pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

SUSQUEHANNA AND JUNIATA RIVER ASSESSMENT REPORT

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EXECUTIVE SUMMARY

The Susquehanna River from the confluence of the Juniata River to the Route 462 bridge near Columbia and the Juniata River from the confluence of the Raystown Branch to the mouth do not meet the Warm Water Fishes (WWF) protected aquatic life use based on DEP's *Continuous physicochemical assessment method*, and DEP's *Semi-wadeable large river macroinvertebrate assessment method* (Figure 1). The *Continuous physicochemical assessment method* has identified high pH as a cause of impairment for both rivers. DEP is currently evaluating the source of impairment. At this time the source of the impairment will be listed as unknown. Currently, there is insufficient information upstream or downstream of these delineations to make assessment determinations using these methods.

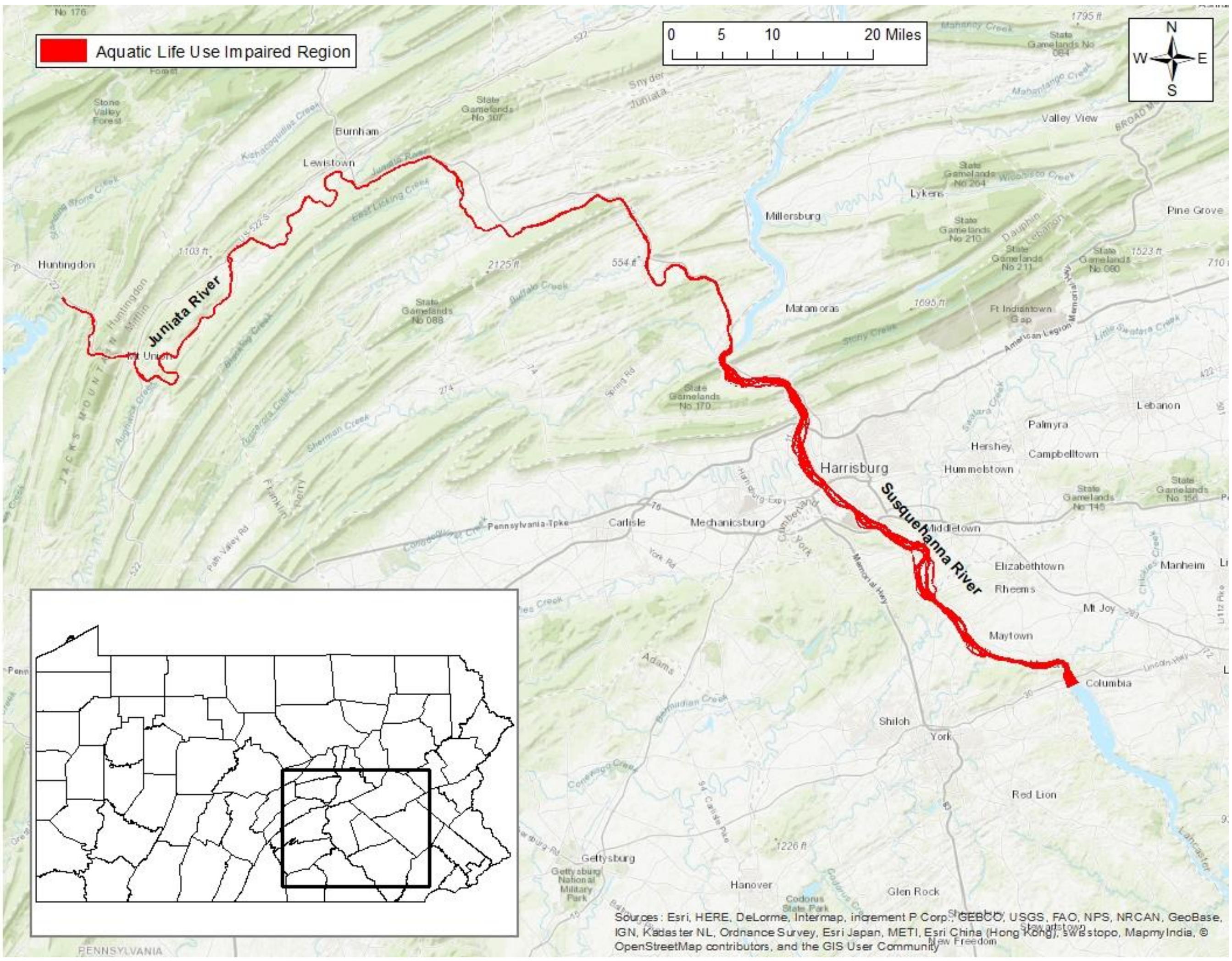

Figure 1. Delineation of the aquatic life use impaired regions of the Juniata and Susquehanna Rivers.

Peer reviewed, scientifically defensible assessment methods are the basis for making use assessment decisions. Both methods became final assessment methods in 2018. This provides the opportunity to develop an aquatic life use assessment for portions of the Susquehanna and Juniata Rivers. These assessment methods are independent evaluations that provide unique measures of water quality for assessing the aquatic life use. More intensive water quality monitoring that was implemented beginning in 2012 and through 2017 provided data that fit the framework of the assessment methods. The assessment of the Juniata River and the Susquehanna River documented exceedances of water quality standards in each year (2012 – 2017). These water quality conditions may have contributed to but are not the primary cause of the population level effect on the River's Smallmouth Bass (SMB) population.

INTRODUCTION

The Susquehanna River drains approximately 71,000 km^2 and is the largest source of fresh water to the Chesapeake Bay (Brown et al. 2005). Most of the Chesapeake Bay and tidal tributaries have been declared impaired by EPA, and on December 29, 2010, EPA established the Chesapeake Bay TMDL for nitrogen, phosphorus, and sediment that includes the Susquehanna River. Consequently, the Susquehanna River has received a large amount of attention concerning nutrient and sediment transport. From a water quality perspective, its size, geomorphological diversity, and the number of people that utilize its resources creates unique opportunities for biologists tasked with assessing protected water uses.

The Susquehanna River has also been the focus of attention in recent years due to mortality of Young-Of-Year (YOY) SMB and reduced recruitment of YOY into the adult population. Throughout the Susquehanna River and its larger tributaries, SMB angling is a popular recreational activity resulting in a great deal of public concern over the health and population of this species. Prior to 2005, no substantial disease-related YOY SMB mortality events were documented in the Susquehanna River, but beginning in 2005, dead and dying YOY SMB were observed in larger numbers, particularly in the middle Susquehanna (between Sunbury and York Haven, Pennsylvania). Since that time, SMB data has suggested the rates of reproduction, growth, and recruitment of younger fish into older age classes were lower than years prior to 2005.

In September 2007, the Susquehanna River Technical Committee, composed of representatives from the Pennsylvania Fish and Boat Commission (PFBC), DEP, United States Geological Survey (USGS), Environmental Protection Agency (EPA), and Susquehanna River Basin Commission (SRBC) was formed and met for the first time. The Committee's primary responsibility was to identify and interpret existing data, determine data gaps, and develop recommendations for future action to restore and maintain the SMB fishery. Beginning in 2012, DEP initiated an unprecedented, large-scale investigation into the potential cause(s) of the SMB decline and to assess the protected uses of the Susquehanna River. The survey design included conventional chemical parameters measured in water and sediment such as nutrients and metals, as well as emerging contaminants. Emerging contaminants are a broad category of compounds attributable to a number of sources including pesticides, pharmaceuticals, fertilizers, and household cleaning products. These chemicals may cause stress or immunosuppression in organisms predisposing them to diseases, similar to what has been observed in SMB.

With the vast amount of research conducted since 2005 including conventional pollutants (ammonia, metals, dissolved oxygen, pH, etc.), emerging contaminants, aquatic communities (macroinvertebrates, fish, algae, mussels), invasive species, and various diseases and parasites, there was a significant need to consolidate resources and data. The data were collected for two purposes: (1) determine the cause(s) for the SMB population decline and (2) assessing the uses of the Susquehanna River.

To achieve the first goal, DEP requested assistance from the EPA to begin the stressor identification process. This method is described as the Causal Analysis/Diagnosis Decision Information System (CADDIS, www.epa.gov/caddis). This process convened a workgroup of over 50 experts from various State, Interstate, Federal, and academic organizations including, the PFBC, DEP, EPA, SRBC, USGS, United States Fish and Wildlife Service (USFWS), and Susquehanna River Heartland Coalition for Environmental Studies (SRHCES). A brief description of this process is described below. To achieve the second goal DEP implemented monitoring protocols and assessment methods described in the DEP *Water quality monitoring protocols for streams and rivers* (Shull and Lookenbill 2018) and the DEP *Assessment methodology for rivers and streams* (Shull and Pulket 2018).

CAUSE(S) OF THE SMALLMOUTH BASS POPULATION DECLINE

The CADDIS report represents a large amount of work from many dedicated professionals across multiple agencies and organizations. It is the compilation of what was the current understanding as it relates to the SMB population decline in the Susquehanna River and clarifies the need for continued research. This report provided greater transparency on work completed from 2012 to 2014. The report identified the two most likely causes of the population decline of SMB as endocrine-disrupting compounds and pathogens and parasites. DEP has summarized the findings through public webinars, a final report, and over 50 worksheets used by the group, which are found on the DEP website.

Subsequent to the CADDIS report, DEP and PFBC entered into an agreement to study the role of Largemouth Bass Virus (LMBV) in causing a decline in SMB. Michigan State University (MSU) was subcontracted to complete an initial study. LMBV is a pathogen that has been consistently isolated from moribund SMB specimens collected from the Susquehanna basin. Clinically diseased fish and apparently healthy fish from the same location have yielded LMBV during the past cell culture analyses. The repeated detection of LMBV in juvenile SMB specimens from diseased populations and the coincident onset of disease and discovery of LMBV in the Susquehanna River basin in 2005 (USFWS, National Wild Fish Health Database), along with the lack of investigations under controlled laboratory conditions, elevated the priority of this study.

