CHIQUES CREEK WATERSHED ALTERNATIVE RESTORATION PLAN

Susquehanna River Basin Commission

February 2019

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

INTRODUCTION

Prior to colonization by European descendants, across Pennsylvania the landscape was dominated by forest for thousands of years (Lothrop et al., 2016). Healthy watersheds and clean water are natural by-products of natural landscapes when climate, land, water, and living parts all operate in balance. Outside of lingering effects of past coal mining practices, it is notable that most of Pennsylvania's severely-degraded watersheds occur in settings where forest covers less than half the landscape. And while extensive reforestation of most modern landscapes is not desirable or practical, understanding the natural processes that lead to healthy watersheds is beneficial to manage, improve, and restore water resources (cost-) effectively.

With more than 95% of its 190-plus miles of overall waterway length failing to meet designated aquatic life status, the Chiques Creek Watershed (CCW) is among Pennsylvania's most extensively impacted watersheds. The dominant land uses in the CCW support agriculture production and urban/suburban development. Given the extent of waterway degradation, it is not coincidence that less than 20% of the CCW is forested or otherwise in a naturalized condition.

The major watershed stressors are:

- Excess suspended sediment (SS) and siltation;
- Physical alterations to streamflow (i.e., dams, culverts, channelized & filled reaches;
- Altered watershed hydrology; and,
- Nutrient enrichment.

In 2001, a Total Maximum Daily Load (TMDL) Plan was approved by the United States Environmental Protection Agency (USEPA) that was intended to reduce excess sediment and nutrient pollution and restore waterway integrity in the CCW. As with many prior watershed pollutant management designs, the 2001 Chickies (*sic*) Creek Watershed TMDL Plan to reduce pollution later was deemed ineffective by oversight agencies mainly due to: (i) the lack of stakeholder involvement during its development; and, (ii) for its absence of a coordinated and accountable strategy to deliver and sustain the resources (i.e., local engagement, technical, financial, etc.) needed to address both point and non-point source (NPS) pollution throughout the watershed.

In 2014, the Pennsylvania Department of Environmental Protection (PADEP) acknowledged that the conventional TMDL Plan for the CCW was ineffective; submitted a proposal to USEPA for the withdrawal of the 2001 TMDL Plan (PADEP's written request for TMDL withdrawal is provided in Appendix A); designated the CCW as a "pilot project" for an Alternative Restoration Plan (ARP); and, recruited a partnership among local and regional resource management organizations to lead ARP development for the CCW.

Importantly, this ARP was developed through combinations of focused technical/scientific support furnished by resource agencies as well as the committed cooperation from many local stakeholder leaders who reflected a broad spectrum of interests and perspectives. Additionally, the ARP is being developed and delivered in phases. The initial ARP phase addresses impacts due to excess SS/siltation; the subsequent ARP phase will address nutrient pollution. Furthermore, the ARP was designed in part based on the key elements required by USEPA for a watershed-based plan.

Of note, this and the subsequent ARP phase is being developed and implemented amidst the broader context of Pennsylvania's Phase III WIP for the overall Chesapeake Bay Watershed (referred to herein as "WIP3"). WIP3 is a state-led initiative being undertaken in Pennsylvania's portion of the Chesapeake Bay Watershed that will specify how, by 2025, the Commonwealth will accomplish its pollution-reduction goals as defined in the Chesapeake Bay TMDL. For more information about Pennsylvania's commitments and requirements related to the Chesapeake Bay TMDL, refer to: http://www.dep.pa.gov/business/water/pages/chesapeake-bay-office.aspx.

This ARP document contains the following elements:

1. Defined causes and sources of aquatic life impairment.

2. Estimated current sediment pollutant loads, a target sediment load expected to foster recovery of healthy aquatic communities, and corresponding pollutant load reductions expected for the various controllable pollutant sources. Additionally, the principal categorical sources of sediment pollutants, as well as land cover types associated with such sources within each of four main watersheds and 14 small subwatersheds, are identified.

3. A local stakeholder-vetted, spatially-explicit, and dynamic database that currently lists > 550 individual Best Management Practice (BMP) opportunities with estimated pollutant-reduction contributions as well as associated costs for each BMP. This BMP database provides a pool of practice types and projects that offer multiple pathways to achieve the load reductions estimated in this ARP. Of note, the BMP opportunity database is dynamic; meaning that new opportunities are expected to be added to the database through time while some identified opportunities will drop out of consideration; however, the overarching goal is to continue to implement pollutant-reduction projects and adopt practices from a generous inventory of vetted opportunities.

