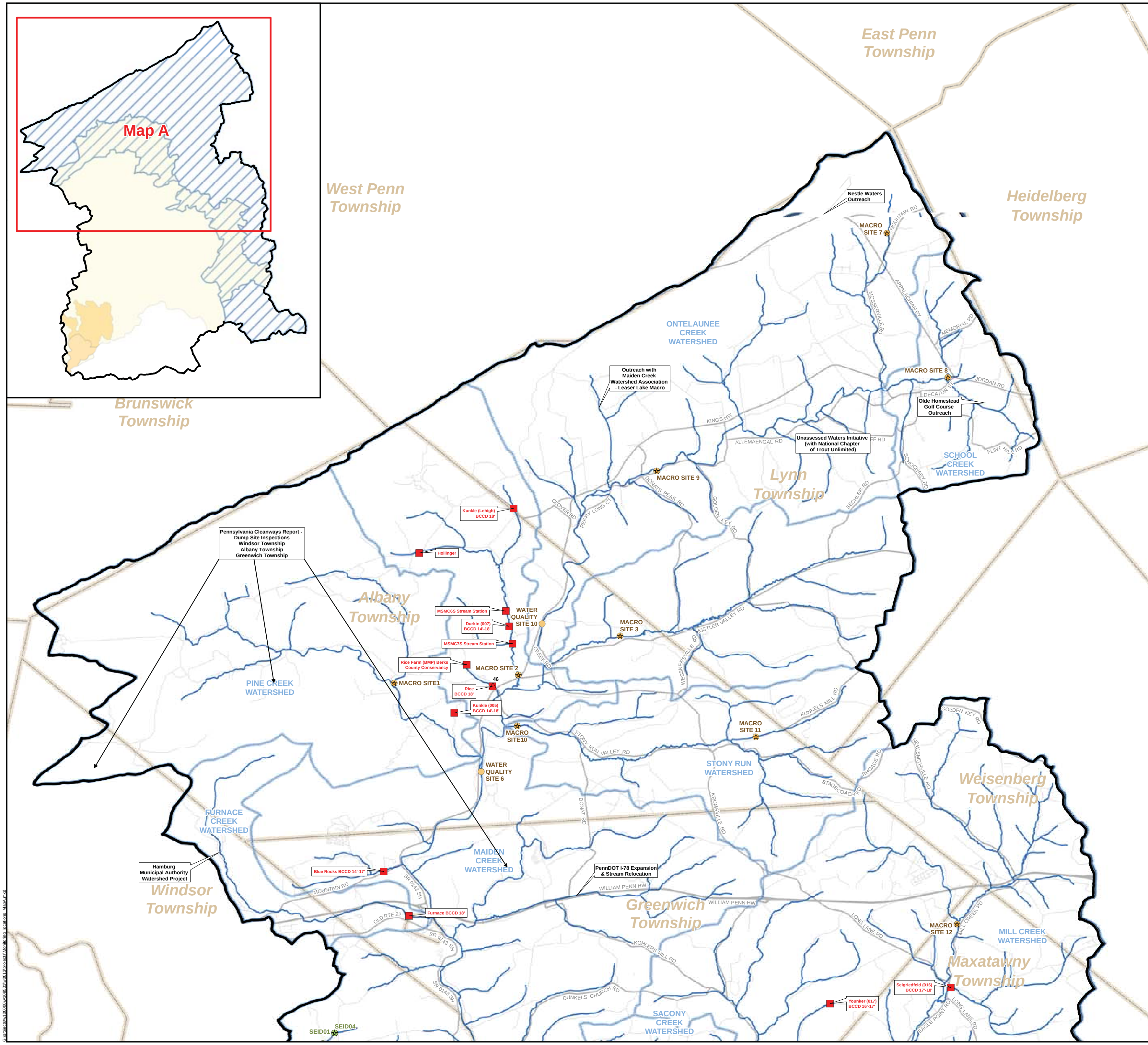

2018 Monitoring Locations Map
Map A
Reading Area Water Authority
Berks County, PA

SAN Monitoring Points
- SAN (Historic Sites)
- WPF (Stroud & PDE)
- Algae Monitoring Site
- Lake Ontelaunee Intake

Biological Monitoring
- Reading Area Water Authority
- Schuylkill Action Network

Water Quality Monitoring
- RAWA
- SAN
- Berks County Conservation District
- Stream
- Road
- Maiden Creek Watershed
- Protection Zone A
- Protection Zone B
- Protection Zone C
- Sub Watershed
- Lake Ontelaunee
- NA Sediment Sampling*
- Municipal Boundary

N

0 5,000 10,000 Feet

1:28,000

Data source:
Monitoring Points, SSM,
Macro sampling, SSM, MCWA, SAN
NA Sediment Sampling, SSM
Water Resources Dicharge, DEP
Stream, DEP
Watershed, ERRI
Roads, PENNDOT, 2014
Municipality Boundaries, PENNDOT, 2012
SWP Zones, SSM, 2016

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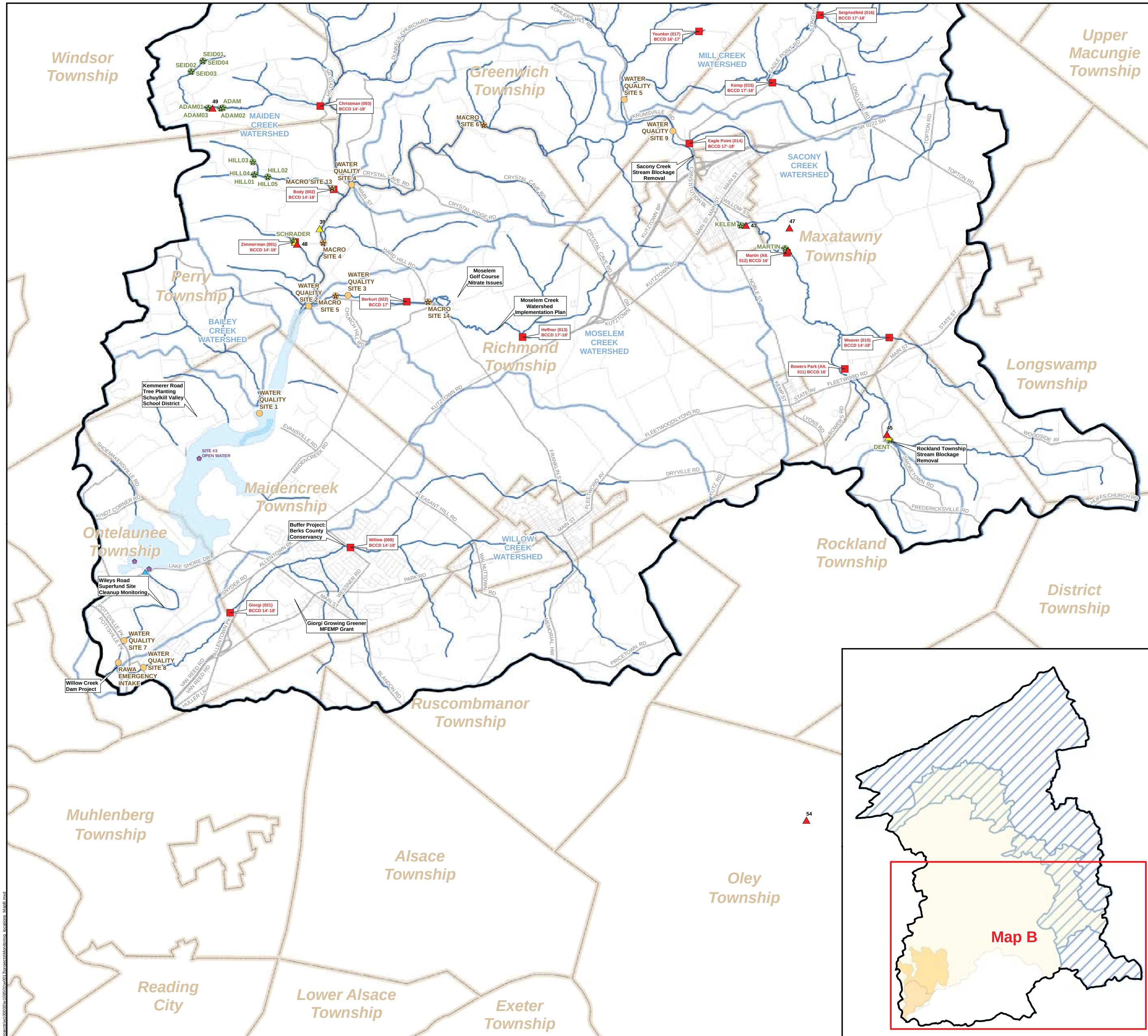
2018 Monitoring Locations Map Map B Reading Area Water Authority Berks County, PA



SAN Monitoring Points
- SAN (Historic Sites)
- WPF (Stroud & PDE)
- Algae Monitoring Site
- Lake Ontelaunee Intake

Biological Monitoring
- Reading Area Water Authority
- Schuylkill Action Network

Water Quality Monitoring
- RAWA
- SAN
- Berks County Conservation District
- Stream
- Road
- Maiden Creek Watershed
- Protection Zone A
- Protection Zone B
- Protection Zone C
- Sub Watershed
- Lake Ontelaunee
- NA Sediment Sampling*
- Municipal Boundary

N

0 5,000 10,000 Feet

1:28,000

Data source:
Monitoring Points, SSM,
Macro sampling, SSM, MCWA, SAN
NA Sediment Sampling, SSM
Water Resources Dicharge, DEP
Stream, DEP
Watershed, ERRI
Roads, PENNDOT, 2014
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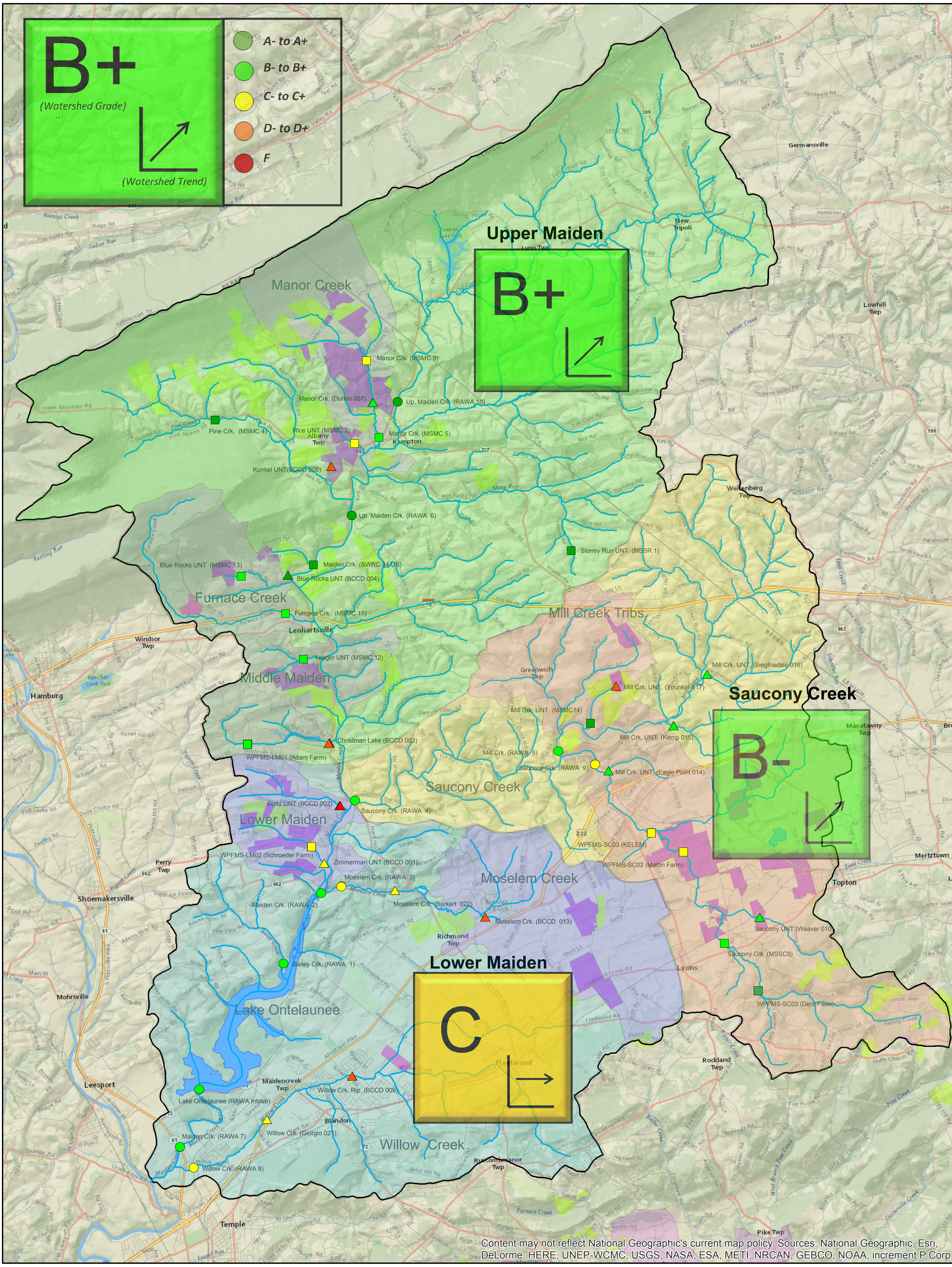


Maiden Creek Water Quality Map
Schuylkill Action Network
Berks County, PA

Figure 2

September 6th, 2018

N

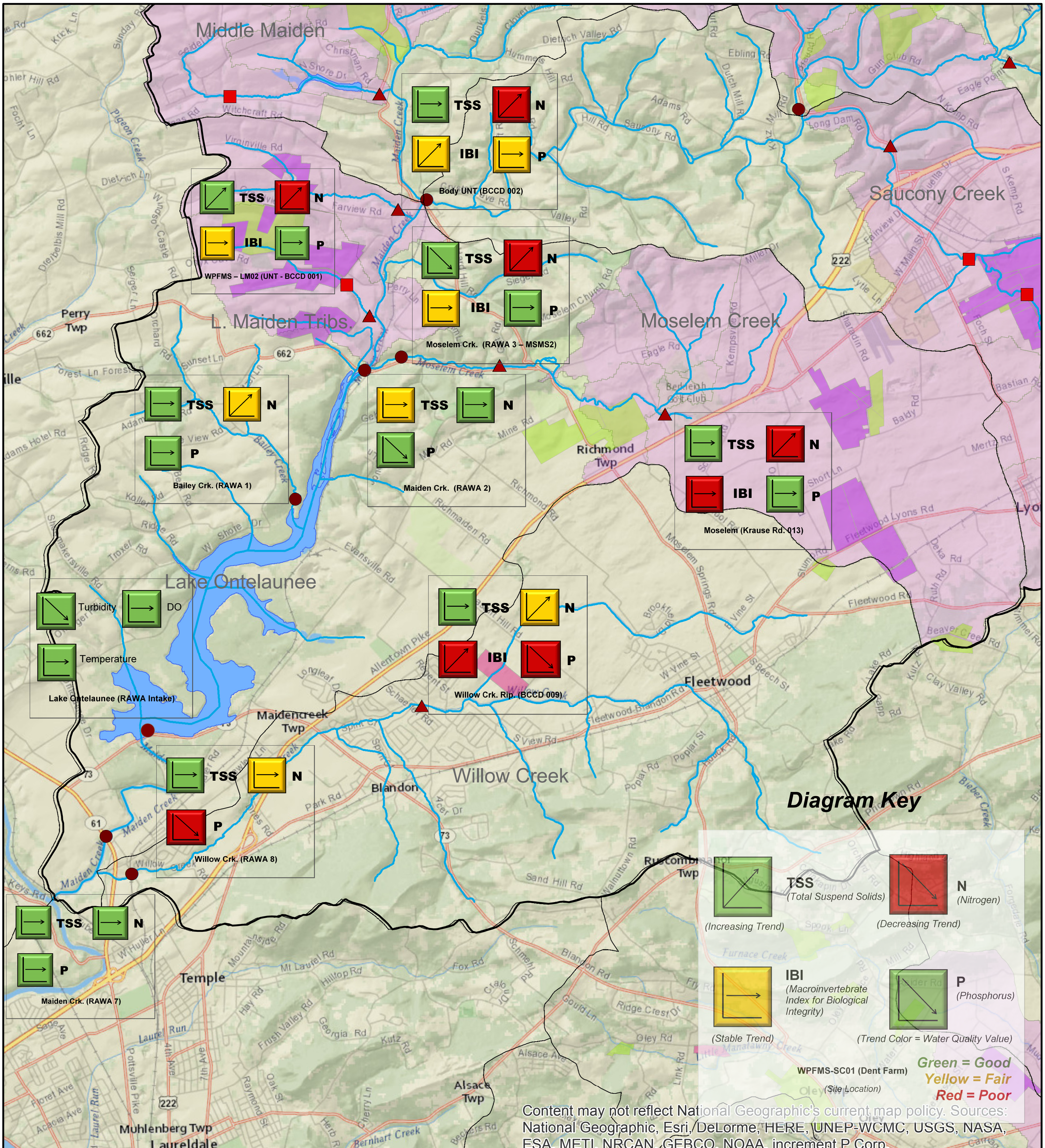
0 0.75 1.5 3 4.5 6 Miles

Legend

- RAWA Sites
- WPF-PDE & SWRC Sites
- BCCD 319 Sites
- Streams
- Lake
- Maiden Creek Watershed
- DWRI Focus Areas (PDE)

Cooperative Landowners Partner

- BN\PDE completed\ongoing
- BN\PDE planned
- SWRC completed\ongoing



Lower Maiden Water Quality Map
Schuylkill Action Network
Berks County, PA

Figure 3

N

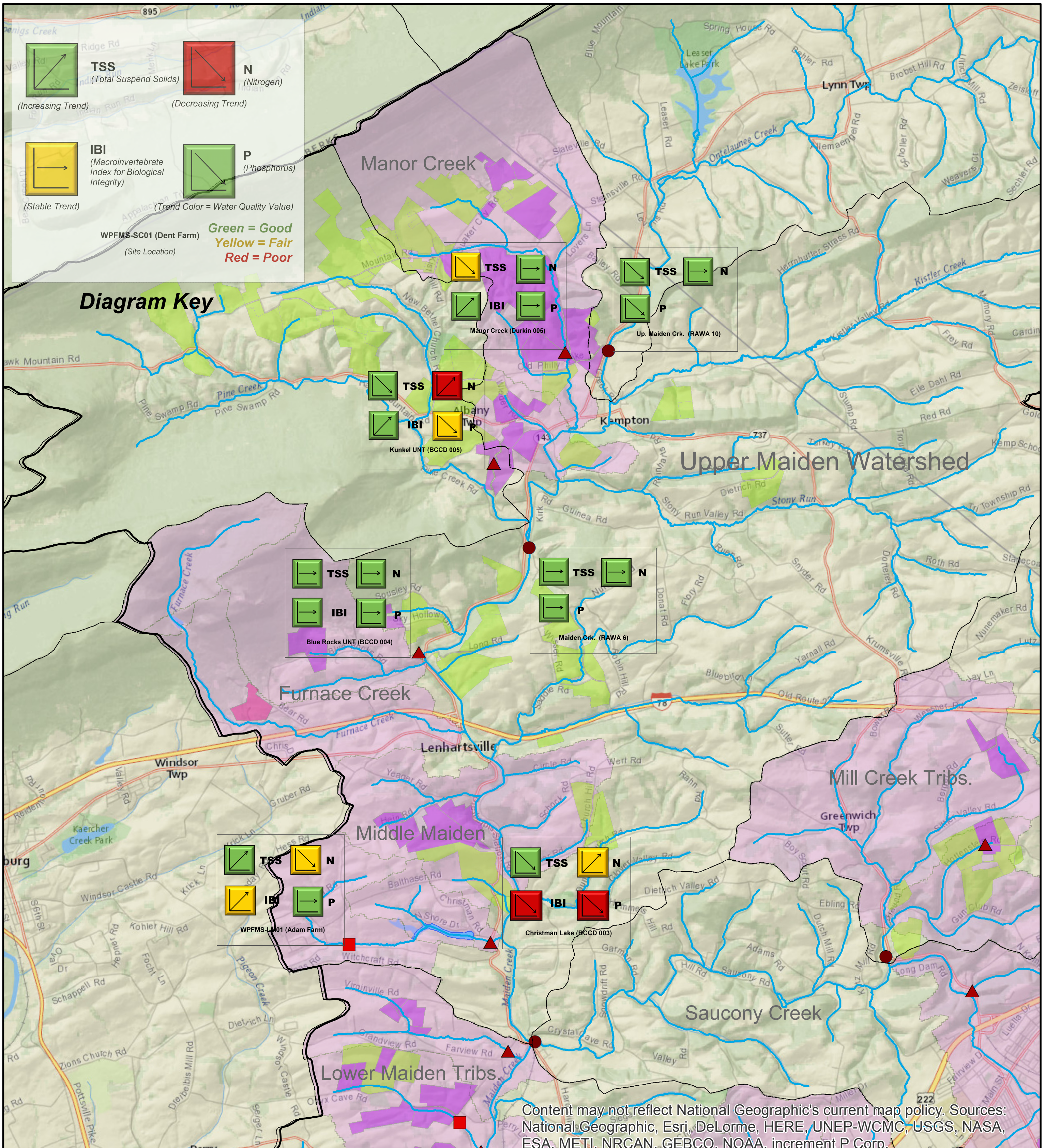
0 0.5 1 2 3 4 Miles

Legend

- RAWA Sites
- WPF-PDE Sites
- BCCD 319 Sites
- Streams
- Lake
- Maiden Creek Watershed