MSU conducted two parts to the study. The first was to determine if five LMBV isolates could cause clinical signs and histopathological changes in juvenile SMB. Of the five isolates, two were obtained from the lower Susquehanna River, one from the Juniata River, one from Pine Creek (Lycoming Co.), and one from the Allegheny River. The second part of the study was to determine the effect that co-infections of LMBV with two opportunistic bacteria (*Aeromonas salmonicida* and *Flavobacterium columnare*) that have been routinely isolated from SMB in the Susquehanna River basin. The results indicated that SMB infected with LMBV exhibited clinical signs and mortality consistent with observations of dead and dying SMB in the Susquehanna River basin. Co-infection of LMBV with bacterial infections demonstrated that co-infection can be very detrimental to juvenile SMB; however, the optimal temperatures for these bacterial infections are lower than instream surface water temperatures recorded at the time of SMB die-offs. These results indicate that LMBV is a likely cause of YOY mortality events at elevated instream water temperatures (Boonthai et al. 2018).

The CADDIS process was a stepwise scientific process to identify the most probable stressors, and the LMBV study was an investigation of a single stressor affecting one species (SMB). CADDIS and the LMBV study were not an assessment of the protected water uses of the Susquehanna River for the Federal Clean Water Act (CWA) Section 303(d) list. Although CADDIS utilized the same data DEP collected for water quality assessments, it is important to note that the CADDIS process analyzed these data using different methods than how the DEP is required to assess protected water uses.

ASSESSMENT

Background

With the exception of the mainstem Juniata River and the Susquehanna River from Sunbury to Holtwood Dam, tributaries and other portions of the River have been fully assessed for aquatic life use. There are generally fewer impaired tributaries in the upper portions of the Susquehanna and West Branch Susquehanna River basins. As the Susquehanna River flows south through its middle reaches, the number of impaired tributaries increases; therefore, the percent contribution of these waters to the Susquehanna River also increases (Figure 2). From the confluence of the West Branch to the confluence of the Juniata River, the Susquehanna

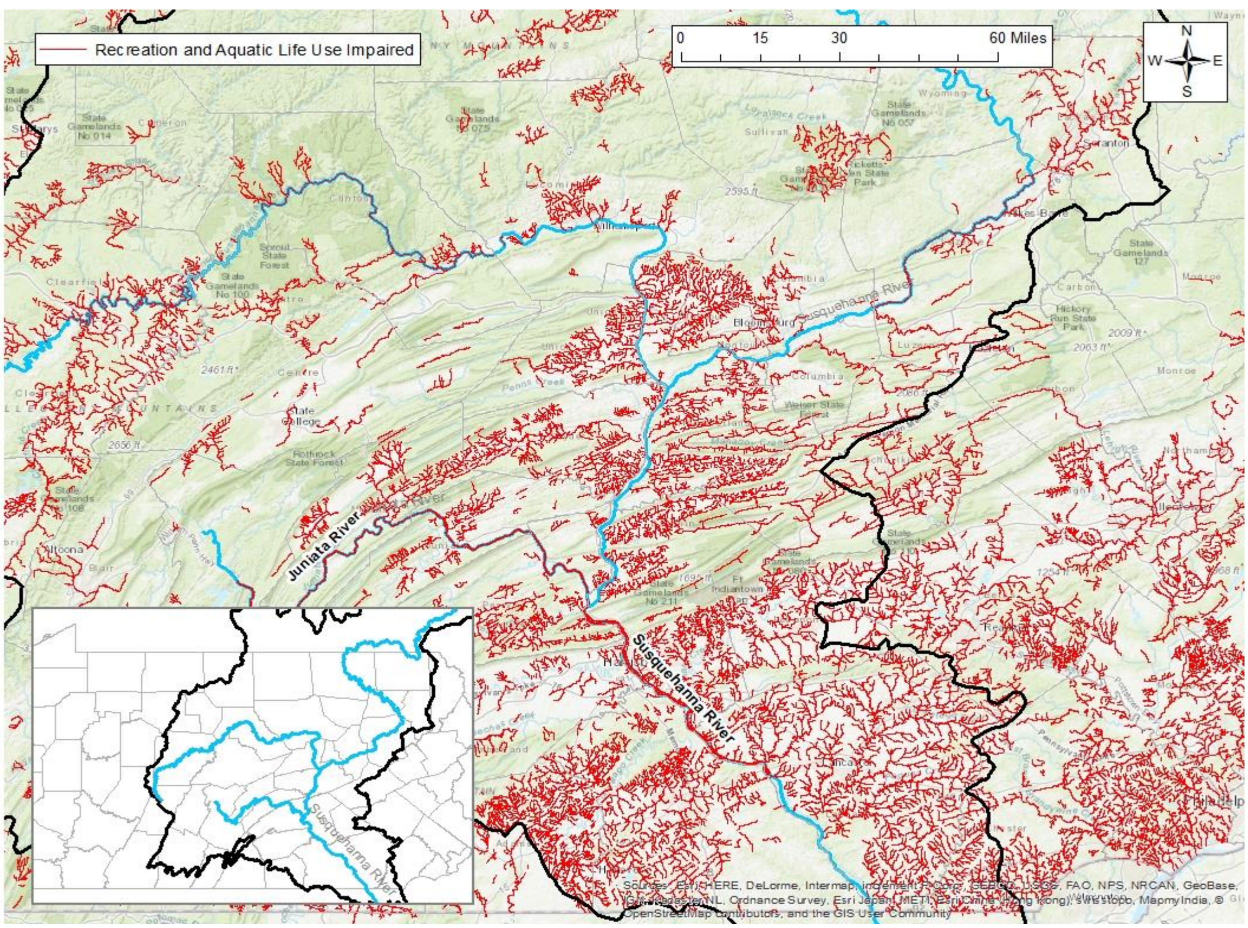

Figure 2. Recreation and aquatic life use impaired waters within and around the delineated areas of impairment on the Juniata and Susquehanna Rivers.

River exhibits two significantly different and incompletely mixed water quality influences with varying water quality conditions hugging each shore. Tributaries or portions of tributaries, including Penns Creek and Mahantango Creek (west shore of the River in Juniata and Snyder Counties), currently have both aquatic life and recreational use impairments. Continuing south, the Juniata River introduces a third significant water quality influence that does not mix, resulting in three significantly different and incompletely mixed water quality influences with, again, varying water quality conditions hugging each shore (Figure 3). Additional tributaries, or portions of tributaries farther downriver, including Conodoguinet, Yellow Breeches, Codorus, and Swatara Creeks, also have both aquatic life and recreational use impairments, which results in the tributaries degrading the water quality of the River (Figure 2).

Figure 3. Approximate delineation of distinct water quality differences on the Susquehanna River at Rockville, PA.

The lower Susquehanna River then flows into a series of four major impoundments. The impoundments present new challenges for DEP biologists to monitor and assess the River, including the need to develop appropriate methods to measure and assess water quality. Many of the tributaries to the impounded lower reaches are routinely being assessed, and as a result, significant aquatic life and recreational use impairments have been identified and appropriately listed for these lower Susquehanna River subbasins (Figure 2).

Since the 2016 Pennsylvania integrated water quality monitoring and assessment report (Integrated Report), DEP staff have made significant progress in developing additional data collection protocols and assessment methods, which have been implemented to assess previously unassessed portions of the Susquehanna River. *DEP's Semi-wadeable large river* *macroinvertebrate data collection protocol* (Shull 2018b) and the accompanying *Semi-wadeable large river macroinvertebrate assessment method* (Shull 2018a) is a monitoring and assessment approach based on DEP's long-standing macroinvertebrate methods for wadable streams, but with requirements for collecting supplemental data and modifications to account for the lack of homogenous water quality conditions that are prevalent throughout the lower Susquehanna River (Figure 4). Semi-wadeable rivers are defined as predominantly free-flowing systems with drainage areas >1,000 mi^2 and have physical characteristics that allow for riffle and run sections to occur with relative frequency.

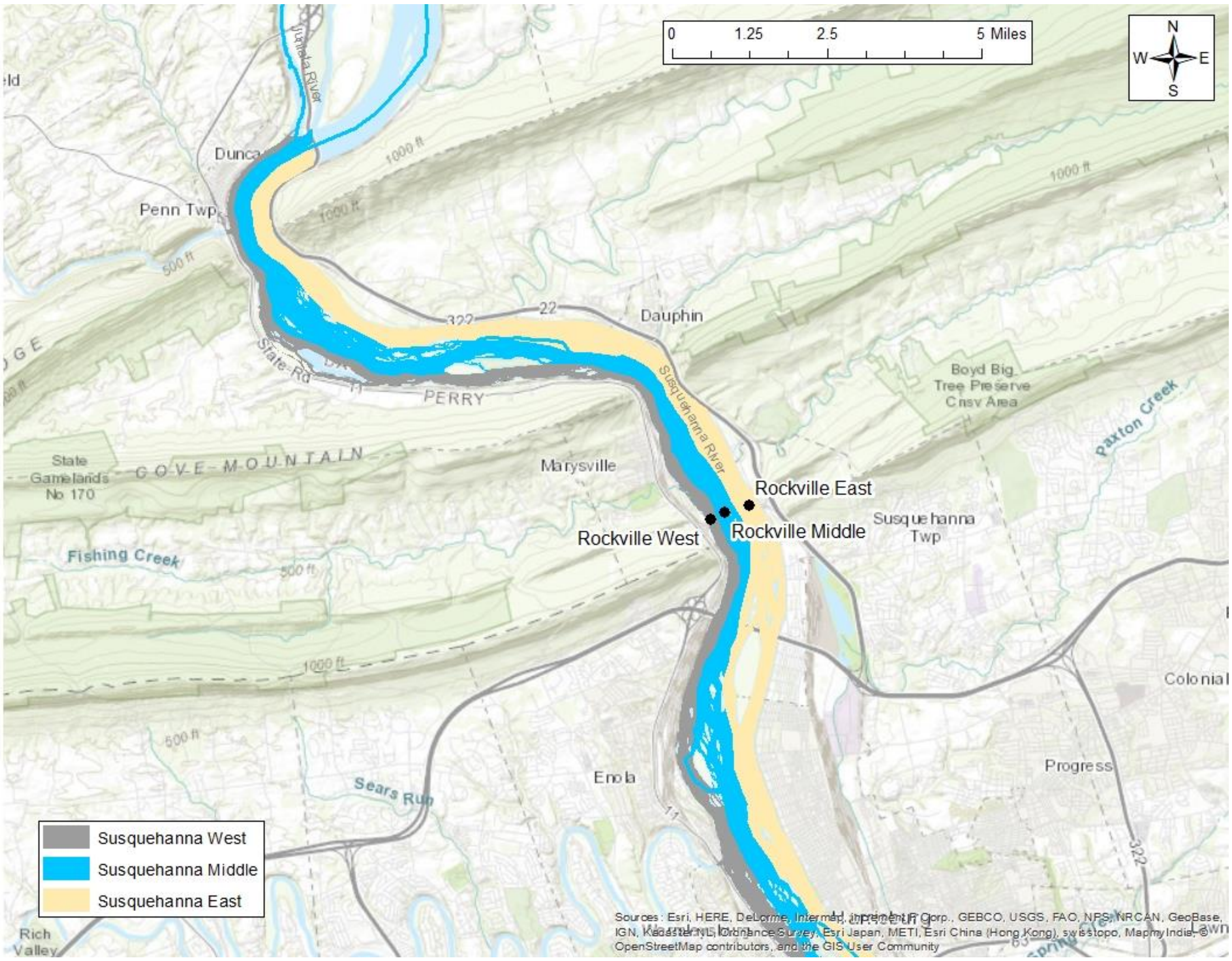

Figure 4. Susquehanna River water quality delineations and Rockville sites.

DEP has also developed an updated *Continuous physicochemical data collection protocol* (Hoger et al. 2018) and a new *Continuous physicochemical assessment method* (Hoger 2018c). Continuous Instream Monitoring (CIM) data have been collected by DEP since 2007, and by cooperating agencies like the USGS for decades prior. Beginning in 2012, the DEP implemented CIM at six locations on the Susquehanna River and at two locations on the Juniata River (DEP 2013). In 2013, DEP and partners implemented CIM at four locations on the Susquehanna River, at two locations on the Juniata River, at several locations on Susquehanna River basin tributaries, and at several locations outside the Susquehanna River basin (DEP 2014). CIM reports are developed to characterize CIM data. The DEP maintains CIM reports on its website.

Annual Variation and Critical Conditions

A significant contributor to annual variation in water quality is the amount and timing of precipitation (Figure 5). These data demonstrate the difficulty in accurately assessing water quality with a temporally limited data set. The first three years of the study were characterized by elevated flow through the critical summer and early fall periods. In 2016, however, a significant decrease in precipitation led to a prolonged decrease in flow and significant changes in water quality. Elevated precipitation will result in increased surface water discharge, which can moderate stressful conditions. The Department has documented in past surveys that elevated discharge can reduce daily fluctuations of dissolved oxygen (DO), pH, and temperature, and increase daily minimum DO values and decrease maximum pH and temperature values (Bendick 2018a, Bendick 2018b, Bendick et al. 2018, Hoger 2018a, Hoger 2018b, Lorson 2018).

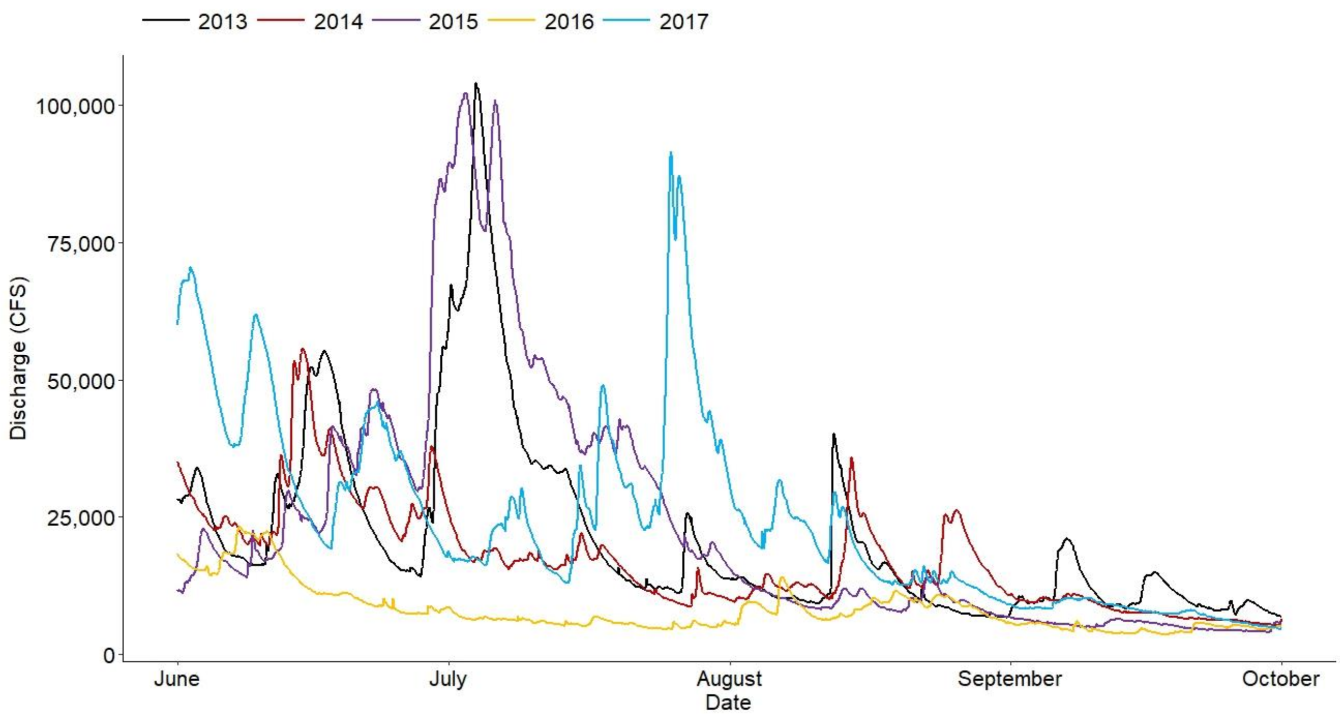

Figure 5. Discharge data from USGS station 01570500 for the summer and early fall from 2013-2017.

Continuous Instream Monitoring (CIM)

The assessment of CIM data incorporates water quality standards from 25 PA Code §93.7 and the 99-percent frequency rule from §96.3 (Hoger 2018c). Because sondes at Susquehanna and Juniata River locations (Figure 6) recorded parameters every 30 minutes, a non-attainment of water quality criteria is reached if at least 176 exceedances are measured over a 365-day rolling period (176 readings > 1% of a year).

Continuous pH data for the Susquehanna River and the Juniata River did not meet the 99% requirement for the maximum (9.0) criteria found at §93.7 (Table 1). The most exceedances occurred in 2016 on the Juniata River at Newport. This site did not meet the 99% requirement in any year from 2013 through 2016 (Bendick 2018b). Additional CIM locations located upriver from Newport, Lewistown and Newton Hamilton, did not meet the 99% requirement in at least one year. Newton Hamilton did not meet in 2016 and was not monitored in 2013 and 2014 (Hoger 2018a). Lewistown did not meet in 2014 and was not monitored in 2016 (Bendick 2018a). On the Susquehanna River, three sites were sampled at the Rockville location (Rockville West, Rockville Middle, Rockville East) and two sites were sampled at the Marietta location (Marietta West and Marietta East). Rockville West did not meet in 2014, 2015, or 2016. Rockville Middle did not meet in 2016. Rockville East did not meet in 2013 and 2014 (Hoger 2018b). Marietta West and East both met in 2013, 2015 and 2016, but did not meet in 2014 (Lorson 2018). DO exceedances of the criteria minimum (5.0 mg/L) found at §93.7 were documented in 2016 at Newton Hamilton and Rockville West, but the exceedances did not exceed 1% of the time (Table 1).