Cooperative Landowners Partner

- BN\PDE completed\ongoing
- BN\PDE planned
- SWRC completed\ongoing
- DWRI Focus Areas (PDE)



Upper Maiden Water Quality Map
Schuylkill Action Network
Berks County, PA

Figure 4

N

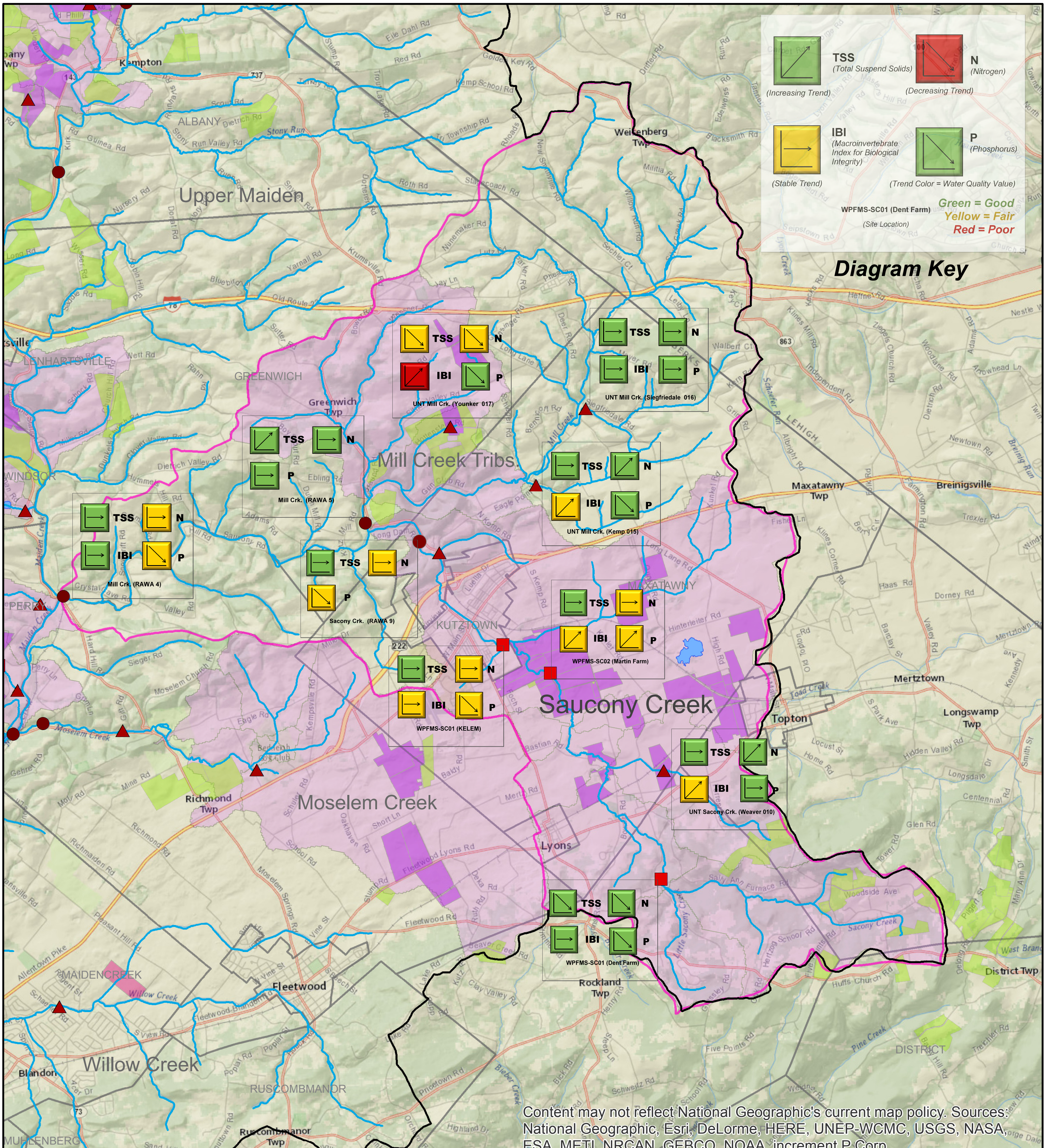
0 0.5 1 2 3 4 Miles

Legend

- RAWA Sites
- WPF-PDE Sites
- BCCD 319 Sites
- Streams
- Lake
- Maiden Creek Watershed

Cooperative Landowners Partner

- BN\PDE completed\ongoing
- BN\PDE planned
- SWRC completed\ongoing
- DWRI Focus Areas (PDE)



Saucony Creek Water Quality Map
Schuylkill Action Network
Berks County, PA

Figure 5

N

0 1.5 3 4.5 6 Miles

Legend

- RAWA Sites
- WPF-PDE Sites
- BCCD 319 Sites
- Streams
- Lake
- Maiden Creek Watershed
- Saucony Creek Watershed

Cooperative Landowners Partner

- BN\PDE completed\ongoing
- BN\PDE planned
- SWRC completed\ongoing
- DWRI Focus Areas (PDE)

LIST OF APPENDICES

Nitrogen and Phosphorus in Agricultural Streams

Nitrogen is a critical nutrient that is generally used and reused by plants within natural ecosystems, with minimal "leakage" into surface or ground water, where nitrogen concentrations remain very low (Vitousek et al., 2002). When nitrogen is applied to the land in amounts greater than can be incorporated into crops or lost to the atmosphere through volatilization or denitrification, however, nitrogen concentrations in streams can increase. The major sources of excess nitrogen in predominantly agricultural watersheds are fertilizer and animal waste; other sources include septic systems and atmospheric deposition. The total nitrogen concentration in streams consists of nitrate, the most common bioavailable form; organic nitrogen, which is generally less available to biota; and nitrite and ammonium compounds, which are typically present at relatively low levels except in highly polluted situations. Excess nitrate is not toxic to aquatic life, but increased nitrogen may result in overgrowth of algae, which can decrease the dissolved oxygen content of the water, thereby harming or killing fish and other aquatic species (U.S. EPA, 2005). Excess nitrogen also can lead to problems in downstream coastal waters, as discussed further in the N and P Loads in Large Rivers indicator.

Phosphorus also is an essential nutrient for all life forms, but at high concentrations the most biologically active form of phosphorus (orthophosphate) can cause water quality problems by overstimulating the growth of algae. In addition to being visually unappealing and causing tastes and odors in water supplies, excess algal growth can contribute to the loss of oxygen needed by fish and other animals. Elevated levels of phosphorus in streams can result from fertilizer use, animal wastes and wastewater, and the use of phosphate detergents. The fraction of total phosphorus not in the orthophosphate form consists of organic and mineral phosphorus fractions whose bioavailability varies widely.

This indicator reports nitrogen and phosphorus concentrations in stream water samples collected from 1992 to 2001 by the U.S. Geological Survey's (USGS's) National Water Quality Assessment (NAWQA) program, which surveys the condition of streams and aquifers in study units throughout the contiguous U.S. Specifically, this indicator reflects the condition of 129 to 133 streams draining watersheds where agriculture is the predominant land use (the exact number of sites with available data depends on the analyte), according to criteria outlined in Mueller and Spahr (2005). These watersheds are located in 36 of the 51 NAWQA study units (i.e., major river basins). Sites were chosen to avoid large point sources of nutrients (e.g., wastewater treatment plants). At each stream site, samples were collected 12 to 25 times each year over a 1-to-3-year period; this indicator is based on a flow-weighted annual average of those samples. Related indicators report the concentrations of nitrogen and phosphorus in small wadeable streams, regardless of land use (in contrast to this more focused indicator), and nitrate concentrations in ground water in agricultural watersheds.

For nitrogen, the indicator reports the percentage of streams with average concentrations of nitrate and total nitrogen in one of five ranges: less than 1 milligram per liter (mg/L); 1-2 mg/L; 2-6 mg/L; 6-10 mg/L; and 10 mg/L or more. This indicator measures nitrate as N, i.e., the fraction of the material that is actually nitrogen. Measurements actually include nitrate plus nitrite, but because concentrations of nitrite are typically insignificant relative to nitrate, this mixture is simply referred to as nitrate. Naturally occurring levels of nitrate and total nitrogen vary substantially across the country, and statistical analyses of water quality data suggest that appropriate reference levels range from 0.12 to 2.2 mg/L total N, such that some streams in the lowest category (less than 1 mg/L) may still exceed recommended water quality criteria (U.S. EPA, 2002).

Concentrations of total phosphorus and orthophosphate (as P) are reported in four ranges: less than 0.1 mg/L, 0.1-0.3 mg/L, 0.3-0.5 mg/L, and 0.5 mg/L or more. There is currently no national water quality criterion for either form to protect surface waters because the effects of phosphorus vary by region and are dependent on physical factors such as the size, hydrology, and depth of rivers and lakes. Nuisance algal growths are not uncommon in rivers and streams below the low reference level (0.1 mg/L) for phosphorus in this indicator, however (Dodds and Welch, 2000), and statistical analyses of water quality data suggest that more appropriate reference levels for total P range from 0.01 to 0.075 mg/L, depending on the ecoregion (U.S.

EPA, 2002). Some streams in the lowest category may exceed these recommended water quality criteria.

What the Data Show

Average flow-weighted nitrate concentrations were 2 mg/L or above in about 60 percent of stream sites in these predominantly agricultural watersheds (Exhibit 1). About 13 percent of stream sites had nitrate concentrations of at least 10 mg/L (the slightly smaller percentage of streams with total N above 10 mg/L is an artifact of the flow-weighting algorithm). Nearly half of the streams sampled had total nitrogen concentrations in the 2-6 mg/L range, and 78 percent had concentrations of 2 mg/L or above.

Nearly half of the streams in agricultural watersheds had average annual flow-weighted concentrations of orthophosphate (as P) of at least 0.1 mg/L (Exhibit 2). Approximately 85 percent of the streams had concentrations of total phosphorus of 0.1 mg/L or above, while 13 percent had at least 0.5 mg/L total phosphorus.

Limitations

- These data represent streams draining agricultural watersheds in 36 of the major river basins (study units) sampled by the NAWQA program in the contiguous U.S. While they were chosen to be representative of agricultural watersheds across the United States, they are the result of a targeted sample design, and may not be an accurate reflection of the distribution of concentrations in all streams in agricultural watersheds in the U.S.

- This indicator does not provide information about trends over time, as the data in Mueller and Spahr (2005) only represent the first cycle of the NAWQA program. NAWQA has completed its second cycle of sampling (2002–2011) and has initiated a third cycle.

Data Sources

Summary data for this indicator were provided by USGS's NAWQA program. These data have been published in Mueller and Spahr (2005), along with the individual sampling results on which the analysis is based.

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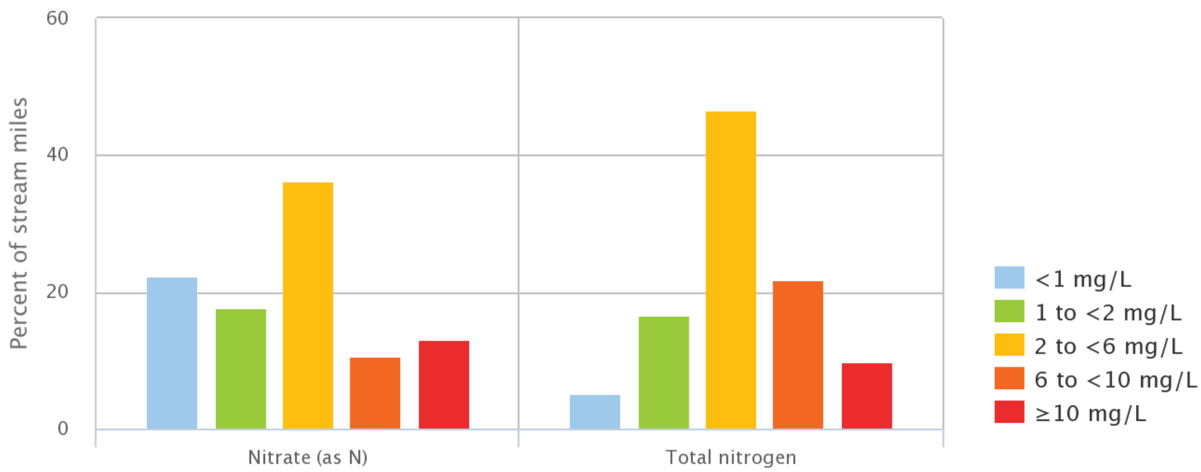
Exhibit 1. Nitrogen in streams in agricultural watersheds of the contiguous U.S., 1992–2001

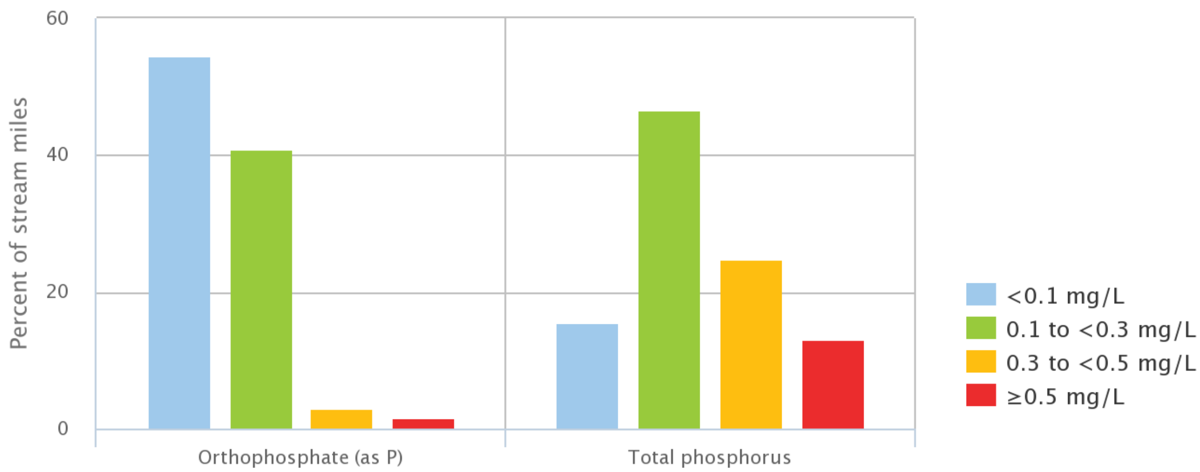


Coverage: Nitrate data from 130 stream sites; total nitrogen data from 133 stream sites. Stream sites are in watersheds where agriculture is the predominant land use. These watersheds are within 36 major river basins studied by the USGS NAWQA program.

Trend analysis has not been conducted because these data represent one cycle of sampling. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: Mueller and Spahr, 2005

Exhibit 2. Phosphorus in streams in agricultural watersheds of the contiguous U.S., 1992–2001



Coverage: Orthophosphate data from 132 stream sites; total phosphorus data from 129 stream sites. Stream sites are in watersheds where agriculture is the predominant land use. These watersheds are within 36 major river basins studied by the USGS NAWQA program.

Trend analysis has not been conducted because these data represent one cycle of sampling. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: Mueller and Spahr, 2005

Appendix B

§ 93.7. Specific water quality criteria.

(a) Table 3 displays specific water quality criteria and associated critical uses. The criteria associated with the Statewide water uses listed in § 93.4, Table 2 apply to all surface waters, unless a specific exception is indicated in § § 93.9a—93.9z. These exceptions will be indicated on a stream-by-stream or segment-by-segment basis by the words ''Add'' or ''Delete'' followed by the appropriate symbols described elsewhere in this chapter. Other specific water quality criteria apply to surface waters as specified in § § 93.9a—93.9z. All applicable criteria shall be applied in accordance with this chapter, Chapter 96 (relating to water quality standards implementation) and other applicable State and Federal laws and regulations.

TABLE 3

Parameter	*Symbol*	*Criteria*	*Critical Use**
Alkalinity	Alk	Minimum 20 mg/l as CaCO3, except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.	CWF, WWF, TSF, MF
Ammonia Nitrogen	Am	The maximum total ammonia nitrogen concentration (in mg/L) at all times shall be the numerical value given by: un-ionized ammonia nitrogen (NH_3-N) x ($\log^{-1}[pK_T-pH] + 1$), where: un-ionized ammonia nitrogen = 0.12 x f(T)/f(pH) $f(pH) = 1 + 10^{1.03(7.32-pH)}$ f(T) = 1, T ›= 10°C $f(T) = 1 + 10^{(9.73-pH)}$, T ‹ 10°C $1 + 10(^{pK_T-pH})$ and pK_T = , the dissociation 0.090 +…constant for ammonia in water. 2730 (T + 273.2) [] The average total ammonia nitrogen concentration over any 30 consecutive days shall be less than or equal to the numerical value given by: un-ionized ammonia nitrogen (NH_3-N) x ($\log^{-1}[pK_T-pH] + 1$), where: un-ionized ammonia nitrogen = 0.025 x f(T)/f(pH) f(pH) = 1, pH ›= 7.7 $f(pH) = 10^{0.74(7.7-pH)}$, pH ‹ 7.7	CWF, WWF, TSF, MF

		f(T) = 1, T ›= 10°C f(T) = 1 + $10^{(9.73\text{-pH})}$, T ‹ 10°C 1 + 10($^{pK_T\text{-pH}}$) The pH and temperature used to derive the appropriate ammonia criteria shall be determined by one of the following methods: 1) Instream measurements, representative of median pH and temperature —July through September. 2) Estimates of median pH and temperature—July through September—based upon available data or values determined by the Department. For purposes of calculating effluent limitations based on this value the accepted design stream flow shall be the actual or estimated lowest 30-consecutive-day average flow that occurs once in 10 years.	
Bacteria	Bac_1	(Fecal coliforms/ 100 ml)—During the swimming season (May 1 through September 30), the maximum fecal coliform level shall be a geometric mean of 200 per 100 milliliters (ml) based on a minimum of five consecutive samples each sample collected on different days during a 30-day period. No more than 10% of the total samples taken during a 30-day period may exceed 400 per 100 ml. For the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 per 100 milliliters (ml) based on a minimum of five consecutive samples collected on different days during a 30-day period.	WC
	Bac_2	(Coliforms/100 ml)—Maximum of 5,000/100 ml as a monthly average value, no more than this number in more than 20 of the samples collected during a month, nor more than 20,000/100 ml in more than 5% of the samples.	PWS
Chloride	Ch	Maximum 250 mg/l.	PWS
Color	Col	Maximum 75 units on the platinum-cobalt scale; no other colors perceptible to the human eye.	PWS
Dissolved Oxygen		The following specific dissolved oxygen criteria recognize the natural process of stratification in lakes, ponds and impoundments. These criteria apply to flowing freshwater and to the epilimnion of a naturally stratified lake, pond or impoundment. The hypolimnion in a naturally stratified lake, pond or impoundment is protected by the narrative water quality criteria in § 93.6 (relating to general water quality criteria). For nonstratified lakes, ponds or impoundments, the dissolved oxygen criteria apply throughout the lake, pond or impoundment to protect the critical uses.	
	DO_1	For flowing waters, 7-day average 6.0 mg/l; minimum 5.0 mg/l. For naturally reproducing salmonid early life stages, applied in accordance with subsection (b), 7-day average 9.0 mg/l; minimum 8.0 mg/l. For lakes, ponds and impoundments, minimum 5.0 mg/l.	CWF
	DO_2	7-day average 5.5 mg/l; minimum 5.0 mg/l.	WWF
	DO_3	For the period February 15 to July 31 of any year, 7-day average 6.0 mg/l; minimum 5.0 mg/l. For the remainder of the year, 7-day average 5.5 mg/l; minimum 5.0 mg/l.	TSF
Fluoride	F	Daily average 2.0 mg/l.	PWS
Iron	Fe_1	30-day average 1.5 mg/l as total recoverable.	CWF, WWF, TSF, MF
	Fe_2	Maximum 0.3 mg/l as dissolved.	PWS

Manganese	Mn	Maximum 1.0 mg/l, as total recoverable.	PWS
Nitrite plus Nitrate	N	Maximum 10 mg/l as nitrogen.	PWS
Osmotic Pressure	OP	Maximum 50 milliosmoles per kilogram.	CWF, WWF, TSF, MF
pH	pH	From 6.0 to 9.0 inclusive.	CWF, WWF, TSF, MF
Phenolics (except § 307(a)(1) (33 U.S.C.A. § 1317(a)(1)), Priority Pollutants)	Phen	Maximum 0.005 mg/l.	PWS
Sulfate	Sul	Maximum 250 mg/l.	PWS
Temperature		Maximum temperatures in the receiving water body resulting from heated waste sources regulated under Chapters 92a, 96 and other sources where temperature limits are necessary to protect designated and existing uses.	See the following table.