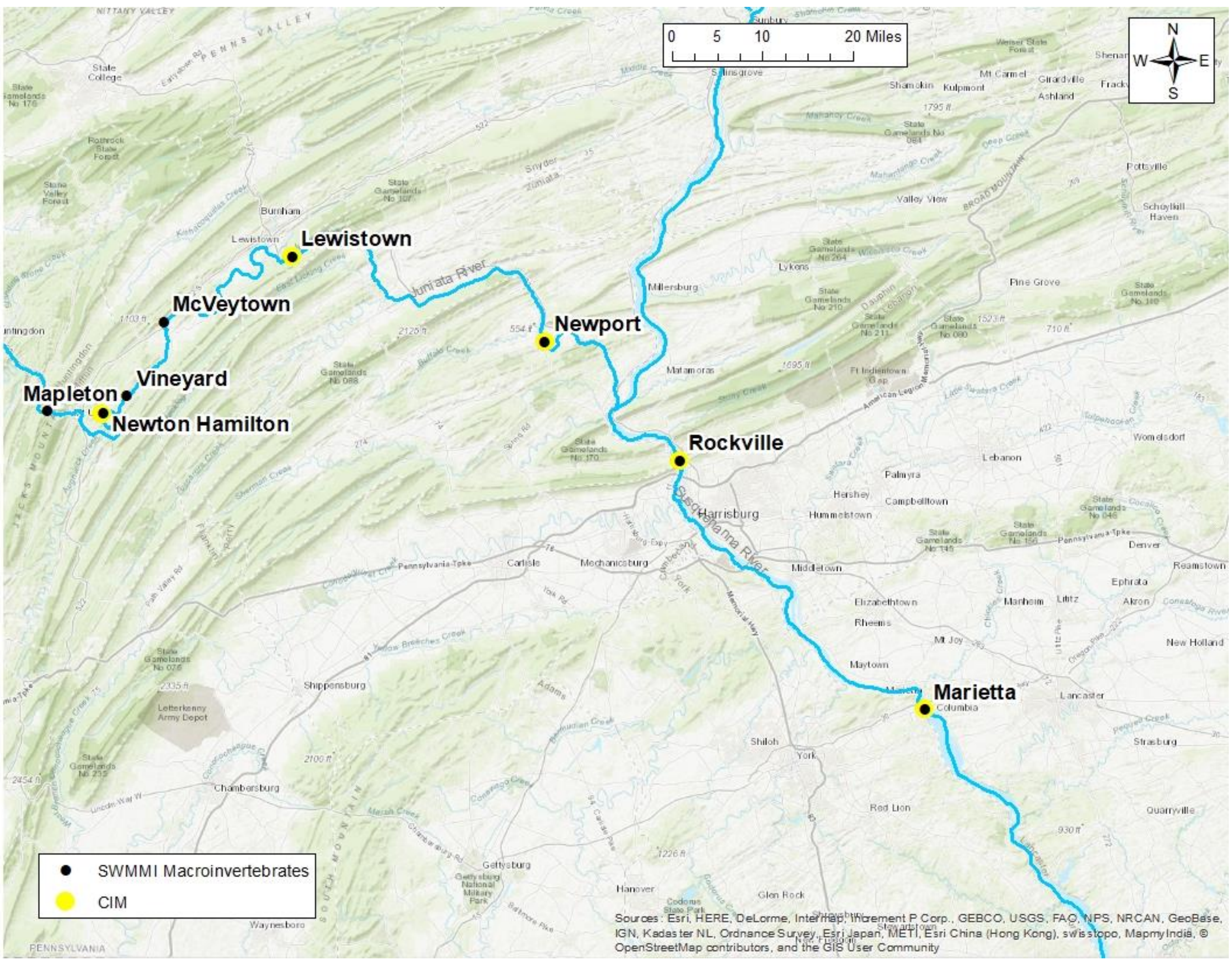

Figure 6. Semi-wadeable macroinvertebrate 2012-2017 and continuous instream monitoring locations 2013-2016.

Table 1. DO and pH exceedances for Susquehanna and Juniata River locations.

YEAR	PH EXCEEDANCE NO.	PH EXCEEDANCE %	DO EXCEEDANCE NO.	DO EXCEEDANCE %
Juniata River at Newton Hamilton				
2015	112	0.64	0	0.00
2016	452	2.58	31	0.18
Max 365*	452	2.58	31	0.18
Juniata River at Lewistown Narrows				
2013	106	0.60	0	0.00
2014	196	1.12	0	0.00
2015	4	0.02	0	0.00
Max 365*	302	1.72	0	0.00
Juniata River at Newport				
2013	276	1.58	0	0.00
2014	764	4.36	0	0.00
2015	319	1.82	0	0.00
2016	1022	5.83	0	0.00
Max 365*	1022	5.83	0	0.00
Susquehanna River at Rockville West				
2013	0	0.00	0	0.00
2014	666	3.80	0	0.00
2015	204	1.16	0	0.00
2016	565	3.22	151	0.86
Max 365*	734	4.19	151	0.86
Susquehanna River at Rockville Middle				
2013	123	0.70	0	0.00
2014	11	0.06	0	0.00
2015	0	0.00	0	0.00
2016	560	3.20	0	0.00
Max 365*	560	3.20	0	0.00
Susquehanna River at Rockville East				
2013	181	1.03	0	0.00
2014	507	2.89	0	0.00
2015	79	0.45	0	0.00
2016	10	0.06	0	0.00
Max 365*	590	3.37	0	0.00
Susquehanna River at Marietta West				
2013	0	0.00	0	0.00
2014	223	1.27	0	0.00
2015	112	0.63	0	0.00
2016	5	0.02	0	0.00
Max 365*	327	1.87	0	0.00
Susquehanna River at Marietta East				
2013	0	0.00	0	0.00
2014	183	1.04	0	0.00
2015	119	0.67	0	0.00
2016	30	0.17	0	0.00
Max 365*	302	1.72	0	0.00

*Max 365 is the maximum number of exceedances for a 365-day rolling period

Delineating CIM Assessment

While CIMs provide a thorough record of water quality conditions at a given point, additional data may be necessary to understand the spatial extent to which the CIM data apply. Multiple CIM locations were established on the Susquehanna and Juniata Rivers, and exceedances of pH criteria were observed at each location. To further aid in spatial delineation and to determine if tributaries may be contributing to the impairment, discrete measurements were collected throughout the area (Figures 7 – 9). Discrete measurements document that exceedances of the pH criteria maximum (9.0) found at §93.7 have occurred throughout the Juniata River and in select Juniata River tributaries. Exceedances of pH criteria documented in Juniata River tributaries indicate that these tributaries are likely contributing to the nonattainment of the WWF protected aquatic life use on the Juniata River. Additional work will be required to further evaluate tributary contribution to the nonattainment and to complete aquatic life use assessments specifically for these tributaries.

Additional CIM monitoring has been completed on Susquehanna River basin tributaries in order to complete aquatic life use assessments, but to also better understand the effect tributary water quality has on the River. CIM was implemented on the Conodoguinet Creek, a tributary to the Susquehanna River located downstream of Rockville and across the River from Harrisburg, in 2015 and again in 2016. Data collected in 2016 indicated that the DO criteria minimum (5.0 mg/L) found at §93.7 was not achieved at least 99% of the time (Bendick et al. 2018). Discrete readings were collected throughout the Conodoguinet Creek basin to determine the extent of the low DO conditions. In addition, a cross-section survey was performed at the mouth of the Conodoguinet Creek and

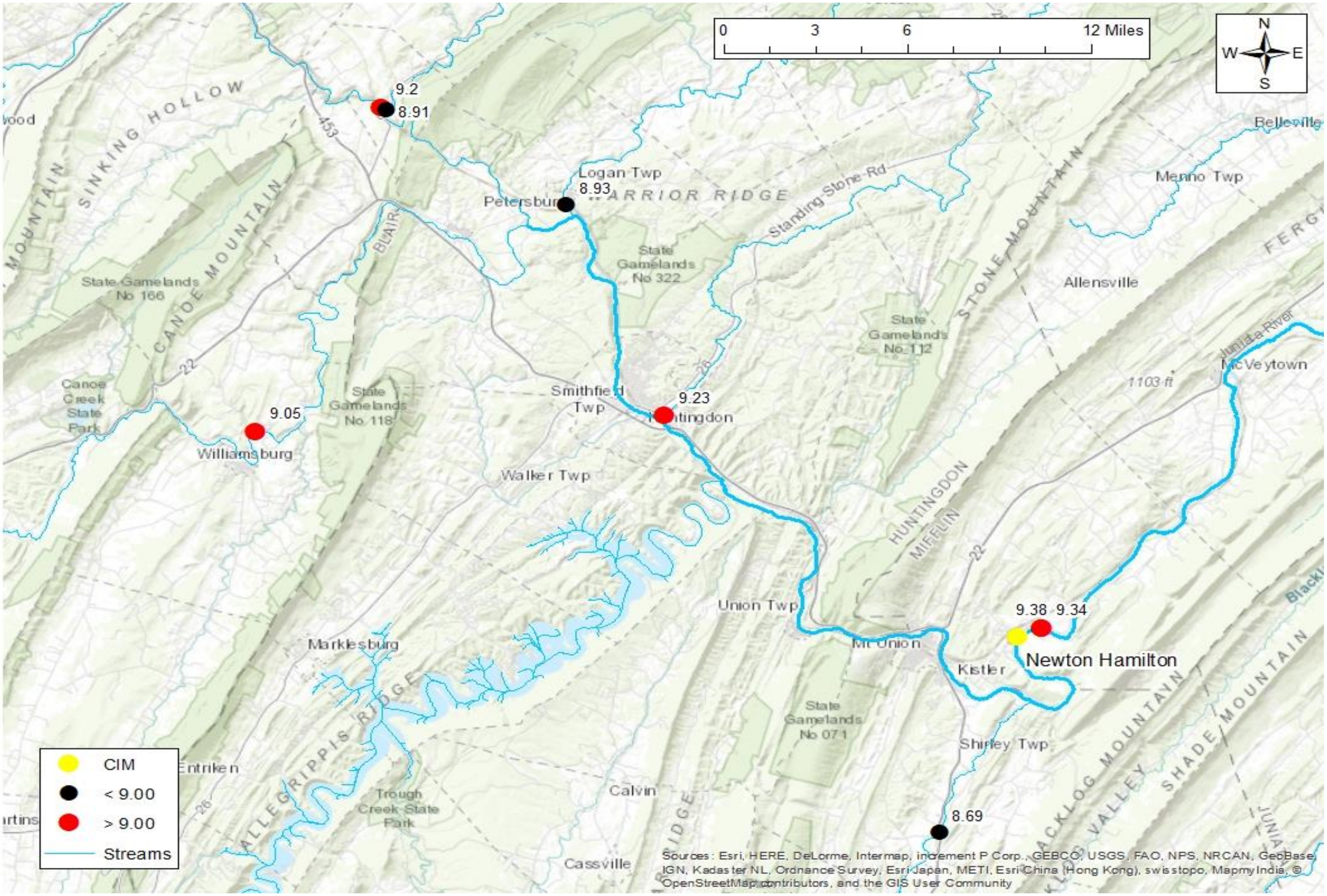

Figure 7. On April 19, 2016 discrete pH readings were collected from the Little Juniata River (9.20), Spruce Creek (8.91), Frankstown Branch Juniata River (9.05), Shaver Creek (8.93), Standing Stone Creek (9.23), Aughwick Creek (8.69), and on the Juniata River at Newton Hamilton (9.38 and 9.34) in Blair and Huntingdon Counties.

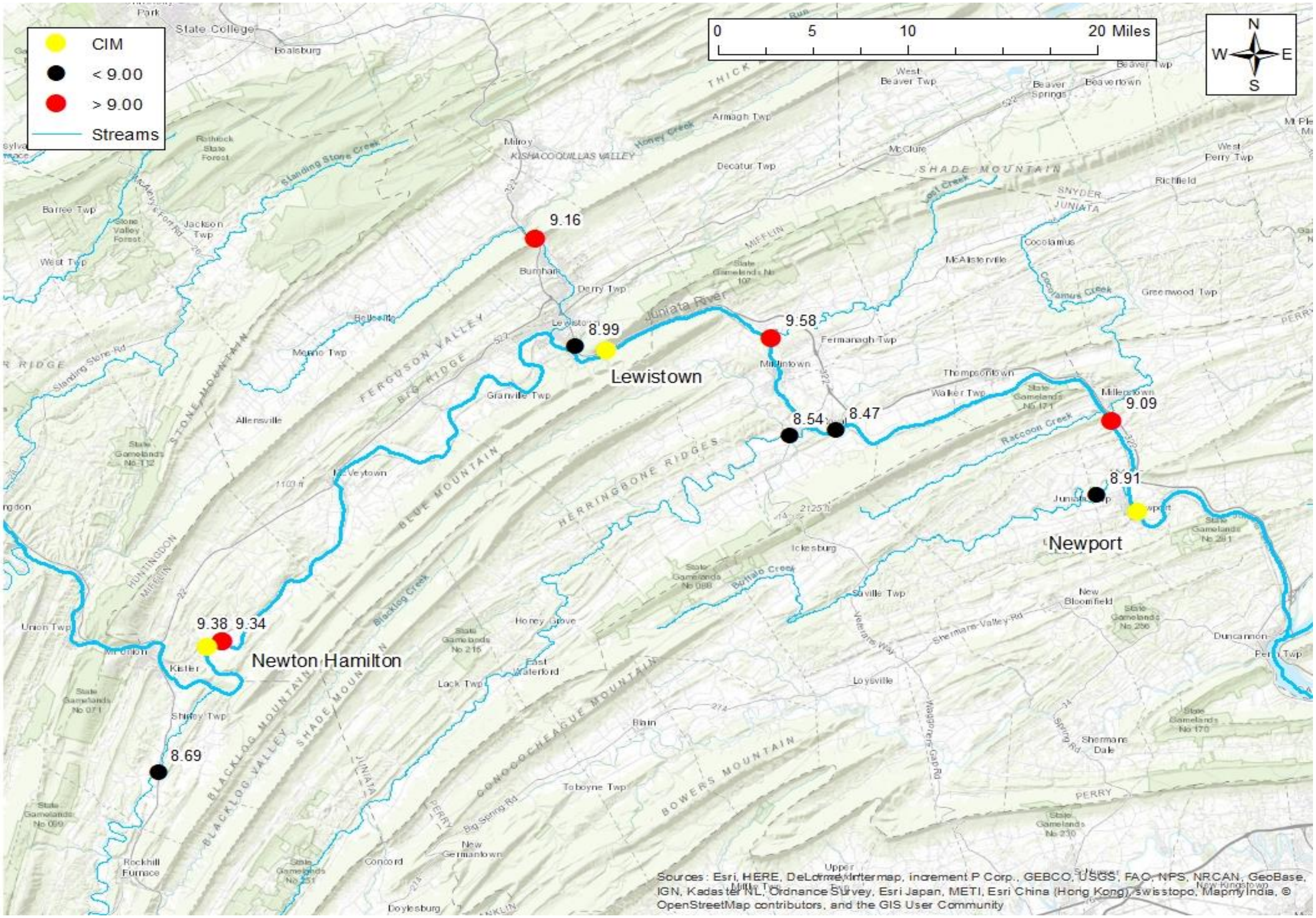

Figure 8. Also, on April 19, 2016 discrete pH readings were collected from Kishacoquillas Creek (9.16), Jacks Creek (8.99), Lost Creek (9.58), Tuscarora Creek (8.54), the Juniata River at Mexico (8.47), Cocolamus Creek (9.09), and Buffalo Creek (8.91) in Huntingdon, Mifflin, Juniata, and Perry Counties.

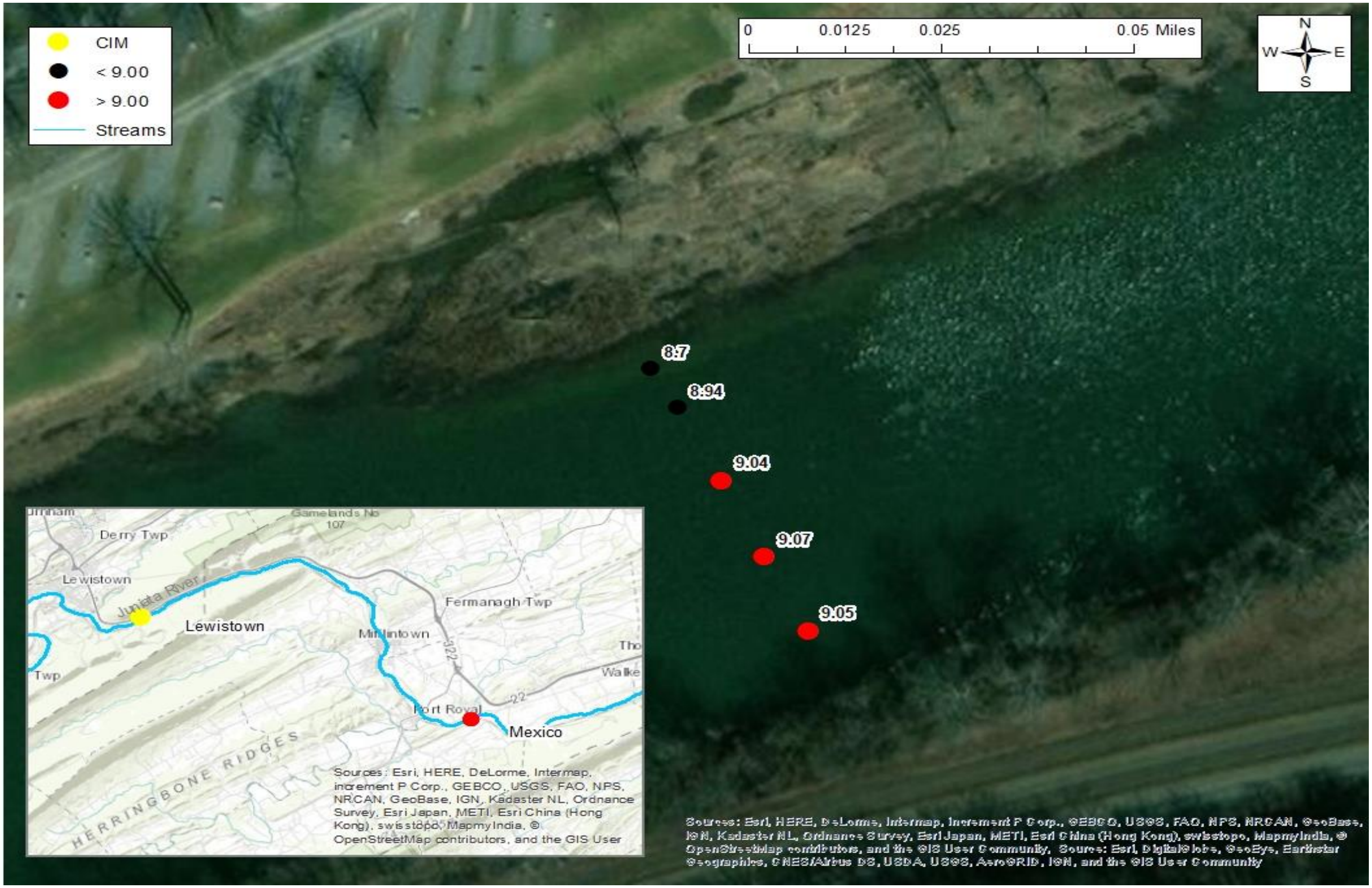

Figure 9. Late in the afternoon on July 7, 2016 five discrete pH readings across a transect were collected on the Juniata River approximately 23 miles upriver from Newport, near Port Royal. Discrete readings ranged from 8.70 to 9.07 with three of five readings above the criterion maximum. The reading collected from the left descending bank was the lowest reading (8.70), which was also significantly different than the remaining four readings (8.94 – 9.07). This indicates some degree of incomplete mix caused by some degree of upriver influence.