SYMBOL: CRITICAL USE: PERIOD	*$TEMP_1$ CWF*	*$TEMP_2$ WWF TEMPERATURE °F*	*$TEMP_3$ TSF*
January 1-31	38	40	40
February 1-29	38	40	40
March 1-31	42	46	46
April 1-15	48	52	52
April 16-30	52	58	58
May 1-15	54	64	64
May 16-31	58	72	68
June 1-15	60	80	70
June 16-30	64	84	72
July 1-31	66	87	74
August 1-15	66	87	80
August 16-30	66	87	87
September 1-15	64	84	84
September 16-30	60	78	78
October 1-15	54	72	72
October 16-31	50	66	66
November 1-15	46	58	58
November 16-30	42	50	50
December 1-31	40	42	42

Parameter	*Symbol*	*Criteria*	*Critical Use**
Total Dissolved Solids	TDS	500 mg/l as a monthly average value; maximum 750 mg/l.	PWS
Total Residual Chlorine	TRC	Four-day average 0.011 mg/l; 1-hour average 0.019 mg/l.	CWF, WWF, TSF, MF

* Critical Use: The designated or existing use the criteria are designed to protect. More stringent site-specific criteria may be developed to protect other more sensitive, intervening uses.

(b) For naturally reproducing salmonids, protected early life stages include embryonic and larval stages and juvenile forms to 30 days after hatching. The DO_1 standard for naturally reproducing salmonid early life stages applies October 1 through May 31. The DO_1 standard for naturally reproducing salmonid early life stages applies unless it can be demonstrated to the Department's satisfaction, that the following conditions are documented: 1) the absence of young of the year salmonids measuring less than 150 mm in the surface water; and 2) the absence of multiple age classes of salmonids in the surface water. These conditions only apply to salmonids resulting from natural reproduction occurring in the surface waters. Additional biological information may be considered by the Department which evaluates the presence or absence of early life stages.

(c) The list of specific water quality criteria does not include all possible substances that could cause pollution. For substances not listed, the general criterion that these substances may not be inimical or injurious to the existing or designated water uses applies. The Department will develop a criterion for any substance not listed in Table 3 that is determined to be inimical or injurious to existing or designated water uses using the best available scientific information, as determined by the Department.

(d) If the Department determines that natural quality of a surface water segment is of lower quality than the applicable aquatic life criteria in Table 3 or 5, the natural quality shall constitute the aquatic life criteria for that segment. All draft natural quality determinations will be published in the *Pennsylvania Bulletin* and be subject to a minimum 30-day comment period. The Department will maintain a publicly available list of surface waters and parameters where this subsection applies, and will, from time to time, submit appropriate amendments to § § 93.9a—93.9z.

Authority

The provisions of this § 93.7 amended under sections 5(b)(1) and 402 of The Clean Streams Law (35 P. S. § § 691.5(b)(1) and 691.402); and section 1920-A of The Administrative Code of 1929 (71 P. S. § 510-20).

Source

The provisions of this § 93.7 amended through March 8, 1985, effective February 16, 1985, 15 Pa.B. 907; amended March 10, 1989, effective March 11, 1989, 19 Pa.B. 968; amended February 11, 1994, effective February 12, 1994, 24 Pa.B. 832; amended April 3, 1998, effective November 4, 1995, 28 Pa.B. 1633; amended July 16, 1999, effective July 17, 1999, 29 Pa.B. 3720; amended November 17, 2000, effective November 18, 2000, 30 Pa.B. 6059; amended February 11, 2005, effective February 12, 2005, 35 Pa.B. 1197; amended January 5, 2007, effective January 6, 2007, 37 Pa.B. 11; amended May 15, 2009, effective May 16, 2009, 39 Pa.B. 2523; amended July 19, 2013, effective July 20, 2013, 43 Pa.B. 4080. Immediately preceding text appears at serial pages (343950) to (343955).

Notes of Decisions

The Department of Environmental Resources is not required to consider the economic consequences to a discharger in establishing water-quality based effluent limitations in a National Pollutant Discharge Elimination System (NPDES) Permit. *Mathies Coal Company v. Department of Environmental Resources*, 559 A.2d 506 (Pa. 1989).

The water quality standards in 25 Pa. Code § 93.7 are to be considered only as one of the major factors in developing discharge limitations, and neither these standards nor effluent limitations based on them in case-by-case DER determinations require a presumption of validity. *Lucas v. Department of Environmental Resources*, 420 A.2d 1 (Pa. Cmwlth. 1980).

Cross References

This section cited in 25 Pa. Code § 93.4b (relating to qualifying as High Quality or Exceptional Value Waters); 25 Pa. Code § 93.8d (relating to development on site-specific water quality criteria); and 25 Pa. Code § 96.3 (relating to water quality protection requirements).

Appendix C: Pennsylvania Rainfall Totals 2007 – 2018

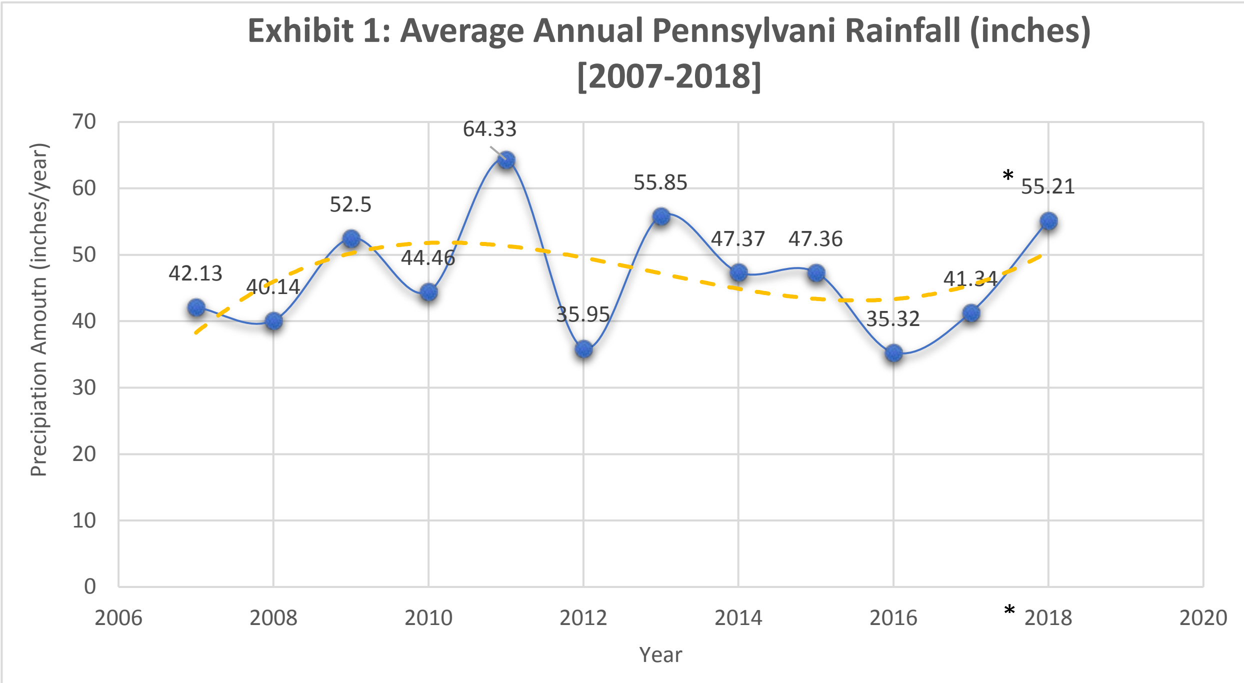
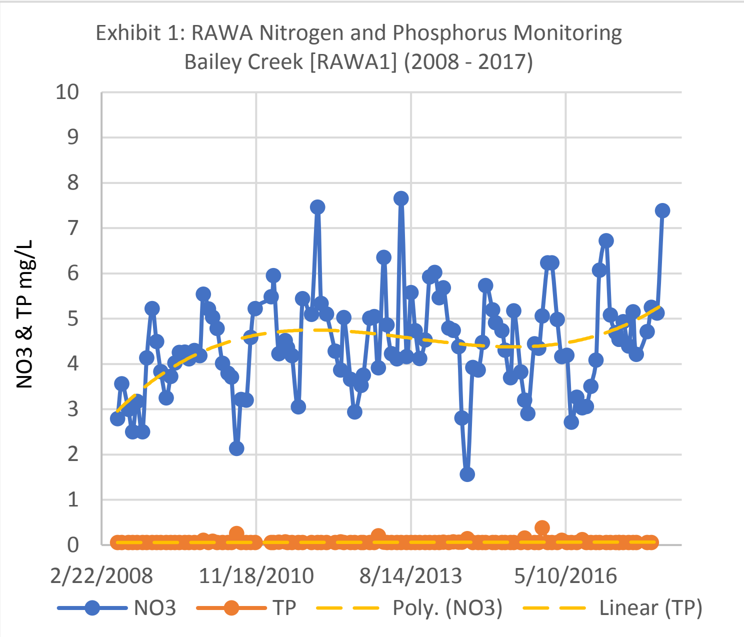
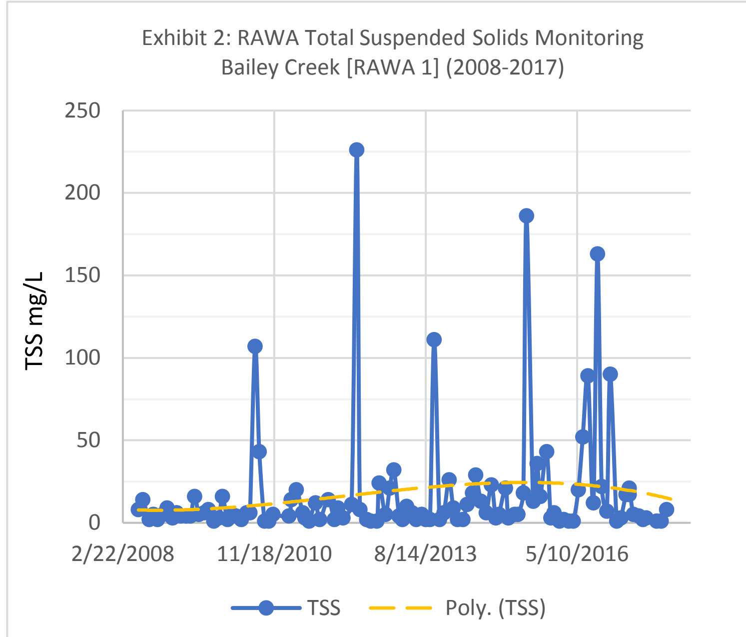


**Exhibit 1: 2018 rainfall totals as of 12/5/2018. The top three rain totals for Pennsylvania have all occurred in last 8 years [2011, 2013, 2018] Rainfall Accumulation Data provided through JCWeather and Weather Underground.*

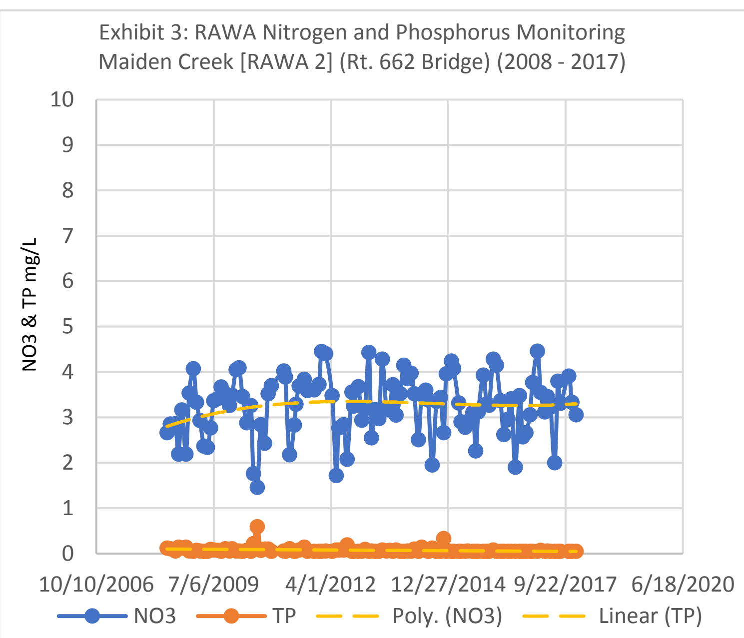
Appendix D: RAWA Water Quality Exhibits

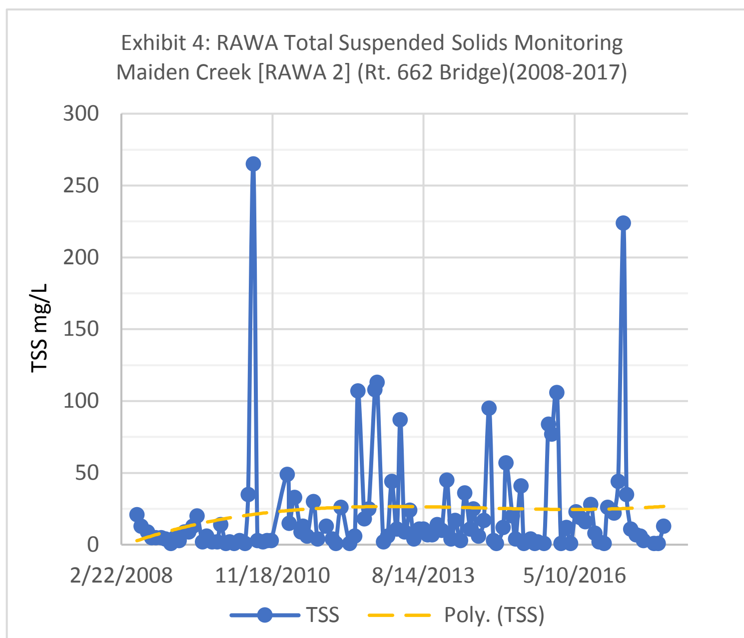
1. Bailey Creek – RAWA 1



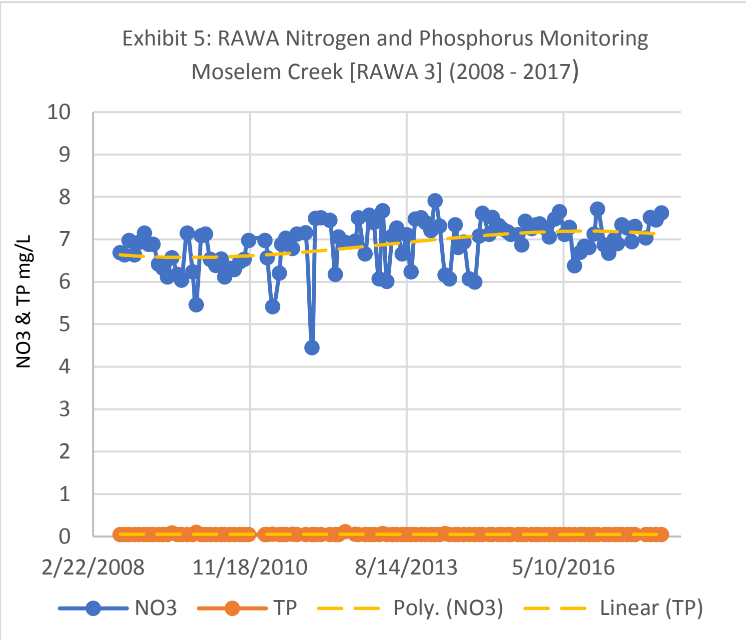


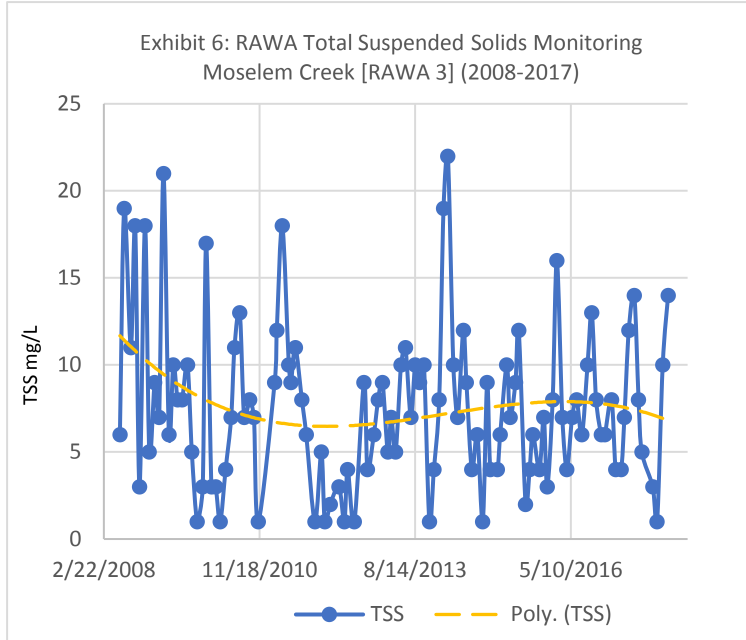
2. Maiden Creek (Rt. 662 Bridge) – RAWA 2