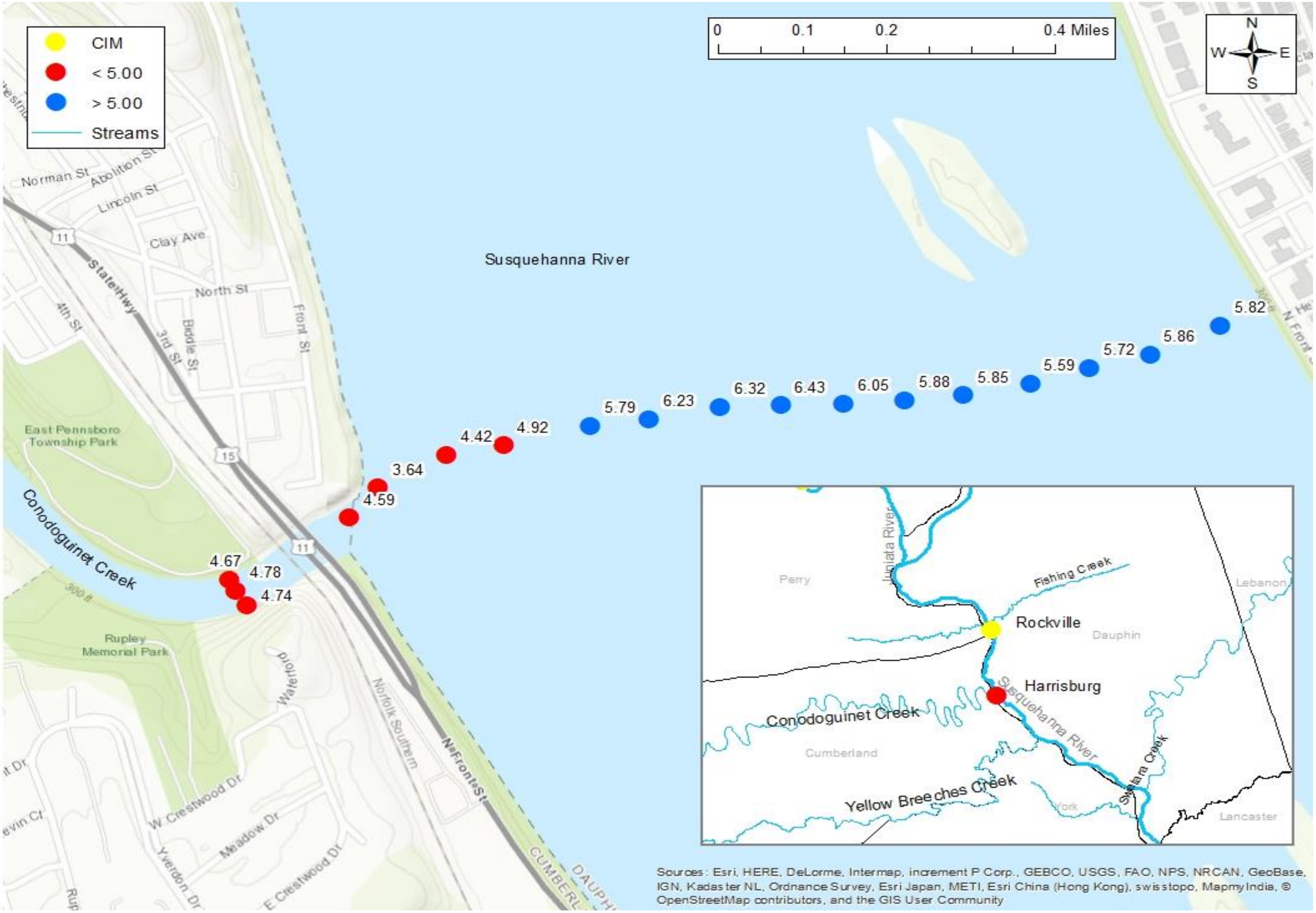

Figure 10. Discrete dissolved oxygen readings collected on July 22, 2016 at the mouth of the Conodoguinet Creek and across a transect on the Susquehanna River.

from the mouth of the Conodoguinet Creek across the entire width of the Susquehanna River. The results indicate that the low DO conditions documented throughout the Conodoguinet Creek basin also extended approximately 250 meters from the mouth of the Conodoguinet Creek out across the Susquehanna River (Figure10).

Semi-wadeable Macroinvertebrates

DEP and partnering agencies have collected thousands of benthic macroinvertebrate samples since the mid-2000's using data collection protocols developed for specific water types that have resulted in aquatic life use assessments for flowing waters across Pennsylvania. Beginning in 2012 DEP staff biologist began to modify the DEP *Wadeable riffle-run stream macroinvertebrate data collection protocol* (Chalfant 2013) in order to collect macroinvertebrate data on the Susquehanna and other large rivers across the Commonwealth. The result is the *Semi-wadeable large river macroinvertebrate data collection protocol* (Shull 2018b), and the accompanying *Semi-wadeable large river macroinvertebrate assessment method* (Shull 2018a).

Semi-wadeable macroinvertebrate samples have been collected from large rivers across the Commonwealth, but an increased effort has focused on the Susquehanna and Juniata Rivers in order to produce a comprehensive aquatic life use assessment. Approximately 57 samples were collected from two locations on the Susquehanna River from the confluence of the Juniata River to Marietta, and 30 samples from 6 locations on the Juniata River from the Raystown Branch Juniata River to the confluence with the Susquehanna River.

Results from the lower Susquehanna River at Rockville indicate nonattainment of the aquatic life use across the three major zones of the River. Summer samples have been collected beginning 2012 through 2017, and fall samples were collected beginning in 2014 through 2017. Fall SWMMI scores are consistently below the impairment threshold (57.0) with the exception of a single sample collected from the Rockville West site in 2015. Samples were not collected from Rockville in the fall of 2017 due to elevated flow. Summer samples are above the impairment threshold (49.0) with the exception of Summer 2014 and Summer 2017 samples collected from the Rockville West and East sites (Table 2).

Cross-section surveys conducted at the lower Susquehanna River Marietta location indicate a fairly homogenous waterbody, although some of the data during certain conditions may demonstrate multiple, distinct zones of influence based on discrete water chemistry, CIM data, and cross-section surveys (Lorson 2018, DEP 2013, DEP 2014). Semi-wadeable macroinvertebrate samples were typically collected from three separate zones at this location beginning in 2013 and through the Summer 2017 samples. Fall 2017 samples were collected as two zonated samples (Marietta East and Marietta West), in addition to a third sample collected as a composite across the entire width of the River in the Fall of 2017.

Results from the lower Susquehanna River at Marietta indicate nonattainment of the aquatic life use. Summer and fall samples were collected beginning in 2013 through 2017. Fall sample scores are variable with at least one sample below the impairment threshold (57.0) each year. None of the sites were consistently above the impairment threshold (57.0) across all years. Summer scores are above impairment thresholds with the exception of the 2013 east sample, the 2015 east sample, and the 2016 middle sample. Samples were not collected from Marietta in the summer of 2014 due to elevated flow (Table 3).

Table 2. SWMMI scores for Susquehanna River at Rockville. Red text delineates an impaired sample score.

SITE	YEAR	SUMMER SWMMI	FALL SWMMI
Rockville East	2012	78.5	
Rockville Middle	2012	81.9	
Rockville West	2012	59.7	
Rockville East	2013	73.5	
Rockville Middle	2013	76.4	
Rockville West	2013	74.1	
Rockville East	2014	45.1	47.7
Rockville Middle	2014	56.4	48.1
Rockville West	2014	47.9	43.5
Rockville East	2015	81.9	54.9
Rockville Middle	2015	77.5	52.0
Rockville West	2015	71.8	59.9
Rockville East	2016	79.2	52.2
Rockville Middle	2016	51.7	49.1
Rockville West	2016	56.9	48.8
Rockville East	2017	43.5	
Rockville Middle	2017	59.8	
Rockville West	2017	39.1	

Table 3. SWMMI scores for Susquehanna River at Marietta. Red text delineates an impaired sample score.

SITE	YEAR	SUMMER SWMMI	FALL SWMMI
Marietta East	2013	33.8	45.8
Marietta Middle	2013	49.1	58.7
Marietta West	2013	73.6	73.2
Marietta East	2014		50.9
Marietta Middle	2014		32.1
Marietta West	2014		57.0
Marietta East	2015	39.6	42.6
Marietta Middle	2015	57.7	70.8
Marietta West	2015	69.5	53.1
Marietta East	2016	59.1	65.3
Marietta Middle	2016	32.5	46.8
Marietta West	2016	57.5	46.3
Marietta East	2017	64.2	54.7
Marietta Middle	2017	52.4	
Marietta West	2017	66.4	70.6
Marietta Composite	2017		66.4

Semi-wadeable macroinvertebrate samples have been collected from six locations on the Juniata River since 2012. Initially in 2012, samples were collected only from the Newport location. In 2013 samples were collected at Lewistown, in 2014 samples were collected at Newton-Hamilton, and in 2016 new locations at Mapleton, Vineyard, and McVeytown.

Results from the upper Juniata River indicate nonattainment of the aquatic life use for all sites, except for the Lewistown location. All fall and summer samples collected from the Lewistown location are above impairment thresholds. Results from the Juniata River at Newport indicate nonattainment of the aquatic life use. All samples are below impairment thresholds with the exception of the summer samples collected in 2012 and 2013 (Table 4).

Table 4. SWMMI scores for Juniata River Red text delineates an impaired sample score.

SITE	YEAR	SUMMER SWMMI	FALL SWMMI
Mapleton	2016	42.7	32.9
Mapleton	2017	41.7	
Newton Hamilton	2014		32.5
Newton Hamilton	2015	52.0	49.0
Newton Hamilton	2016	54.9	39.6
Newton Hamilton	2017	54.4	52.7
McVeytown	2016	46.0	37.4
Vineyard	2016	58.5	29.7
Lewistown	2013	63.5	
Lewistown	2014		62.0
Lewistown	2015	62.5	67.7
Lewistown	2016	76.1	
Newport	2012	63.4	
Newport	2013	52.4	
Newport	2014		39.5
Newport	2015	26.6	44.8
Newport	2016	23.8	27.6
Newport	2017	48.6	55.5

LOAD, YIELD, AND TREND ANALYSIS

The CIM and semi-wadeable data collected on the Susquehanna and Juniata Rivers demonstrates that water quality on large waterbodies is not only affected by upriver tributary influences, but also by yearly and seasonal weather patterns that affect the amount and timing of precipitation and instream flow. Yearly and seasonal flow patterns of the Susquehanna and Juniata Rivers can be highly variable, and consequently water quality can vary as well. This highlights the need to collect multiple years of data across varying conditions to accurately assess large waterbodies. This also highlights the need for statistical summaries to track pollutants that affect water quality.