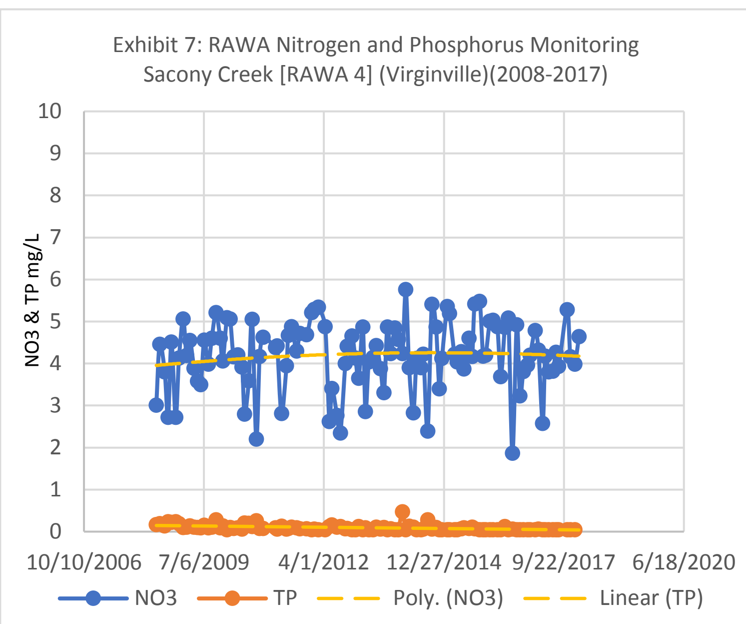


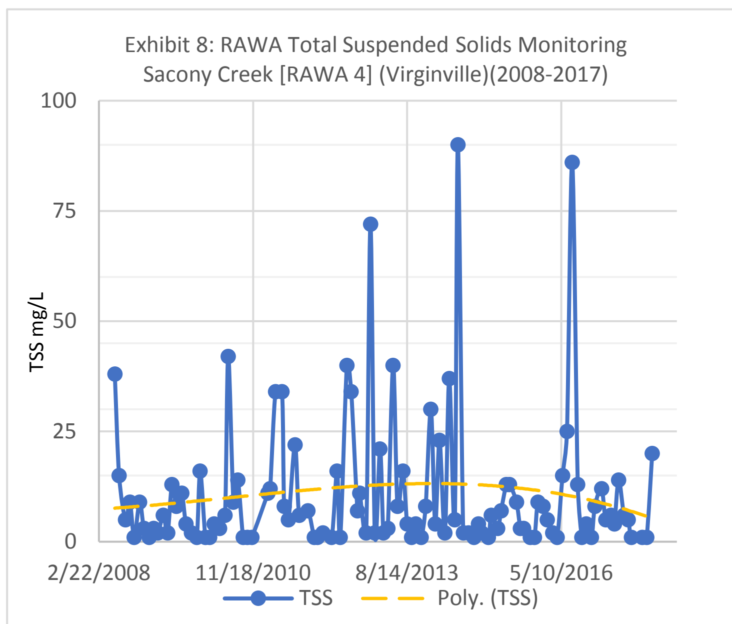
3. Moselem Creek – RAWA 3



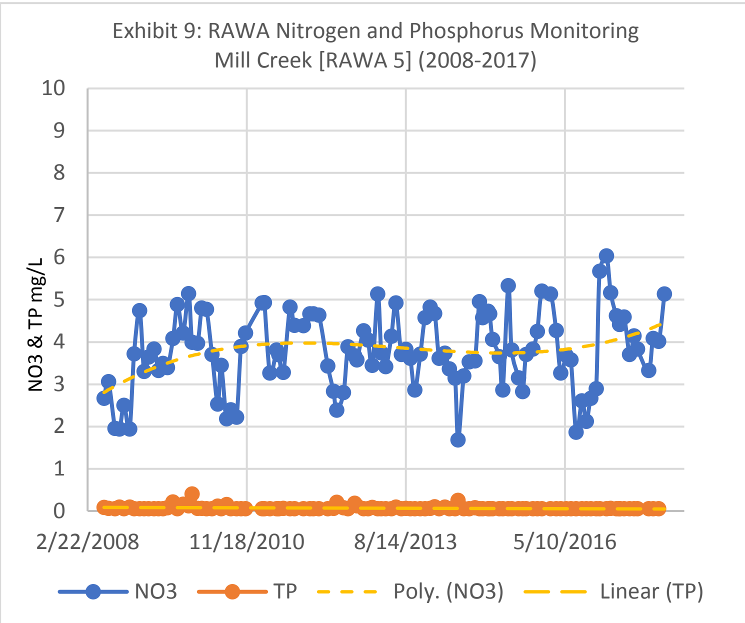


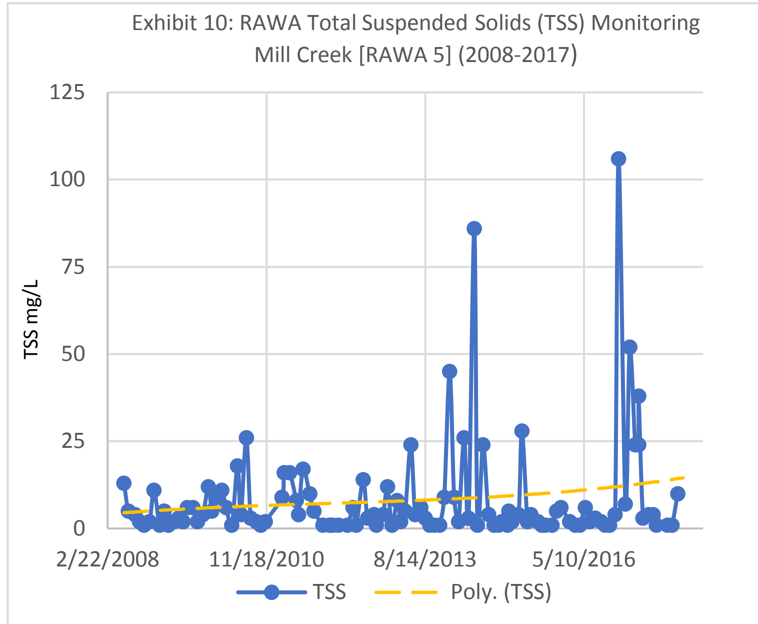
4. Sacony Creek (Virginville) – RAWA 4



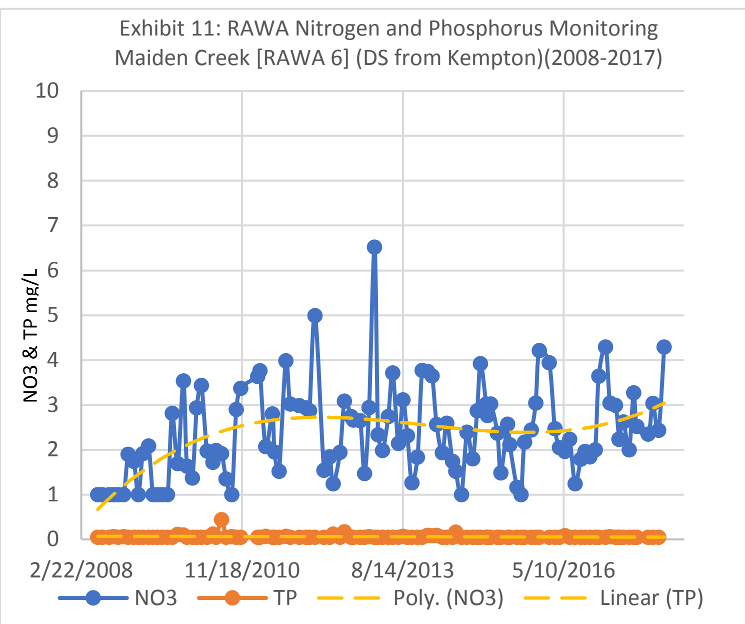


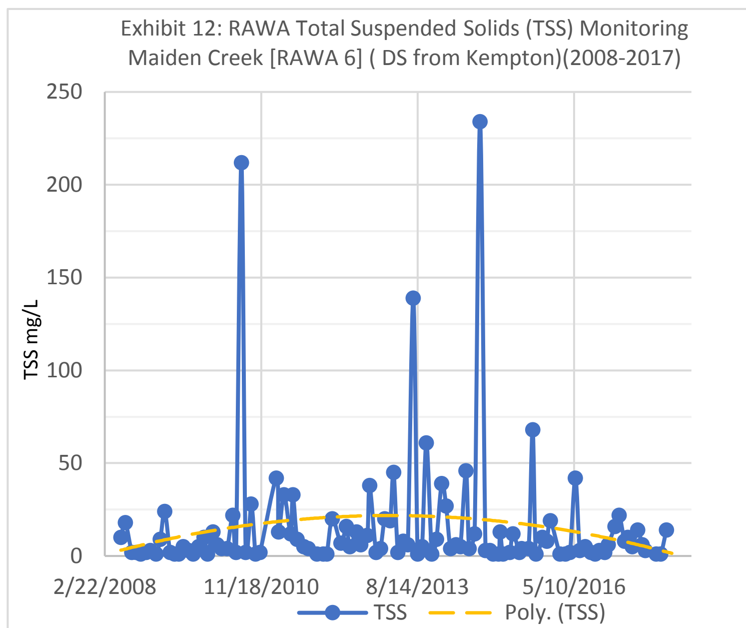
5. Mill Creek – RAWA 5



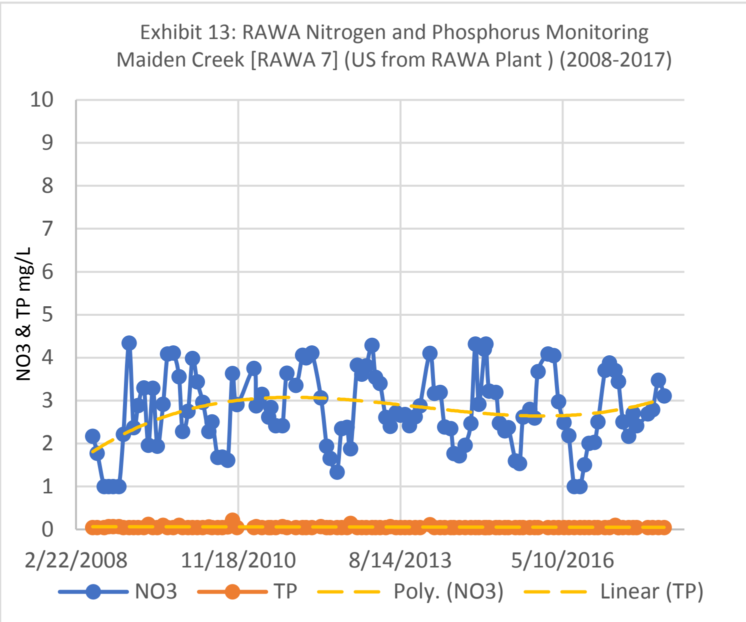


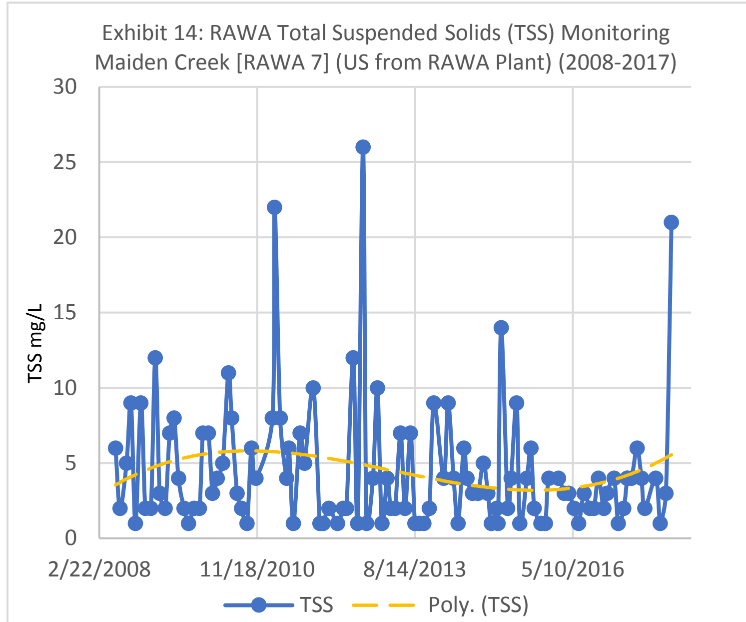
6. Maiden Creek (DS from Kempton) – RAWA 6



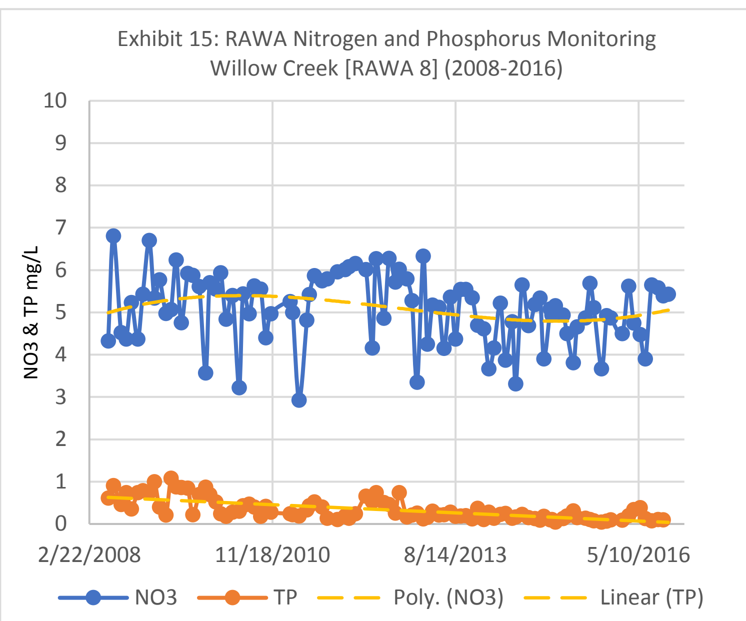


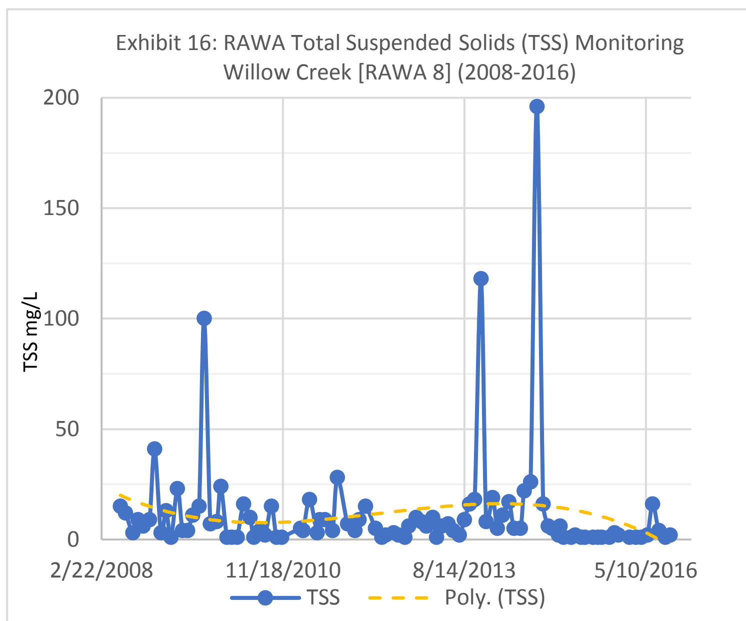
7. Maiden Creek (US from RAWA Plant) – RAWA 7



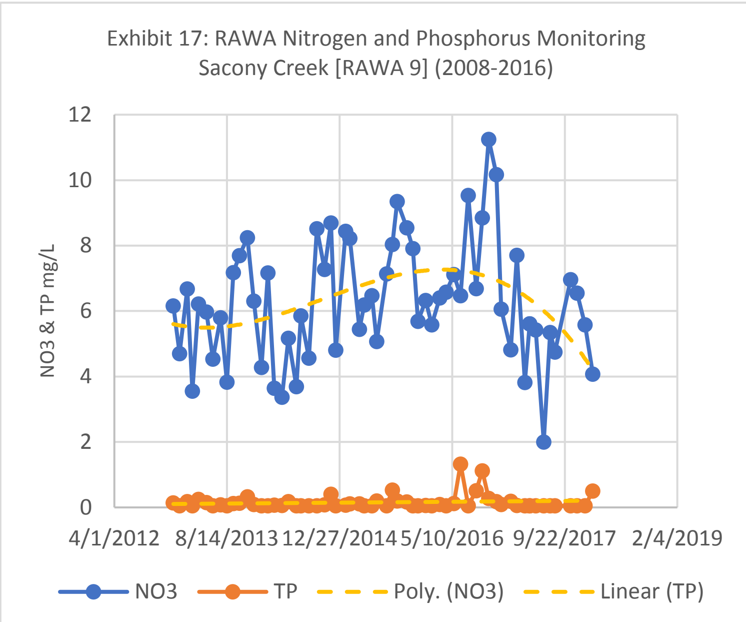


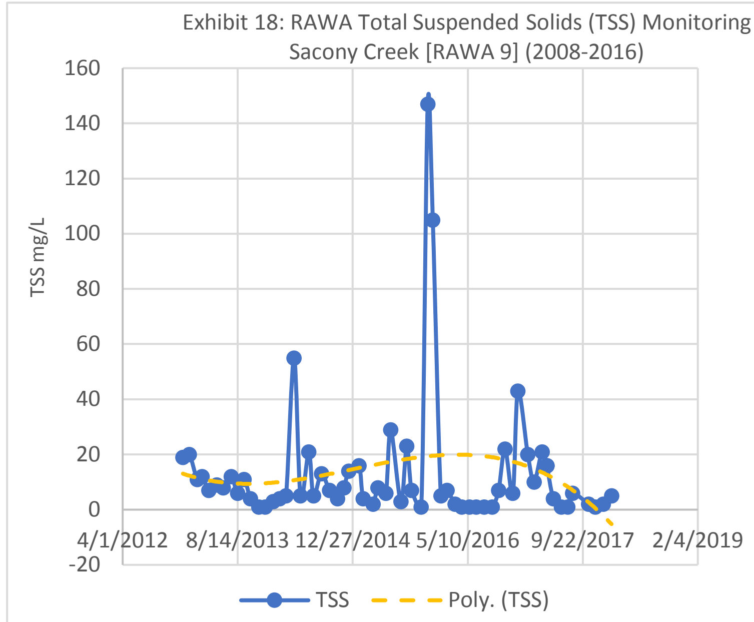
8. Willow Creek – RAWA 8



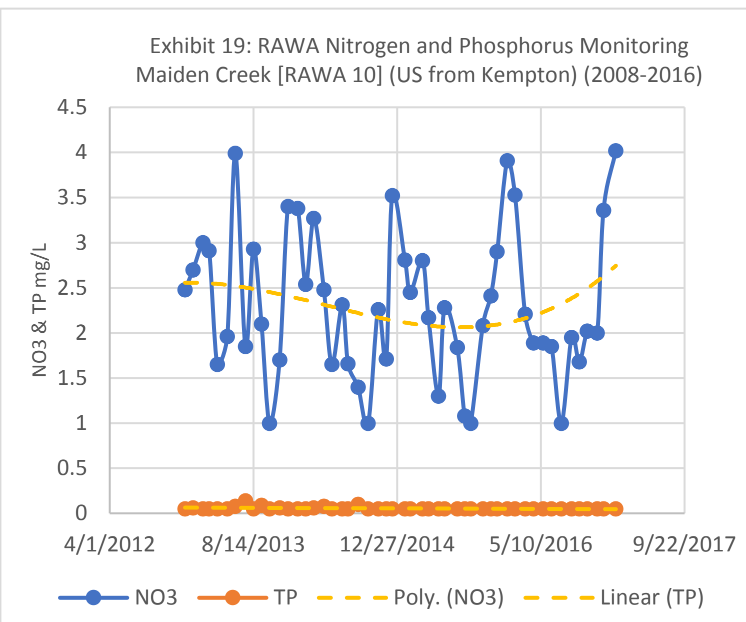


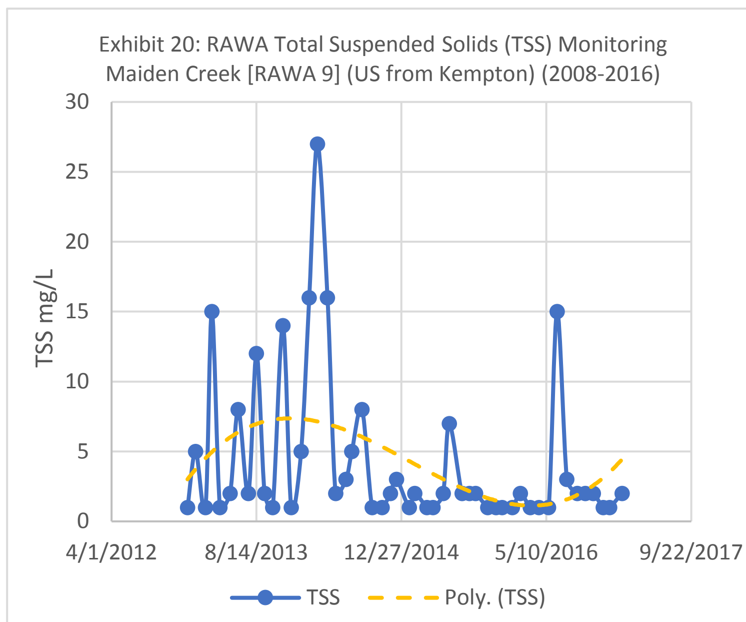
9. Sacony Creek (DS from Kutztown) – RAWA 9





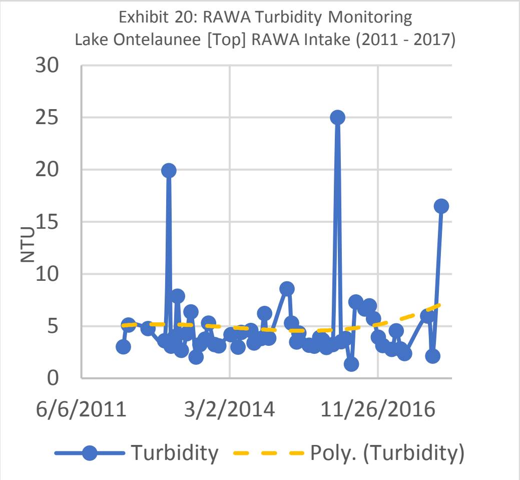
10. Maiden Creek (US from Kempton) – RAWA 10

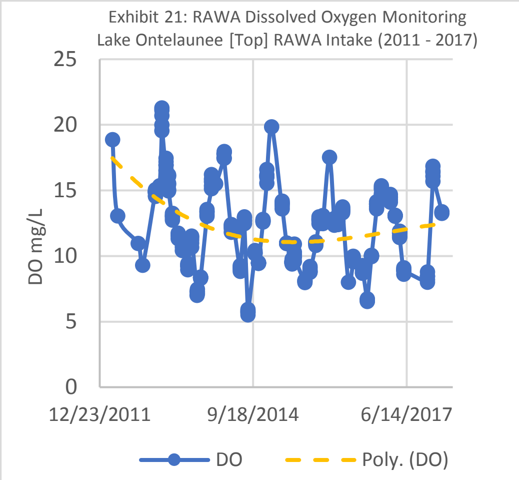


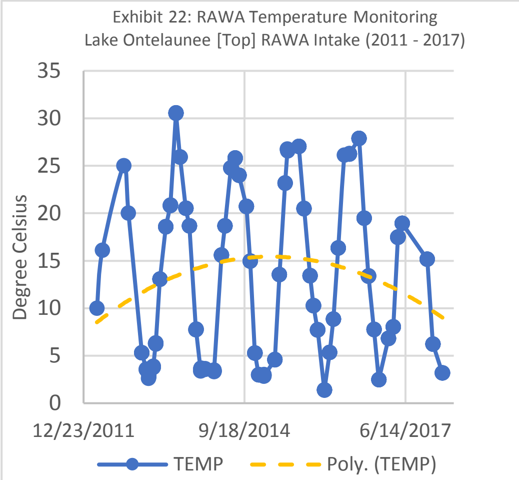


11. Lake Ontelaunee (RAWA Intake)

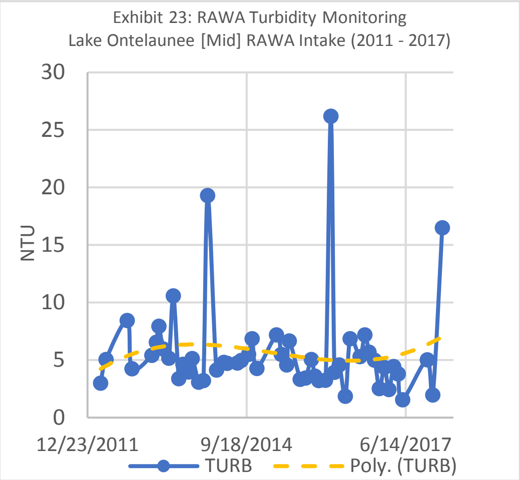
Lake Top

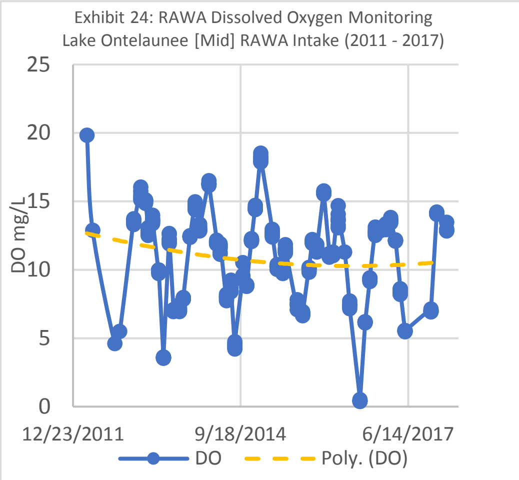


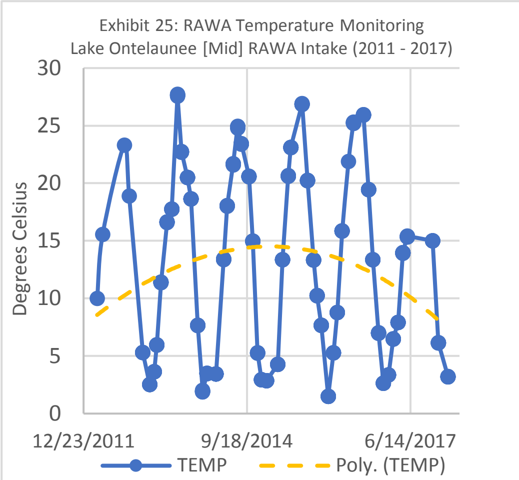




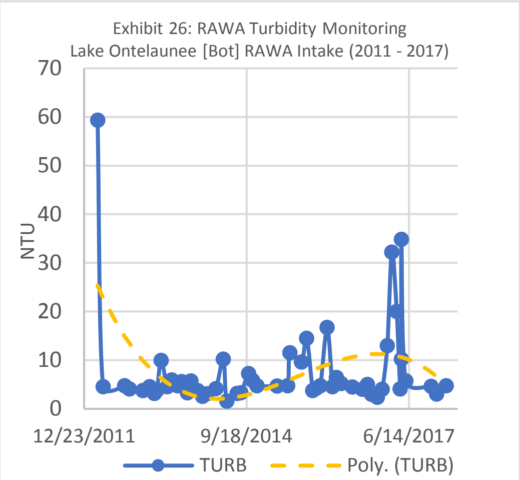
Lake Middle

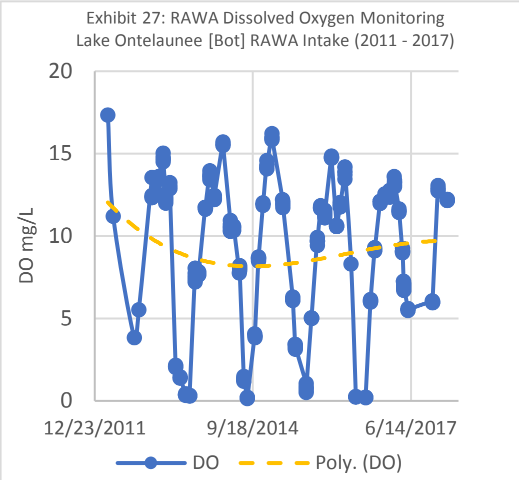


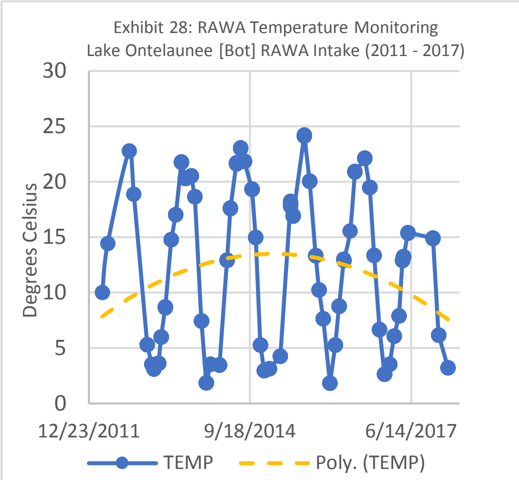




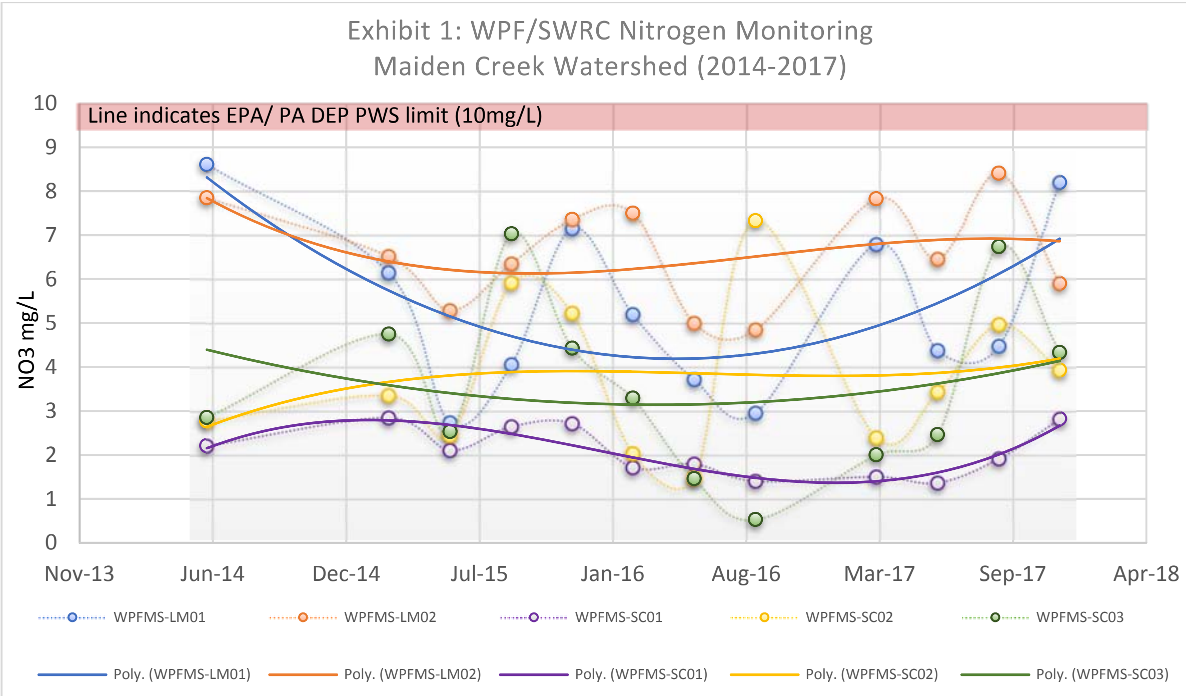
Lake Bottom

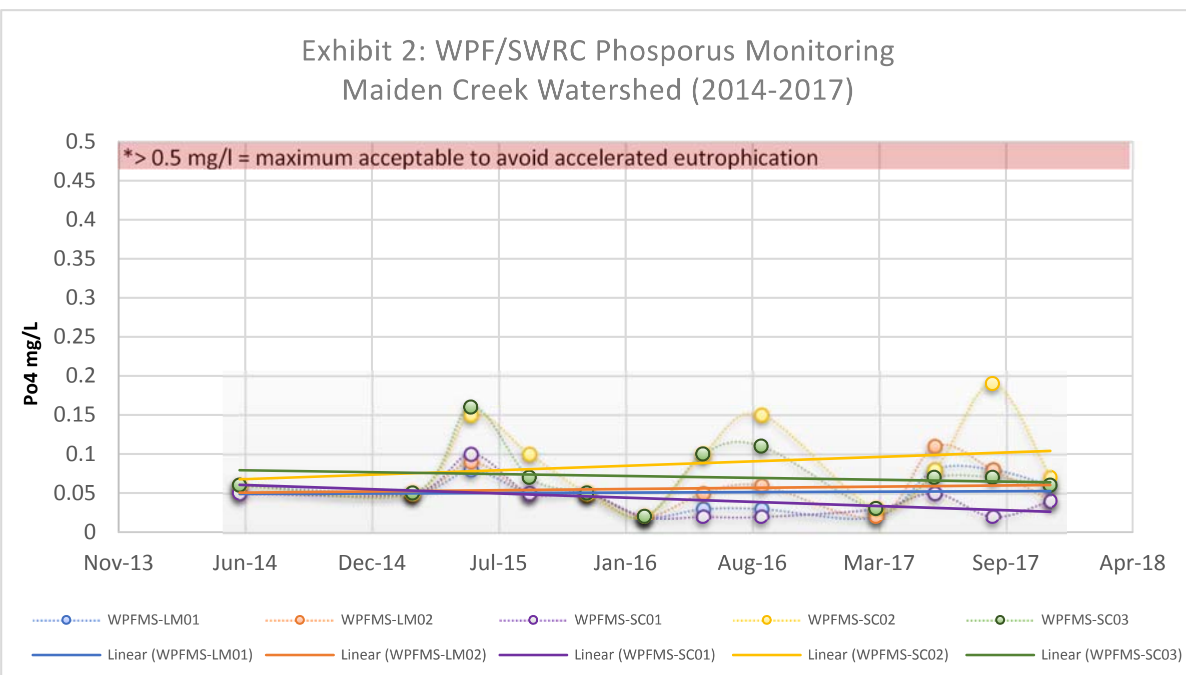






Appendix E: William Penn Foundation & Stroud Water Research Center Water Quality Exhibits





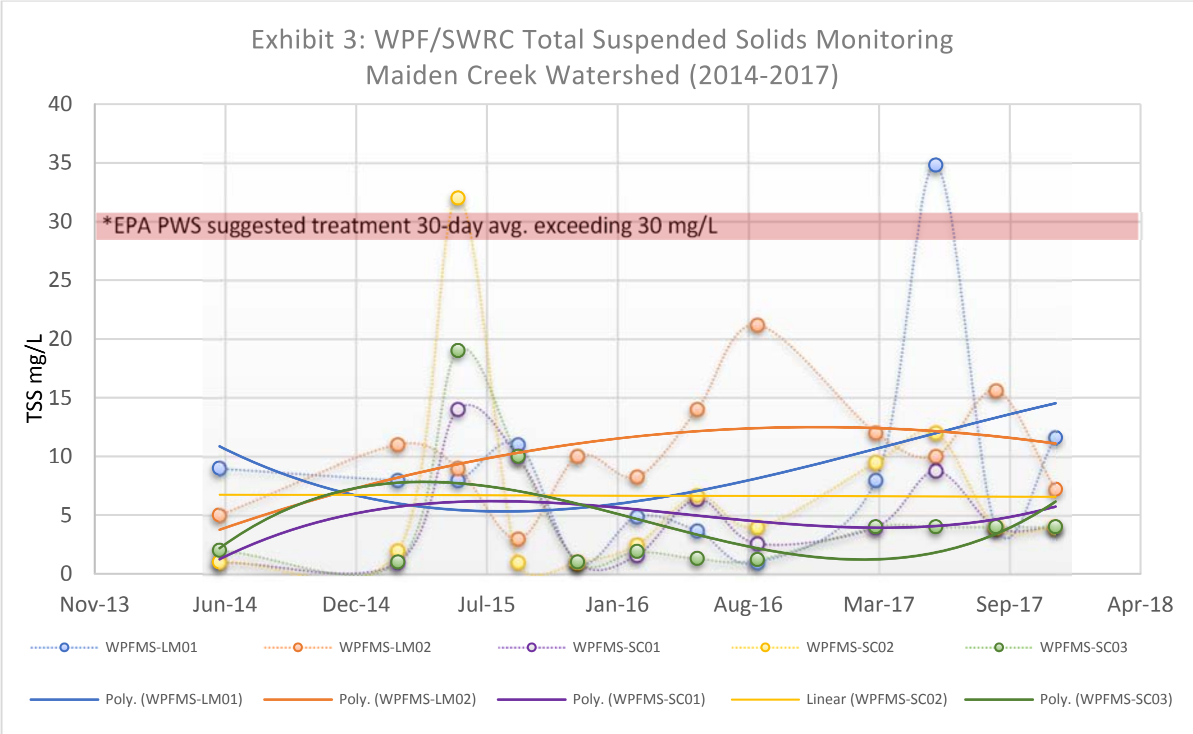
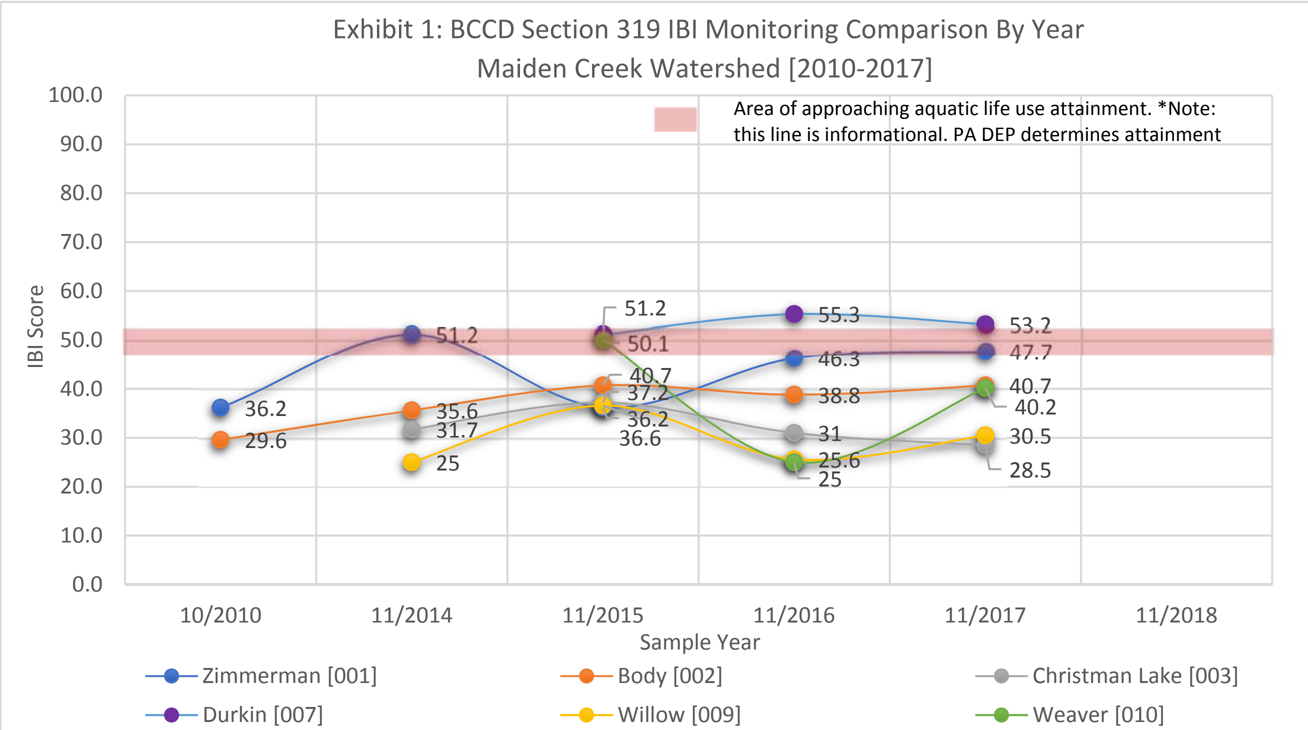
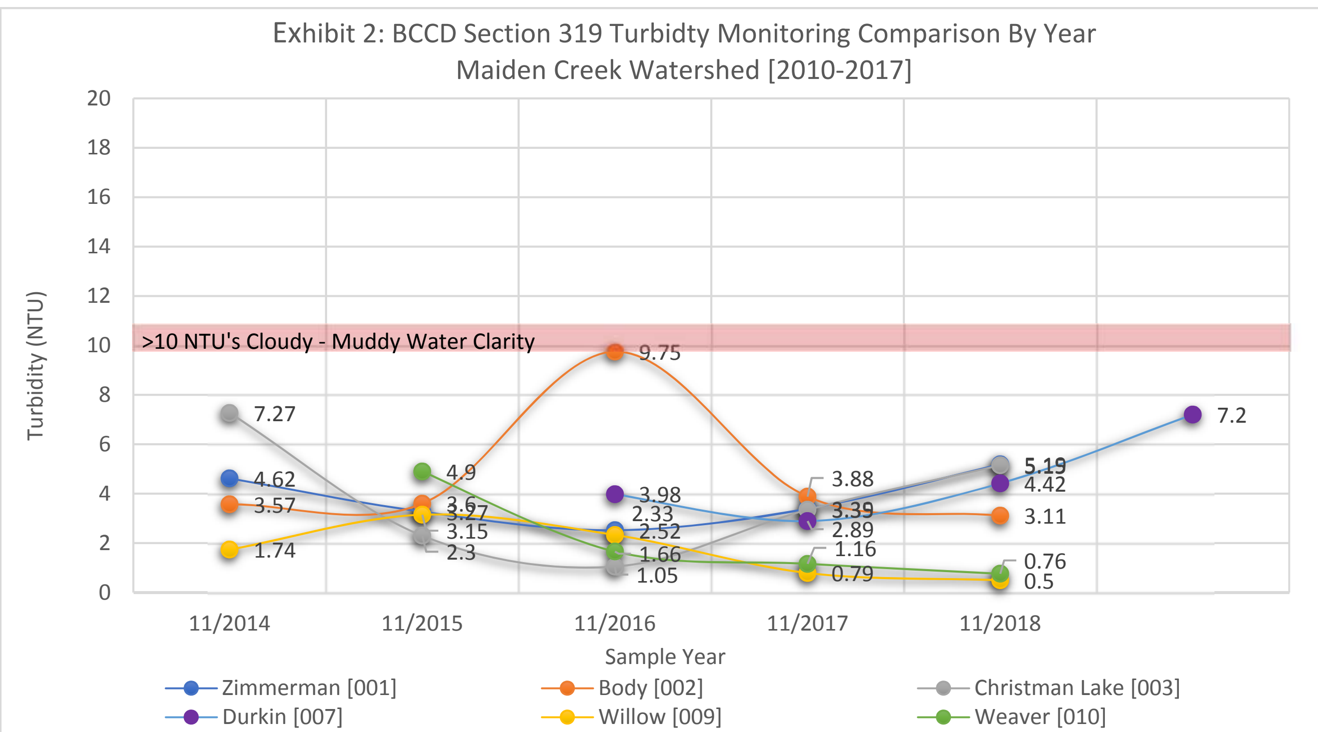