Pollutant loads, yields, and trends are statistical summaries used to evaluate and compare water quality between sites and through time. Water chemistry data are typically expressed as a concentration per volume. The routine collection of water chemistry data, along with discharge, is used to estimate the amount of a pollutant transported through water over a period of time. The watershed area that contributes pollutants is used along with load to characterize yield as an amount per area.

In 1985 standardized sampling methods were implemented to collect water chemistry at select stations throughout the Susquehanna River basin that will produce the necessary data to develop and analyze loads, yields, and trends. The list of locations consists of six mainstem locations and 20 tributary locations. SRBC compiles and analyses these data in a report – *2016 Nutrients and suspended sediment in the Susquehanna River basin* (McGonigal 2018). These stations include the Susquehanna River at Marietta and the Juniata River at Newport, which are categorized as long-term sites (stations established prior to 1990). Water chemistry monitoring was discontinued for the Susquehanna River at Harrisburg in 1995 and reestablished in 2012, which created a gap in the record preventing long-term trend analysis. Data from stations established since 2004 are not used for long-term trends but are appropriate for short-term trends. The SRBC report summarizes that flow-normalized trends in total nitrogen, total phosphorus, and suspended sediment are generally decreasing long-term, with a few exceptions. Recent annual, flow-normalized loads are mixed, showing decreasing loads in dissolved nitrogen at most locations, but increasing loads in suspended sediment, particulate phosphorus, and particulate nitrogen at other locations, including the Juniata River at Newport (McGonigal 2018).

In addition to trend analysis, loads and yields were evaluated location-to-location and year-to-year for the Susquehanna River at Danville, Harrisburg, and Marietta, the West Branch Susquehanna River at Lewisburg, and the Juniata River at Newport. Danville and Lewisburg were included because they are the farthest-downstream, long-term locations on the Upper Mainstem and the West Branch Susquehanna River, respectively. From 2012-17, the highest total phosphorus and total nitrogen loads occurred on the Susquehanna River at Marietta. The highest sediment loads occur at Marietta in 2012 and 2016 and at Harrisburg in 2013, 2014, 2015, and 2017. Data was not available for Harrisburg in 2012. The lowest loads occurred on the Juniata River at Newport. This is likely due to the watershed area for each of these locations, and the fact that Harrisburg and Marietta are the farthest downriver sites where each of the loads from upriver locations contributes to that at the downriver location. It is interesting that suspended sediment load at Harrisburg often exceeds that at Marietta. The highest suspended sediment, total phosphorus, and total nitrogen load across all locations was documented in 2017. The lowest across all locations occurred in 2016 (Figures 11-13). The variation in load from year to year is primarily driven by flow or discharge (McGonigal 2018).

As observed with loads, the highest yields for each site and across all parameters occurred in 2017 and the lowest for each occurred in 2016. The highest suspended sediment yield across all sites occurred at Danville for each year, 2012 – 2017. Danville also had the highest total phosphorus yield for each year, with the exception of 2012 where yields were very similar to Marietta, but just slightly lower. This seems to translate into increased sediment and phosphorus yield at both Marietta and Harrisburg. The highest total nitrogen yield across all sites occurred at Newport in 2012, 2013, and 2014, and at Marietta in 2015, 2016, and 2017 (Figures 14-16).

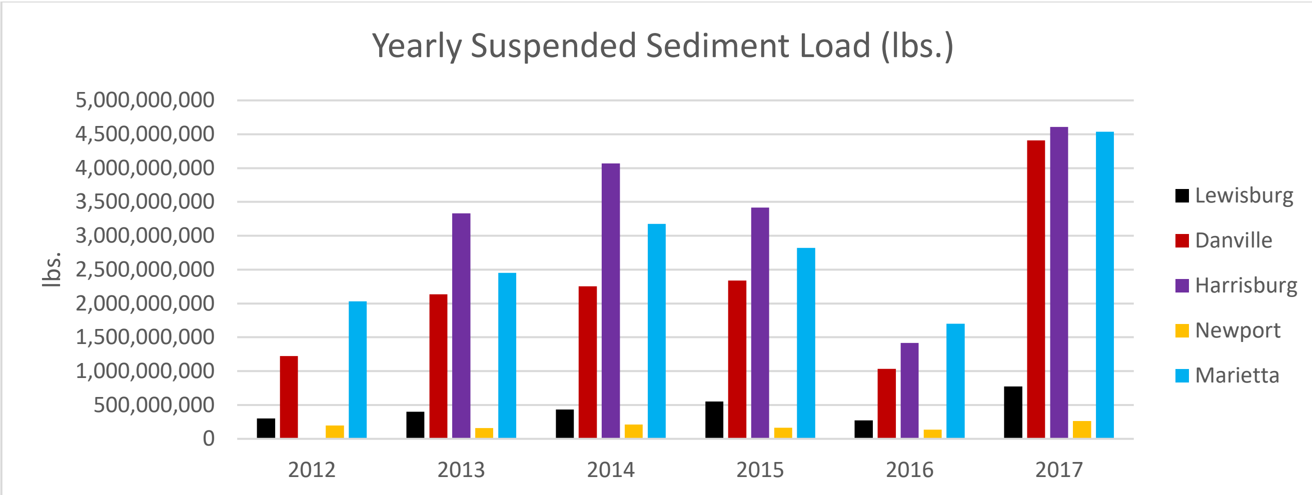

Figure 11. Yearly (2012-2017) suspended sediment load (lbs.) for select Susquehanna and Juniata River locations.

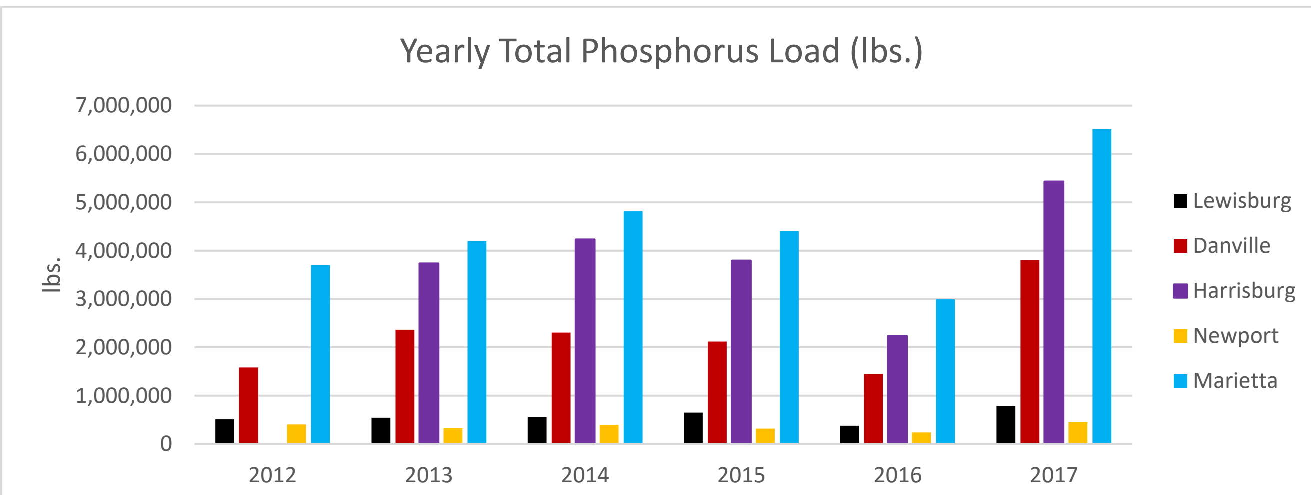

Figure 12. Yearly (2012-2017) total phosphorus (lbs.) for select Susquehanna and Juniata River locations.

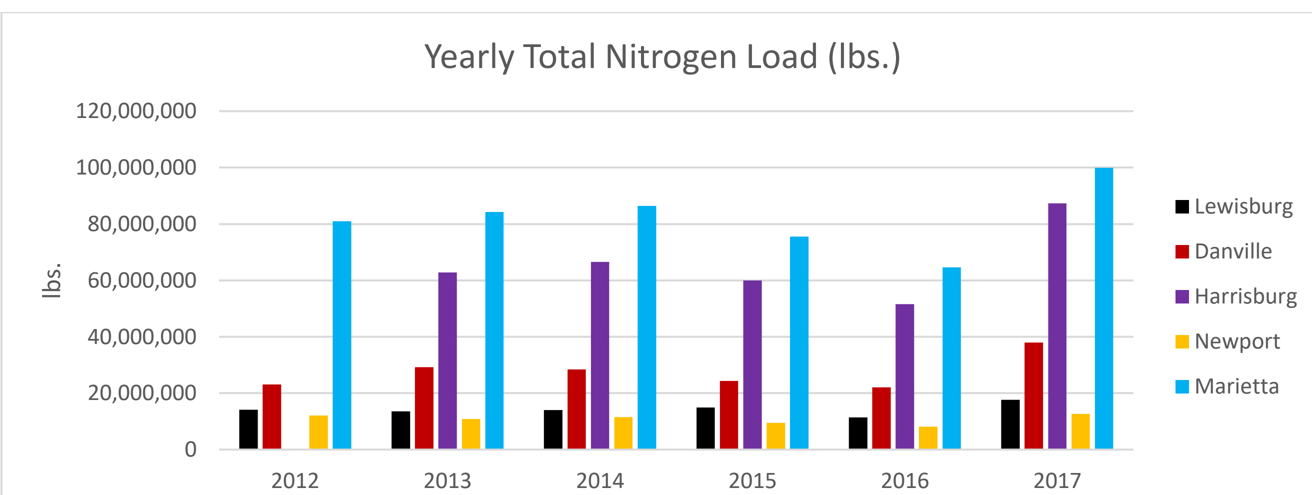

Figure 13. Yearly (2012-2017) total nitrogen load (lbs.) for select Susquehanna and Juniata River locations.