Exhibit 3: WPF/SWRC Total Suspended Solids Monitoring
Maiden Creek Watershed (2014-2017)
TSS mg/L
40
35
30
25
20
15
10
5
0
*EPA PWS suggested treatment 30-day avg. exceeding 30 mg/L
Nov-13
Jun-14
Dec-14
Jul-15
Jan-16
Aug-16
Mar-17
Sep-17
Apr-18
WPFMS-LM01
WPFMS-LM02
WPFMS-SC01
WPFMS-SC02
WPFMS-SC03
Poly. (WPFMS-LM01)
Poly. (WPFMS-LM02)
Poly. (WPFMS-SC01)
Linear (WPFMS-SC02)
Poly. (WPFMS-SC03)

Appendix F: Berks County Conservation District Section 319 NWQI WQ Exhibits





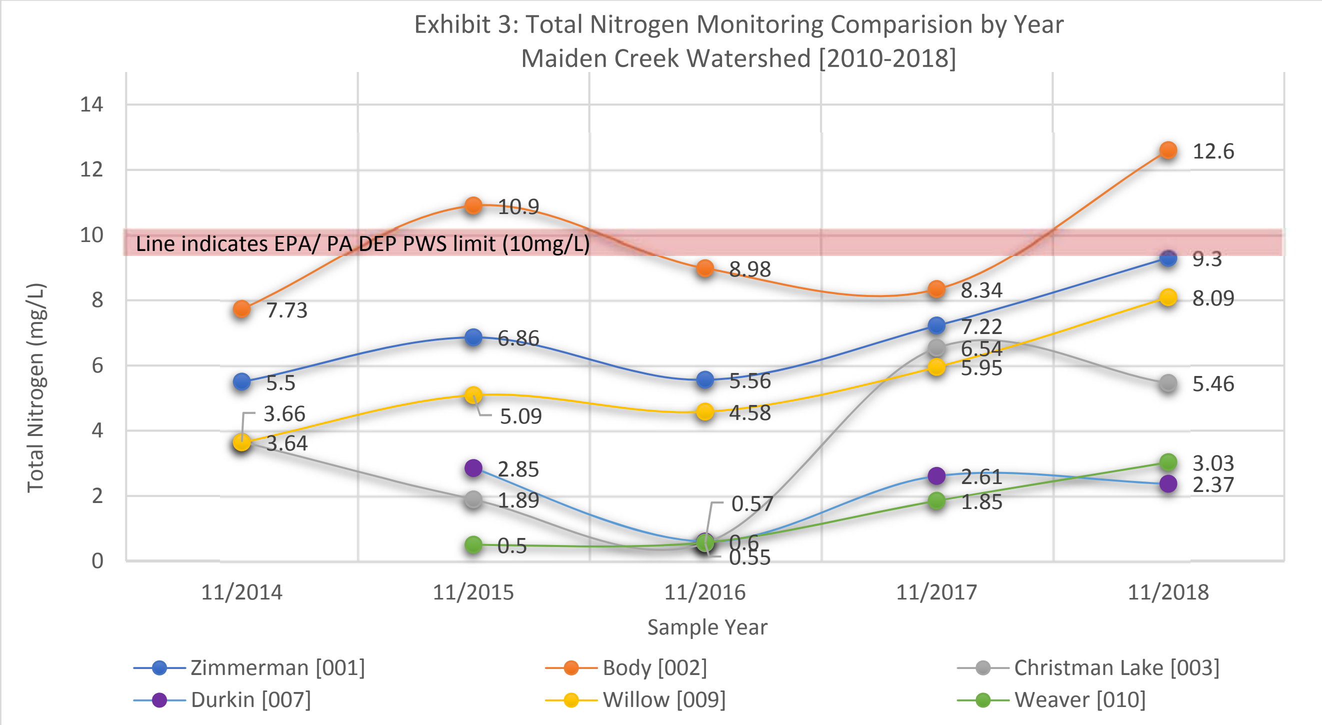


Exhibit 3: Total Nitrogen Monitoring Comparision by Year
Maiden Creek Watershed [2010-2018]
Line indicates EPA/ PA DEP PWS limit (10mg/L)
Total Nitrogen (mg/L)
14
12
10
8
6
4
2
0
7.73
10.9
8.98
8.34
12.6
9.3
8.09
5.5
6.86
5.56
7.22
6.54
5.95
5.46
3.66
3.64
5.09
4.58
2.85
1.89
0.57
0.6
0.55
0.5
2.61
1.85
3.03
2.37
11/2014
11/2015
11/2016
11/2017
11/2018
Sample Year
Zimmerman [001]
Body [002]
Christman Lake [003]
Durkin [007]
Willow [009]
Weaver [010]

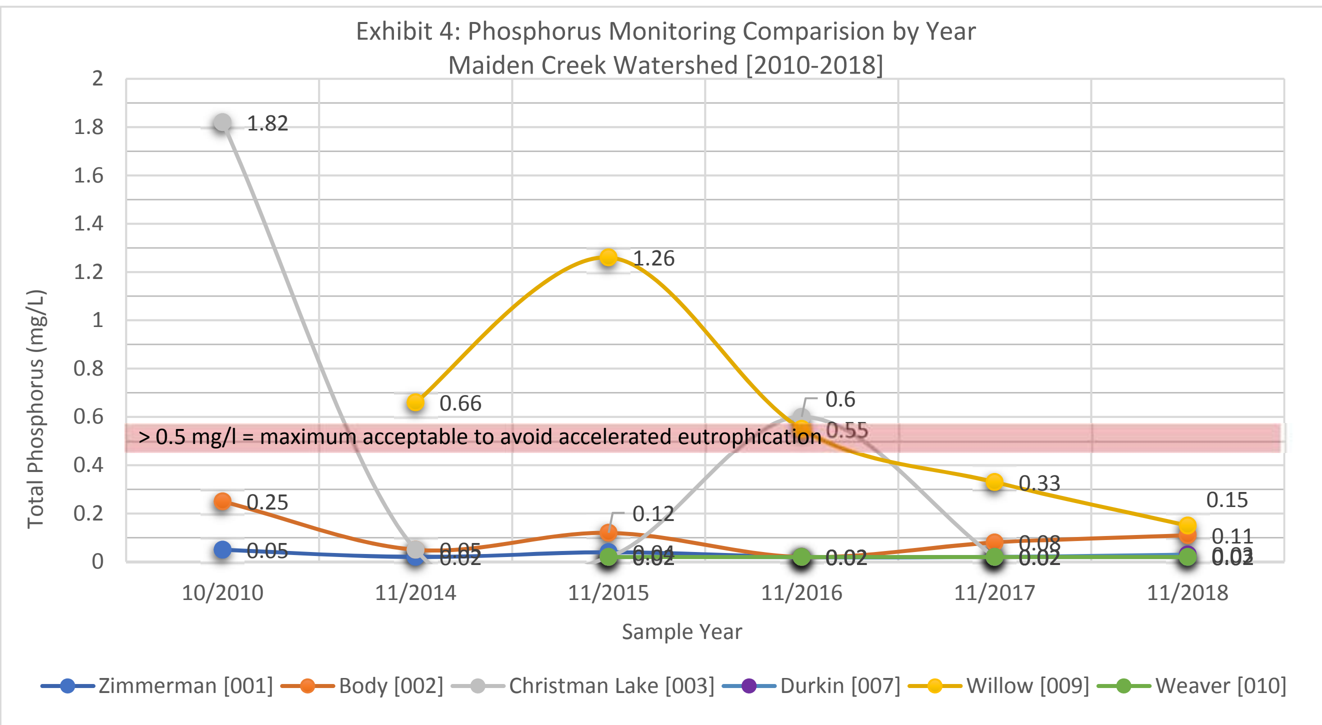


Exhibit 4: Phosphorus Monitoring Comparision by Year
Maiden Creek Watershed [2010-2018]
> 0.5 mg/l = maximum acceptable to avoid accelerated eutrophication
Total Phosphorus (mg/L)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.82
1.26
0.66
0.6
0.55
0.33
0.15
0.25
0.05
0.12
0.11
0.08
0.04
0.02
10/2010
11/2014
11/2015
11/2016
11/2017
11/2018
Sample Year
Zimmerman [001]
Body [002]
Christman Lake [003]
Durkin [007]
Willow [009]
Weaver [010]

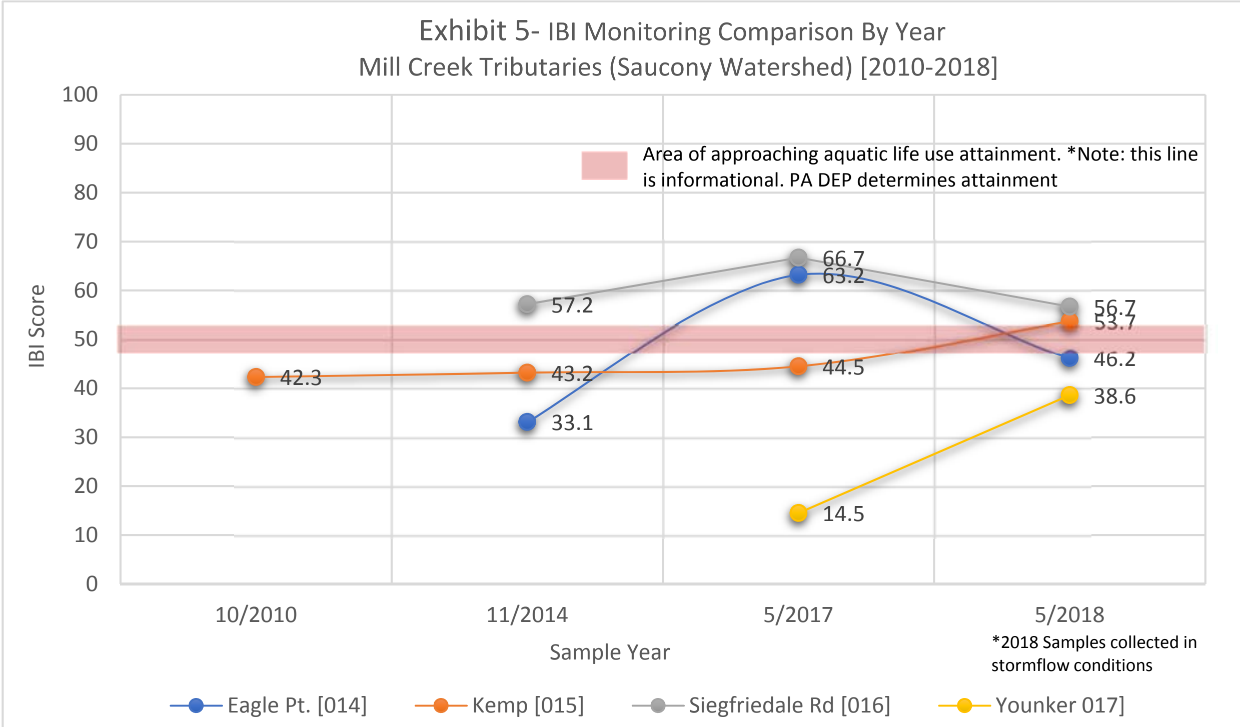


Exhibit 5- IBI Monitoring Comparison By Year
Mill Creek Tributaries (Saucony Watershed) [2010-2018]
Area of approaching aquatic life use attainment. *Note: this line is informational. PA DEP determines attainment
IBI Score
100
90
80
70
60
50
40
30
20
10
0
66.7
63.2
57.2
56.7
53.7
46.2
42.3
43.2
44.5
33.1
38.6
14.5
10/2010
11/2014
5/2017
5/2018
*2018 Samples collected in stormflow conditions
Sample Year
Eagle Pt. [014]
Kemp [015]
Siegfriedale Rd [016]
Younker 017]

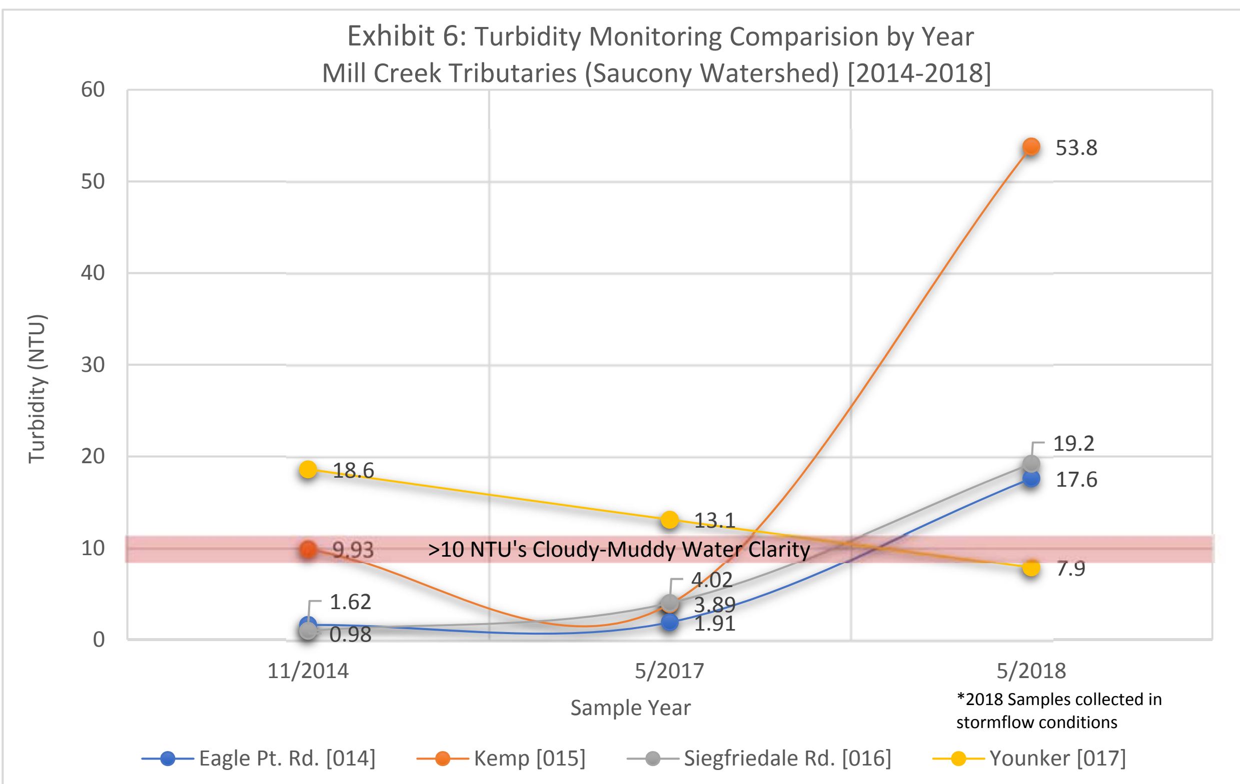


Exhibit 6: Turbidity Monitoring Comparision by Year
Mill Creek Tributaries (Saucony Watershed) [2014-2018]
Turbidity (NTU)
60
50
40
30
20
10
0
53.8
19.2
17.6
18.6
13.1
9.93
>10 NTU's Cloudy-Muddy Water Clarity
7.9
4.02
3.89
1.91
1.62
0.98
11/2014
5/2017
5/2018
*2018 Samples collected in stormflow conditions
Sample Year
Eagle Pt. Rd. [014]
Kemp [015]
Siegfriedale Rd. [016]
Younker [017]

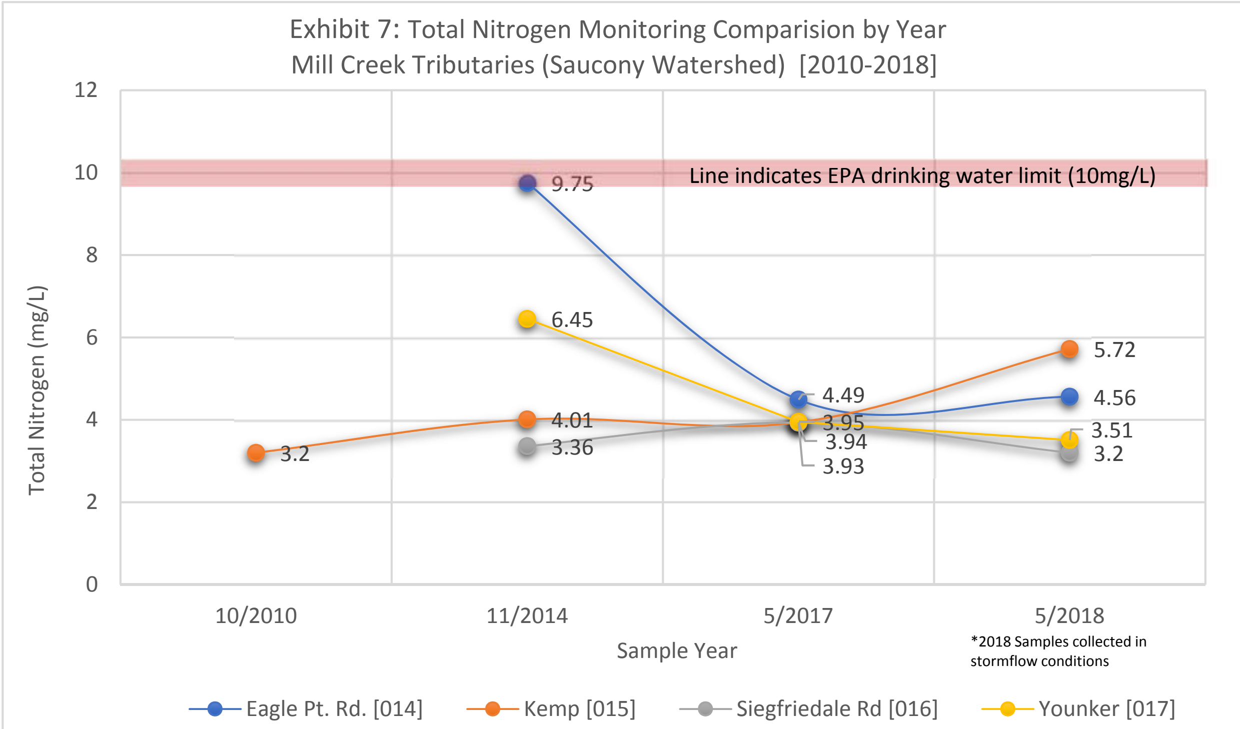


Exhibit 7: Total Nitrogen Monitoring Comparision by Year
Mill Creek Tributaries (Saucony Watershed) [2010-2018]
Total Nitrogen (mg/L)
12
10
8
6
4
2
0
Line indicates EPA drinking water limit (10mg/L)
9.75
6.45
4.01
3.36
3.2
4.49
3.95
3.94
3.93
5.72
4.56
3.51
3.2
10/2010
11/2014
5/2017
5/2018
Sample Year
*2018 Samples collected in stormflow conditions
Eagle Pt. Rd. [014]
Kemp [015]
Siegfriedale Rd [016]
Younker [017]