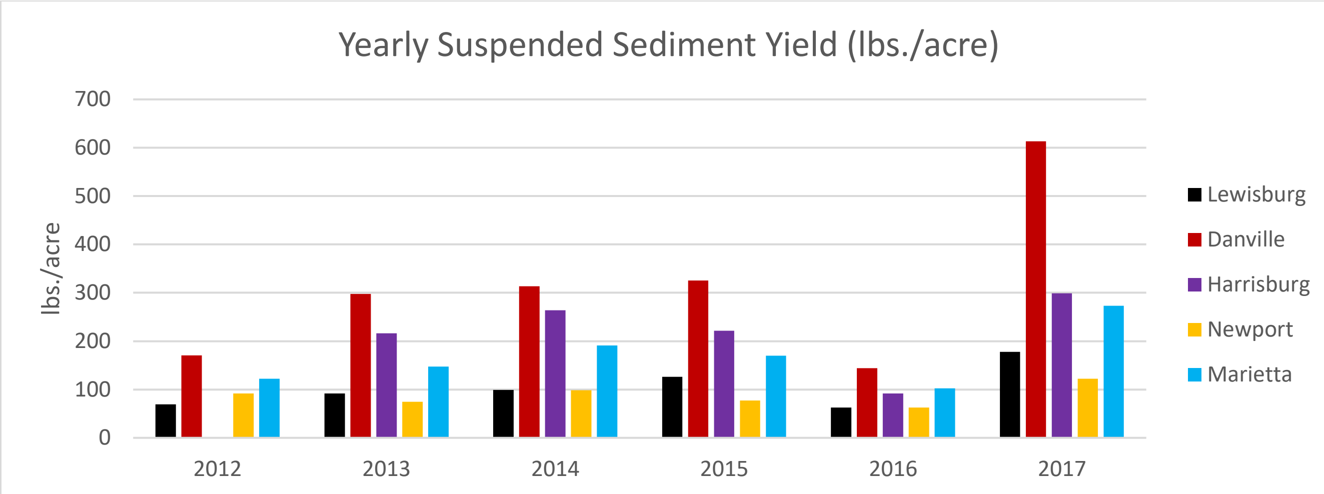

Figure 14. Yearly (2012-2017) suspended sediment yield (lbs./acre) for select Susquehanna and Juniata River locations.

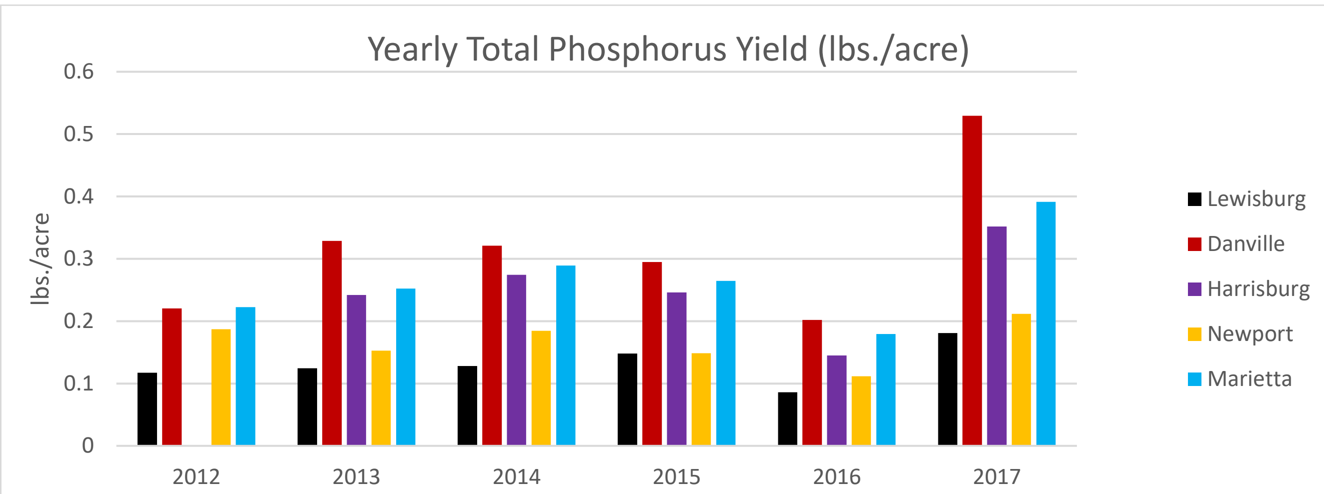

Figure 15. Yearly (2012-2017) total phosphorus yield (lbs./acre) for select Susquehanna and Juniata River locations.

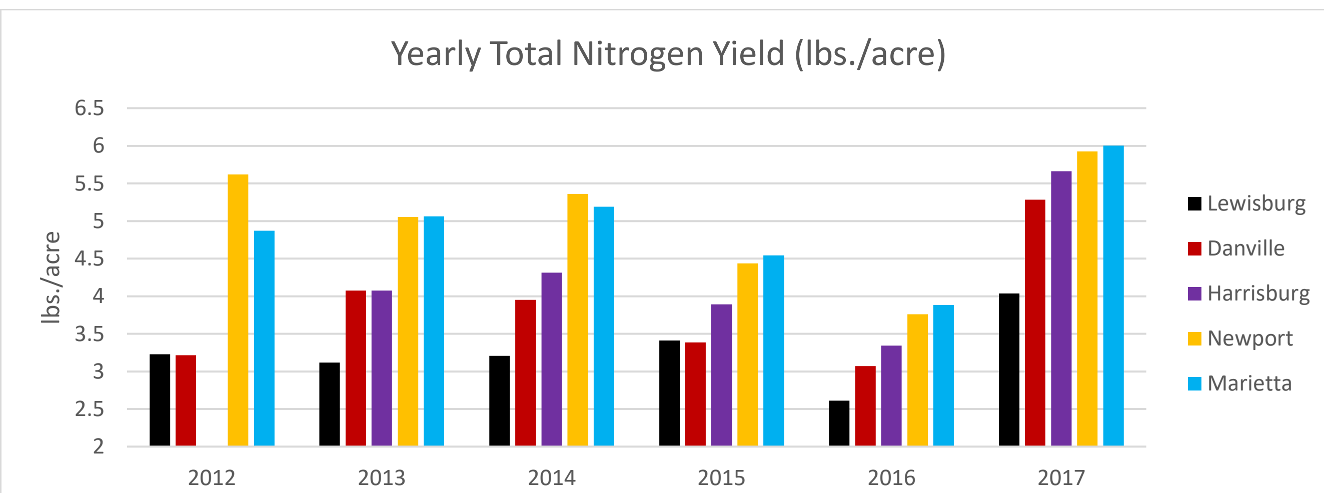

Figure 16. Yearly (2012-2017) total nitrogen yield (lbs./acre) for select Susquehanna and Juniata River locations.

HOW IMPAIRMENTS AND TMDLS ARE ADDRESSING WATER QUALITY IMPAIRMENTS

The entire Susquehanna River basin is included in the Chesapeake Bay TMDL. The TMDL is designed to reduce nutrients and sediment from all sources. In 2016, in order to achieve these goals, DEP and other parties developed a Bay restoration strategy comprised of several short, mid and long-term recommendations, aimed at augmenting the approach to water quality improvements in the Chesapeake Bay watershed. The Bay Plan is a collaborative effort between DEP and the PA Departments of Agriculture, and Conservation and Natural Resources, along with other stakeholders in the design, development, and implementation of this strategy. All parties are working together to coordinate plans, policies, and resources. Six essential recommendations are laid out in the new strategy:

- Site high-impact, low-cost Best Management Practices (BMPs) on the ground.
- Quantify undocumented BMPs in watersheds impaired by agriculture or stormwater.
- Improve reporting, record keeping, and data systems to provide better and more accessible documentation.
- Address nutrient reduction by meeting EPA's goal of inspecting 10 percent of farms in the watershed, ensuring development and implementation of manure management and agricultural erosion and sediment control plans, and enforcement for non-compliance.
- Identify legislative, programmatic, or regulatory changes to provide the additional tools and resources necessary to meet federal pollution reduction goals by 2025.
- Obtain additional resources for water quality improvement.

DEP’s Chesapeake Bay Office coordinates and directs the development, implementation, and funding of the Commonwealth's Chesapeake Bay efforts.

The strategy relies on a mix of technical and financial assistance for farmers, expanded data gathering, improved program coordination and capacity and – when necessary – stronger enforcement and compliance measures. The efforts to reduce nutrients and sediment will result in additional benefits by reducing the amount of herbicides and other compounds in runoff and the sediment, associated with agriculture, reaching the water.

Furthermore, a significant amount of tributary stream miles are impaired in the Susquehanna basin. To address these impairments, DEP and other agencies have been providing funds to local governments, nonprofit, environmental and watershed organizations to ensure restoration efforts are underway. Many in the public, particularly farmers, are aware of – or have participated in – efforts to restore riparian buffers along streams, for example. It is through these efforts at the local watershed scale that real progress toward improving water quality in the Susquehanna River can be made.

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