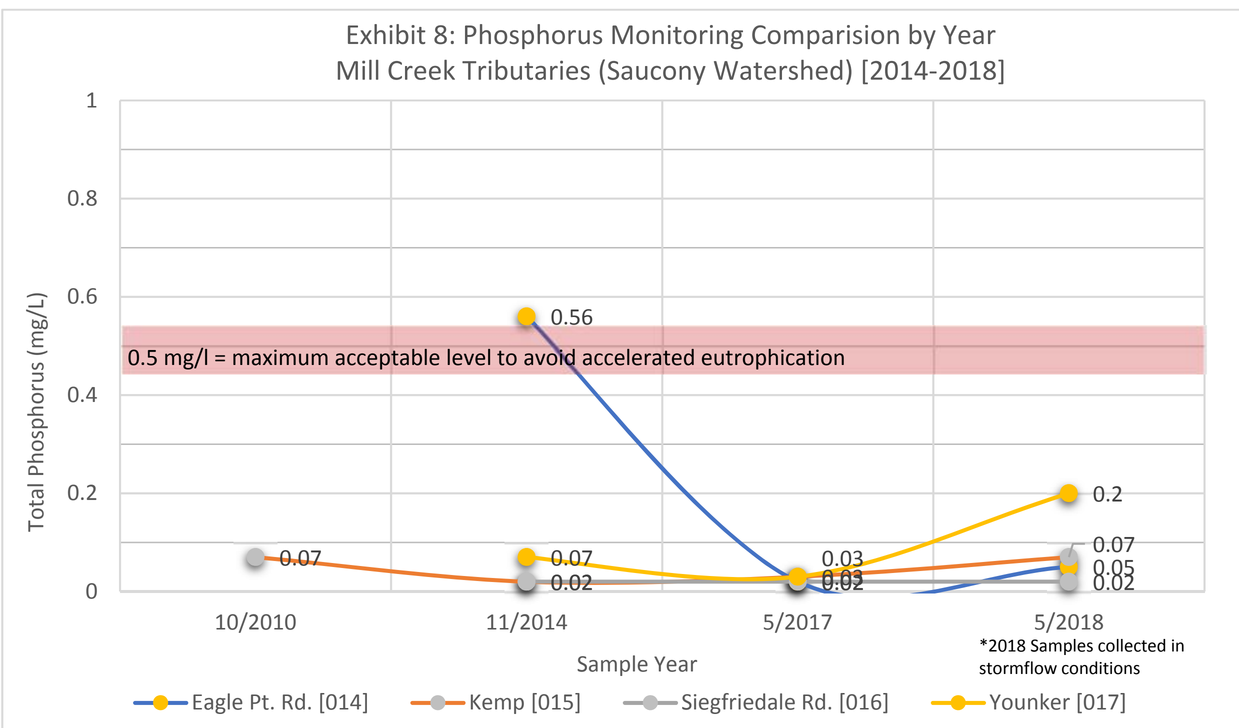


Exhibit 8: Phosphorus Monitoring Comparision by Year
Mill Creek Tributaries (Saucony Watershed) [2014-2018]
Total Phosphorus (mg/L)
1
0.8
0.6
0.4
0.2
0
0.56
0.5 mg/l = maximum acceptable level to avoid accelerated eutrophication
0.07
0.07
0.02
0.03
0.2
0.07
0.05
0.02
10/2010
11/2014
5/2017
5/2018
Sample Year
*2018 Samples collected in stormflow conditions
Eagle Pt. Rd. [014]
Kemp [015]
Siegfriedale Rd. [016]
Younker [017]

Appendix G

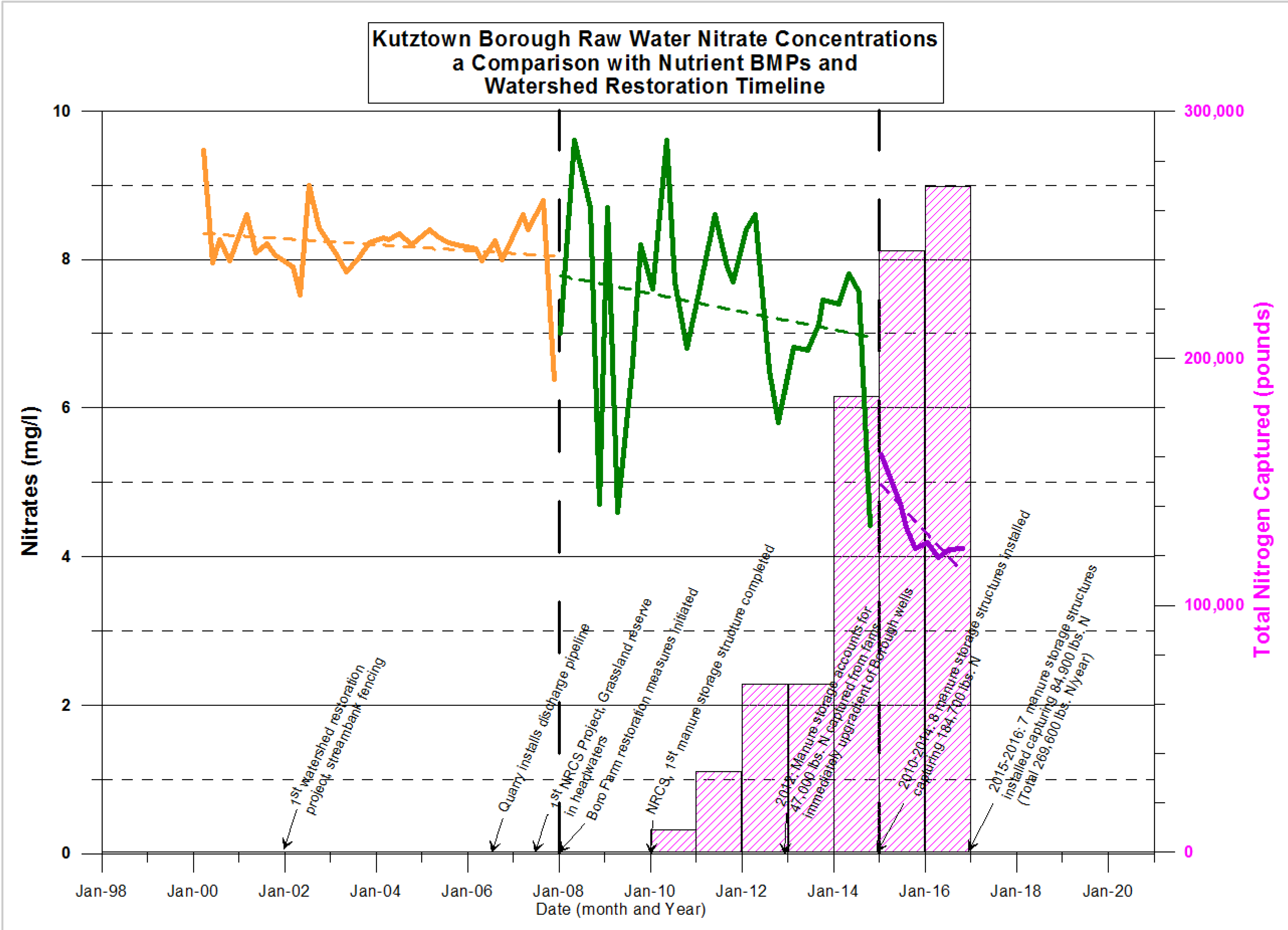


Figure 9
Nitrate Concentrations and Watershed Restoration
Saucony Creek Watershed
Berks County, PA

Nitrogen Capture
2000 - 2007 NO_3-N (mg/l)
2008 - 2014 NO_3-N (mg/l)
2015 - 2016 NO_3-N (mg/l)

Data Source:
Graph, SSM, 2016

SSM GROUP, INC.
Engineering and Environmental Services
Reading | Lehigh Valley | Central Pennsylvania
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12/20/16

Document Path: G:\projects\w100000\w108440\w0025\projects\fig_9_nitrate_conc_restoration_comp.mxd

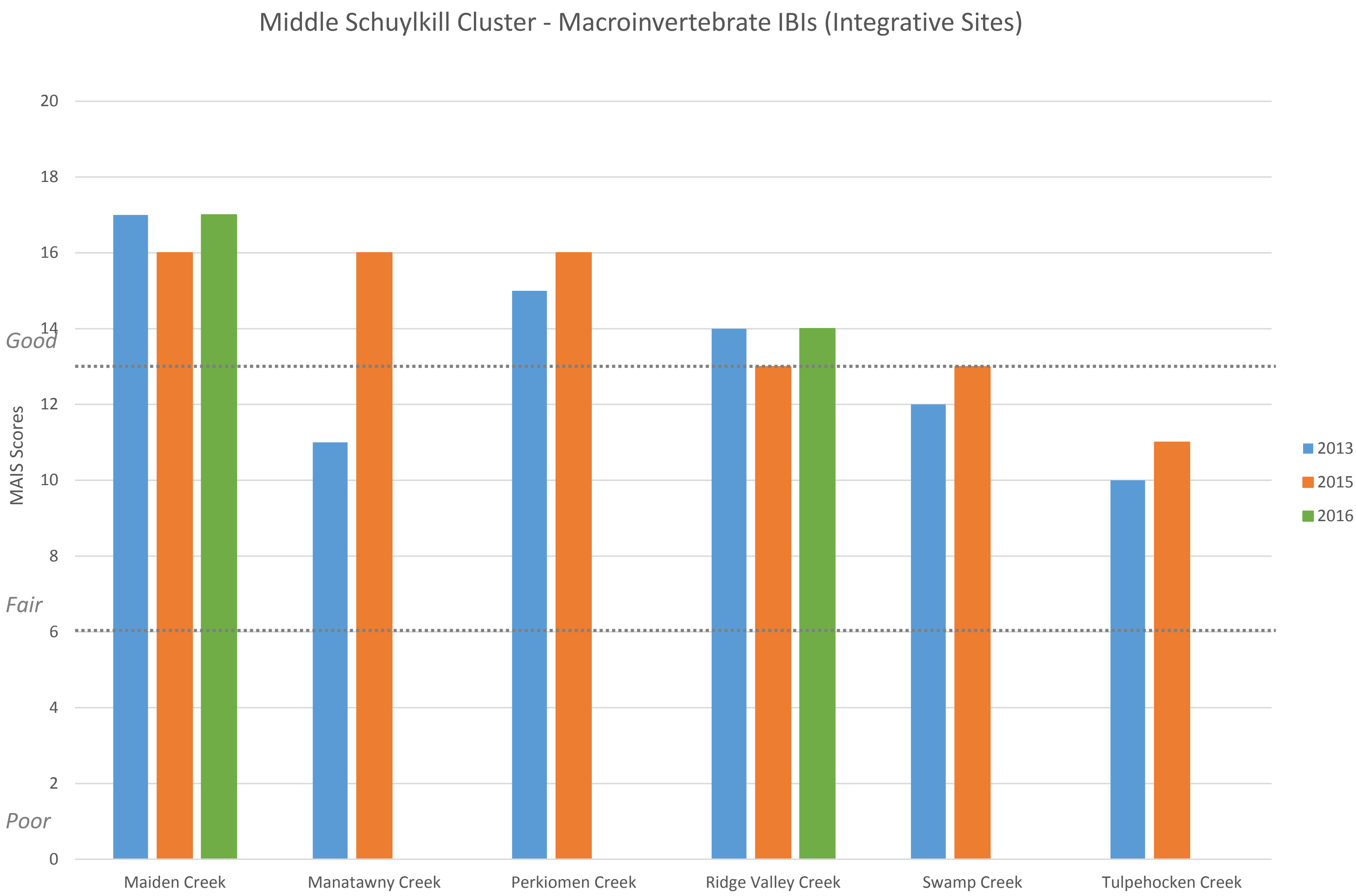
Macroinvertebrate IBI scores

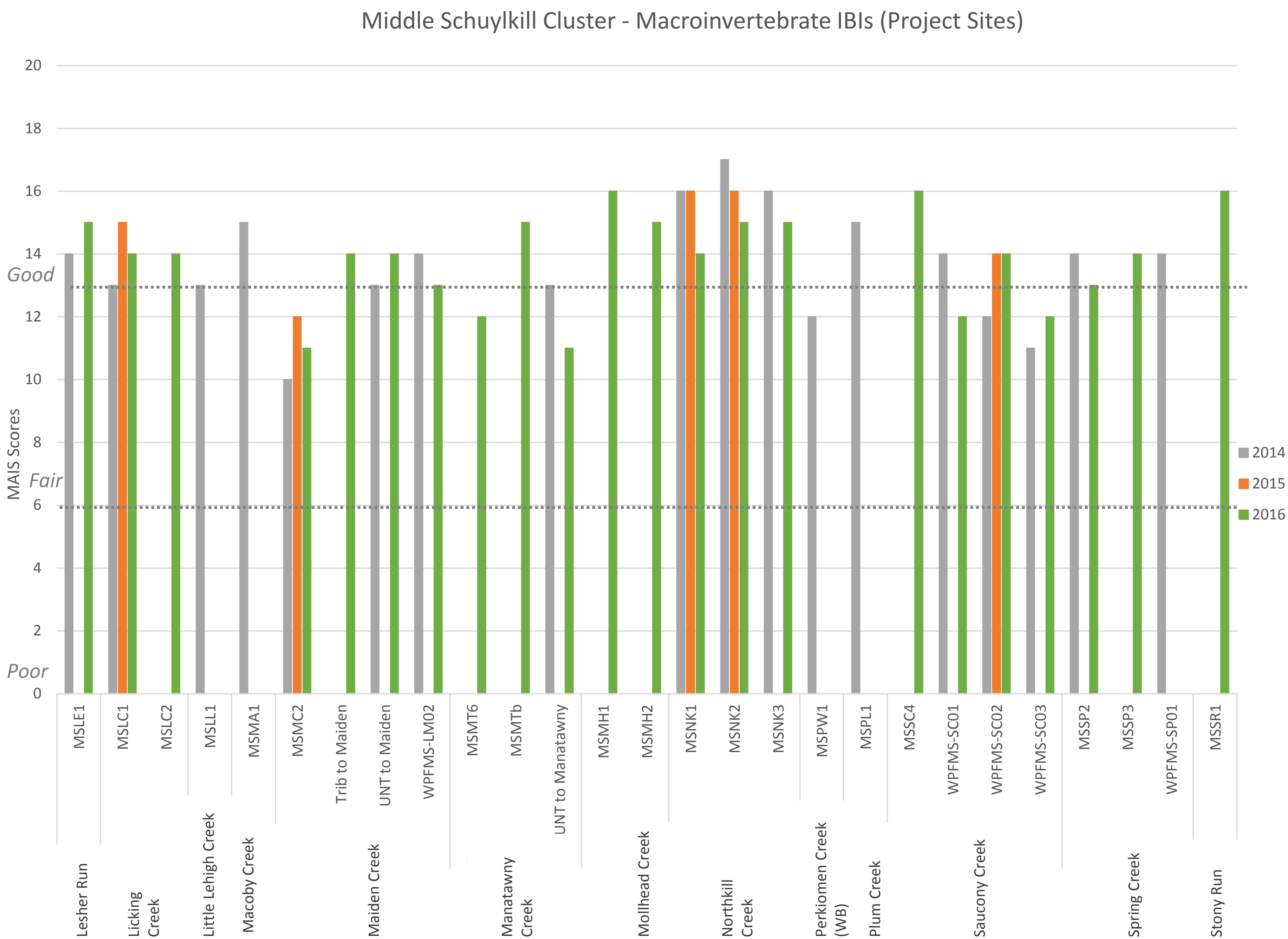
An index of biological integrity (IBI) is a collection of metrics which describe the structure and function of an ecosystem based on its biota. Metric values are converted to scores and yield a total IBI score. These scores can be translated into easily-interpreted regional quality classifications.

Macroinvertebrates:
The Macroinvertebrate Aggregated Index for Streams (MAIS) is a rapid bioassessment protocol designed by Smith and Voshell (1997) based on benthic macroinvertebrate data collected from Maryland, Pennsylvania, and Virginia. It is used by many agencies in the Eastern US and provides family-level aggregated macroinvertebrate metrics. Nine metrics are used to describe the condition of a stream:

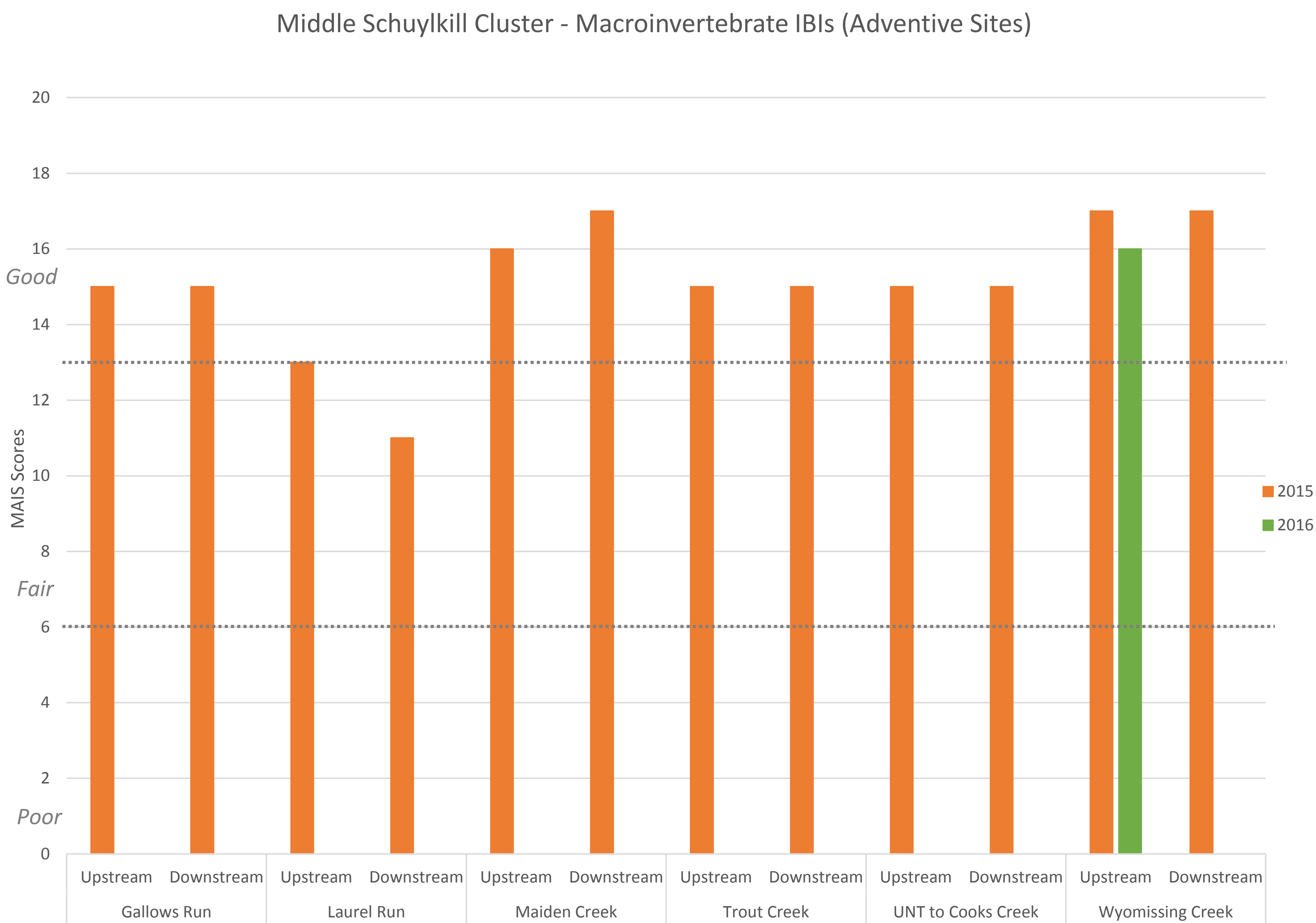
Poor: 0-6
Fair: 6.1-13
Good: >13.1

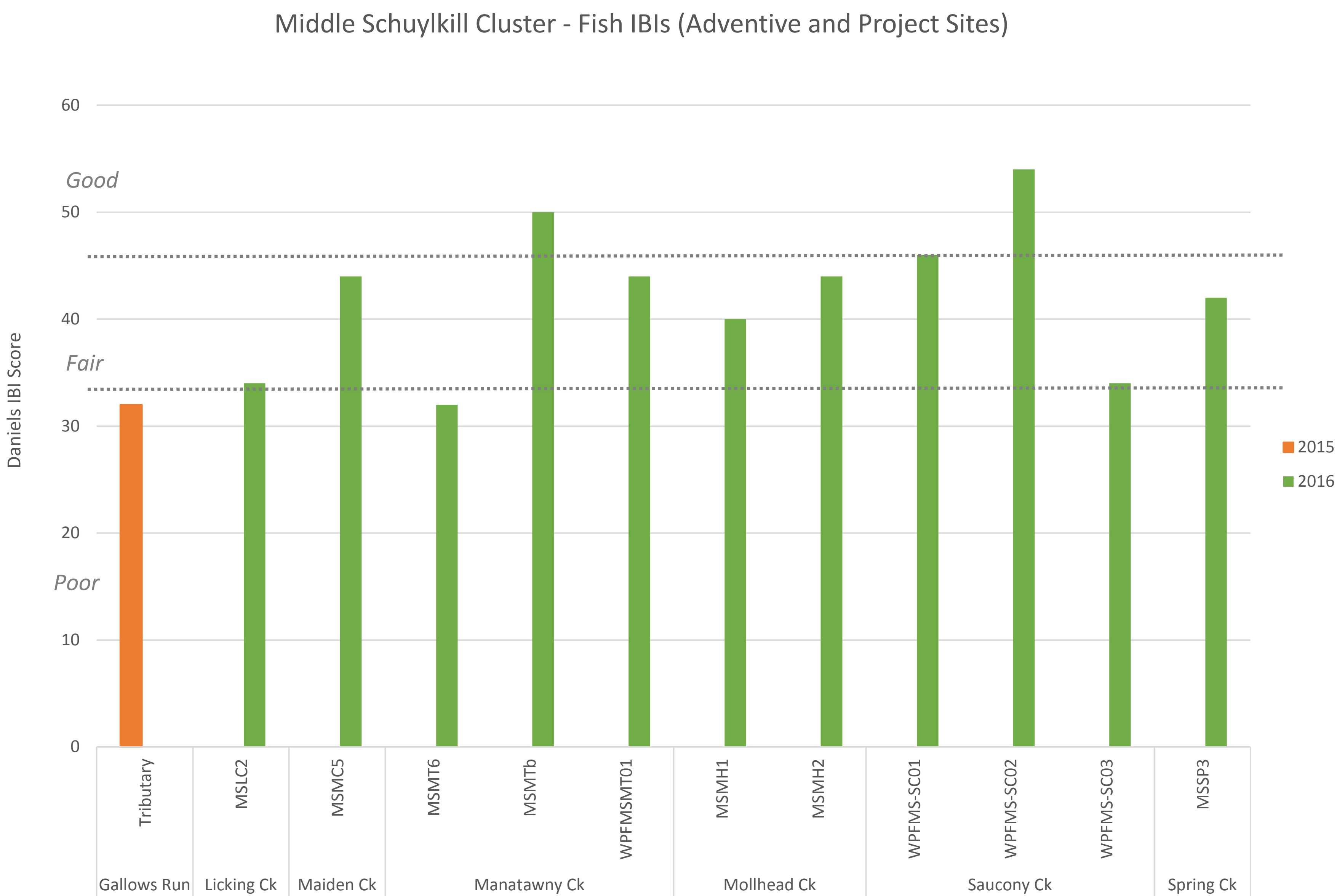
Metric	Definition/Justification
EPT Richness	number of caddisfly, stonefly and mayfly families
# Ephemeroptera	number of mayfly families
% Ephemeroptera	% abundance of mayflies
% Five dominant taxa	five most dominant taxa combined
Simpson Diversity Index	integrates richness and evenness
Modified Hilsenhoff Biotic Index	taxa weighted by pollution tolerance
# Intolerant taxa	number of families with tolerance values of 5 or lower (very sensitive)
% Scrapers	abundance of macroinvertebrates that feed on periphyton
% Haptobenthos	abundance of macroinvertebrates that require clean, coarse, firm substrates

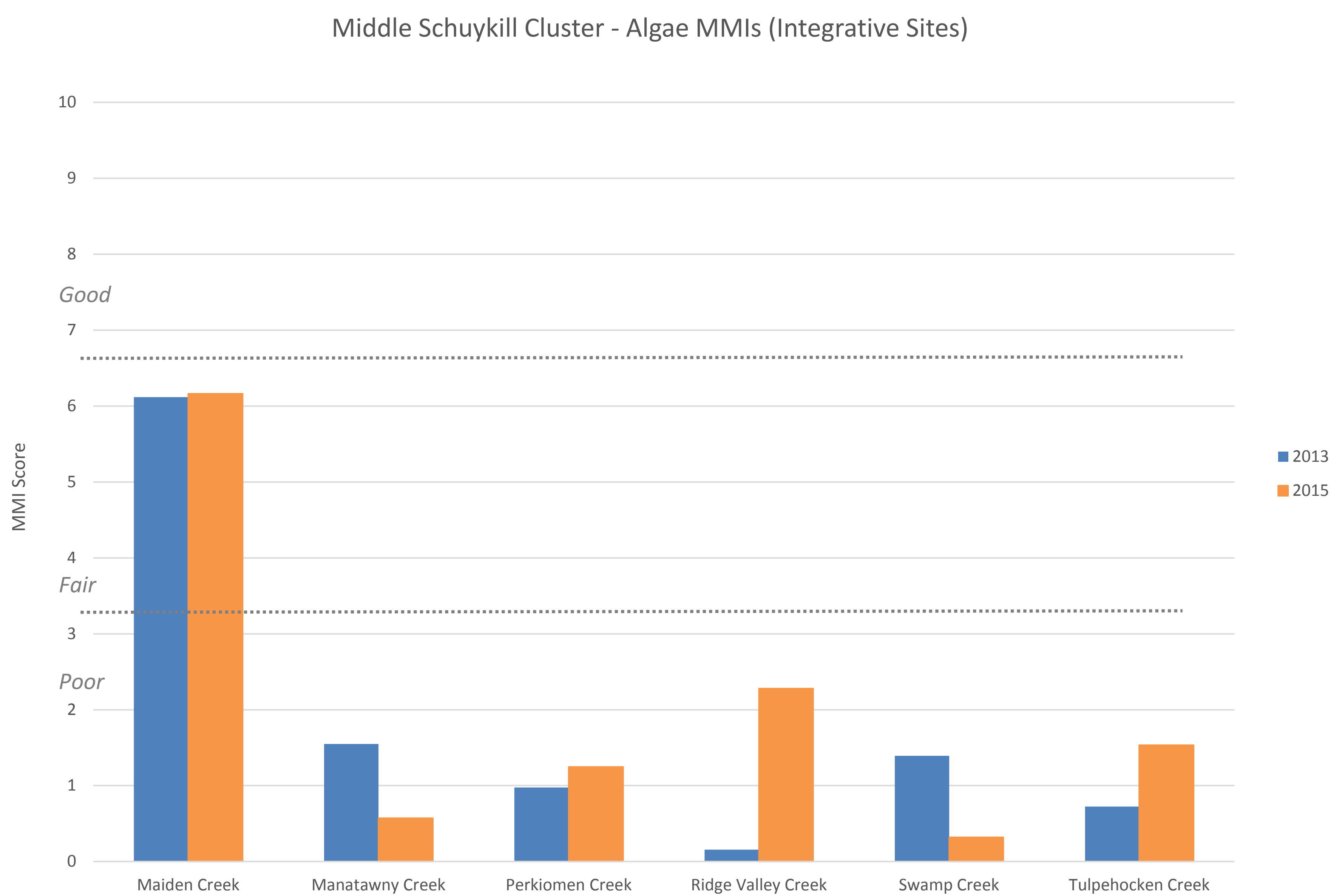

Middle Schuylkill Cluster - Macroinvertebrate IBIs (Integrative Sites)
MAIS Scores
20
18
16
14
12
10
8
6
4
2
0
Good
Fair
Poor
Maiden Creek
Manatawny Creek
Perkiomen Creek
Ridge Valley Creek
Swamp Creek
Tulpehocken Creek
2013
2015
2016

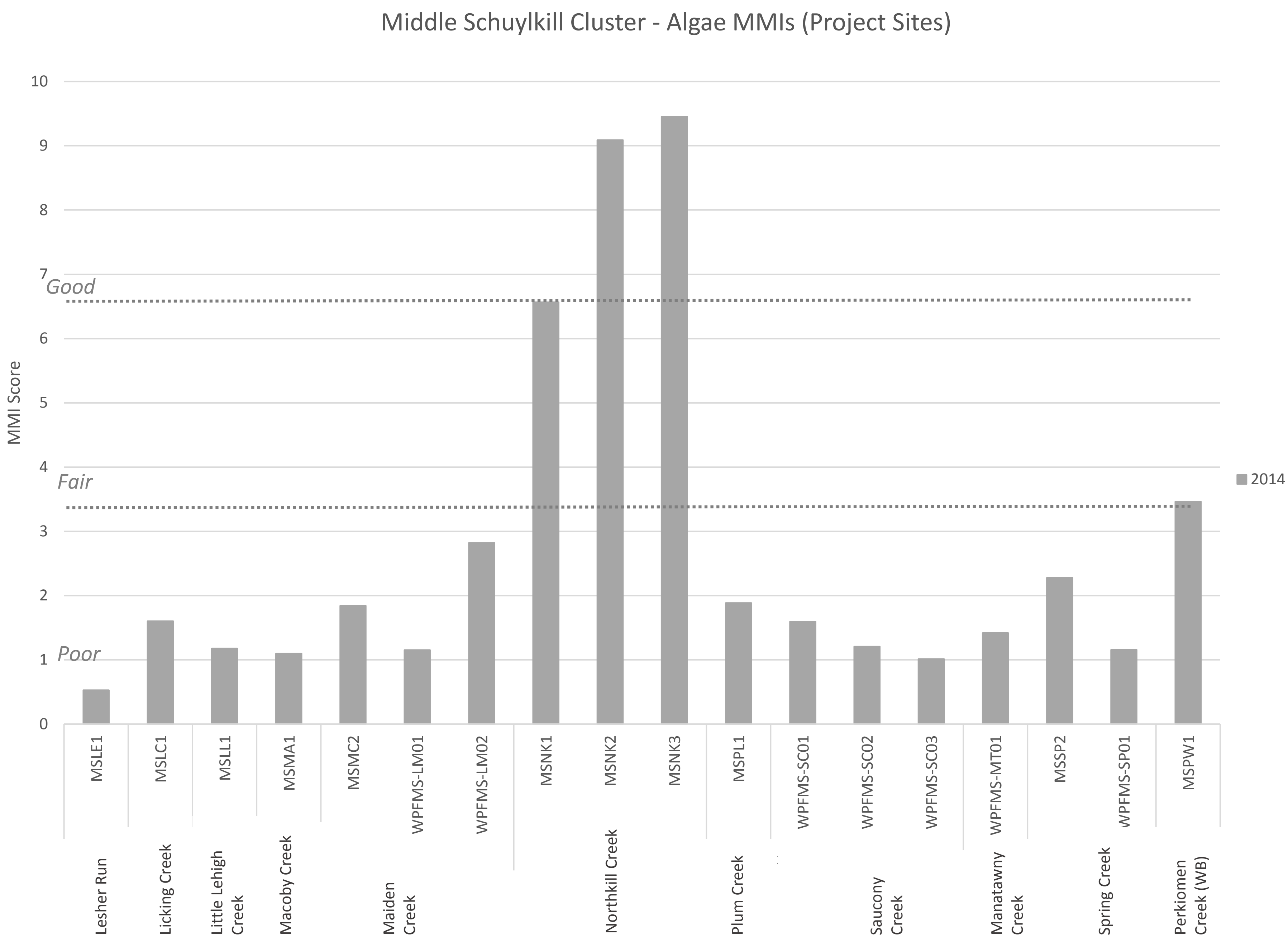


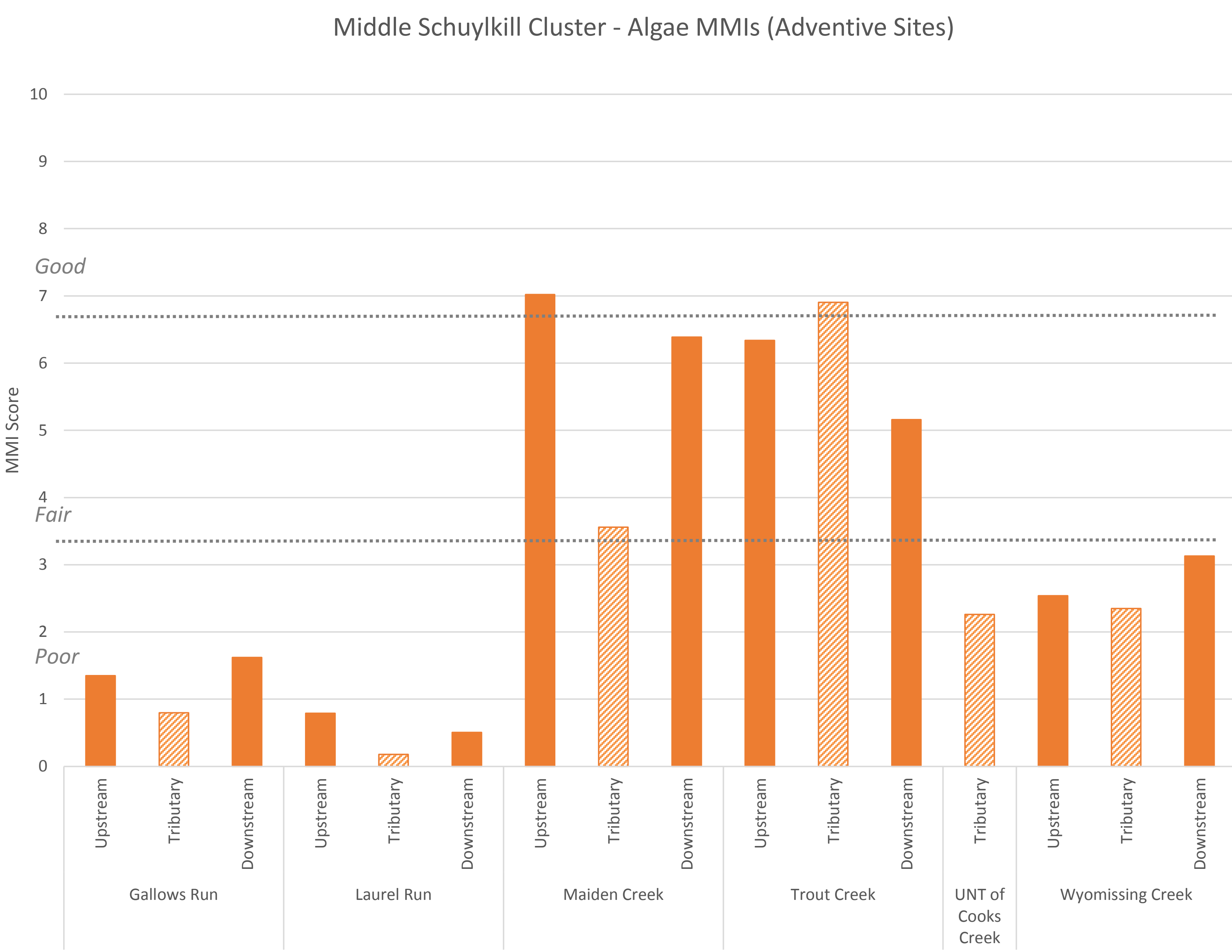
Middle Schuylkill Cluster - Macroinvertebrate IBIs (Project Sites)
MAIS Scores
Good
Fair
Poor
0
2
4
6
8
10
12
14
16
18
20
2014
2015
2016
MSLE1
MSLC1
MSLC2
MSLL1
MSMA1
MSMC2
Trib to Maiden
UNT to Maiden
WPFMS-LM02
MSMT6
MSMTb
UNT to Manatawny
MSMH1
MSMH2
MSNK1
MSNK2
MSNK3
MSPW1
MSPL1
MSSC4
WPFMS-SC01
WPFMS-SC02
WPFMS-SC03
MSSP2
MSSP3
WPFMS-SP01
MSSR1
Lesher Run
Licking Creek
Little Lehigh Creek
Macoby Creek
Maiden Creek
Manatawny Creek
Mollhead Creek
Northkill Creek
Perkiomen Creek (WB)
Plum Creek
Saucony Creek
Spring Creek
Stony Run


Middle Schuylkill Cluster - Macroinvertebrate IBIs (Adventive Sites)
MAIS Scores
20
18
16
14
12
10
8
6
4
2
0
Good
Fair
Poor
2015
2016
Upstream
Downstream
Gallows Run
Laurel Run
Maiden Creek
Trout Creek
UNT to Cooks Creek
Wyomissing Creek


Middle Schuylkill Cluster - Fish IBIs (Adventive and Project Sites)
Daniels IBI Score
60
50
40
30
20
10
0
Good
Fair
Poor
2015
2016
Tributary
MSLC2
MSMC5
MSMT6
MSMTb
WPFMSMT01
MSMH1
MSMH2
WPFMS-SC01
WPFMS-SC02
WPFMS-SC03
MSSP3
Gallows Run
Licking Ck
Maiden Ck
Manatawny Ck
Mollhead Ck
Saucony Ck
Spring Ck


Middle Schuylkill Cluster - Algae MMIs (Integrative Sites)
MMI Score
10
9
8
Good
7
6
5
4
Fair
3
Poor
2
1
0
Maiden Creek
Manatawny Creek
Perkiomen Creek
Ridge Valley Creek
Swamp Creek
Tulpehocken Creek
2013
2015


Middle Schuylkill Cluster - Algae MMIs (Project Sites)
MMI Score
10
9
8
7
6
5
4
3
2
1
0
Good
Fair
Poor
2014
MSLE1
MSLC1
MSLL1
MSMA1
MSMC2
WPFMS-LM01
WPFMS-LM02
MSNK1
MSNK2
MSNK3
MSPL1
WPFMS-SC01
WPFMS-SC02
WPFMS-SC03
WPFMS-MT01
MSSP2
WPFMS-SP01
MSPW1
Lesher Run
Licking Creek
Little Lehigh Creek
Macoby Creek
Maiden Creek
Northkill Creek
Plum Creek
Saucony Creek
Manatawny Creek
Spring Creek
Perkiomen Creek (WB)



Middle Schuylkill Cluster - Algae MMIs (Adventive Sites)
MMI Score
10
9
8
Good
7
6
5
4
Fair
3
2
Poor
1
0
Upstream
Tributary
Downstream
Gallows Run
Laurel Run
Maiden Creek
Trout Creek
UNT of Cooks Creek
Wyomissing Creek