4. Conservative estimates of the costs to achieve sediment pollutant load reductions by this plan and sources of technical and financial assistance that will be relied upon to implement this ARP.

5. Description of information/education components that will be used to enhance and inform public understanding of the project and encourage their ongoing support and participation in selecting, designing, and implementing management measures.

6. A schedule for implementing management measures identified in this ARP.

7. A schedule of interim, measurable milestones for determining whether the management strategy and BMP implementation pace is commensurate with this ARP.

8. A set of criteria that will be used to determine whether loading reductions are being achieved over time and sufficient progress is being made towards attaining water

quality targets and, if not, the criteria for determining whether this ARP warrants revision.

9. A monitoring strategy to evaluate the effectiveness of BMP implementation through time, measured against the criteria established in no. 8 above.

As mentioned, this ARP includes a database with > 550 individual management practice and project opportunities that were identified, vetted by local stakeholders, and modeled for contributions to pollutant load reduction in the CCW. For each practice/project opportunity, the database has location, expected pollutant reduction capacity, and estimated cost information. By design, the BMP opportunities database will be used dynamically and interactively by the agency partnership recruited to lead this pilot project ARP; i.e., the ARP steering committee[1]. As such, the BMP database is intended to function as a resource to facilitate comprehensive planning, prioritization, and tracking of BMP implementation in CCW in an ongoing manner. Moreover, as new BMP opportunities are identified and should existing ones be deemed non-viable, the database will be revised accordingly.

In addition to the individual opportunities identified for the CCW overall, a Flood Resiliency study conducted in the upper reaches of Chiques Creek was undertaken from 2016-2018 as a joint effort between United States Army Corps of Engineers (USACE) and the Susquehanna River Basin Commission (SRBC) with funding primarily provided by PADEP. This Flood Resiliency project resulted in the identification of additional project opportunities that couple benefits for flood risk and sediment pollution reductions. The Chiques Creek Flood Resiliency Study report (SRBC and USACE, 2018) is available via https://www.srbc.net/our-work/programs/planning-operations/docs/chiques-creek-flood-study.pdf.

Although extreme in magnitude, the CCW is not unique for the types of deviation from unimpaired resource conditions. And while dramatic pollutant load reductions are required to achieve success, this ARP shows that various pathways are available to reduce pollutant loads sufficient to support healthy aquatic life communities. To address current sediment contributing activities, management practices/projects will come primarily from the agriculture sector with main emphasis on achieving compliance with erosion and sediment control plans (Ag E&S), expansion of livestock exclusion measures from stream corridors, increased adoption of healthy soil initiatives like conservation tillage and cover crop practices, as well as establishment of riparian forested buffers (RFB). Secondarily, sediment load reductions will derive from urban/suburban settings with main emphasis on establishing bioswales, stormwater basin retrofitting, and streambank stabilization. Additional sediment pollution reductions derive from stream corridor projects that reconnect and restore floodplain functions and/or remove unsafe or antiquated mill dams using designs that eliminate or stabilize legacy sediment accumulations.

Major pollutant sources, especially sediment loads, are caused in part by erosion and sedimentation processes that take place within streams because of disruptions to natural watershed stability. Instability happens where the prevailing (i) substrate particle size and (ii) corresponding sediment load become mismatched to the (iii) slope of stream bed and (iv) streamflow (Lane, 1954).

[1] PADEP, SRBC, and PSU-AEC

Following thousands of years of watershed stability, Colonial development (about three centuries ago) and Industrialization (about 150 years ago) became widespread throughout the region and both social periods altered the millennia-long natural balance into which healthy watersheds had arisen.

The Industrialization (e.g., since ~1850) disruptions to watershed balance took form as diverse, yet commonplace across the SRB, as:

- Dams erected on streams to power mechanical mills;
- Rapid deforestation, conversion to agriculture/urban land cover, and corresponding soil loss;
- Levies built to deflect flood waters;
- Regional and local transportation networks and their associated drainage features;
- Damming large rivers to generate electricity, support navigation/recreation, and mitigate flooding; and,
- Sewer systems that re-route stormwater for human health, safety, and convenience.

Recognizing and understanding the roles of natural watershed processes, as well as the disruptive effects that certain past and ongoing human activities exert on aquatic resources, provides a scientific basis to approach watershed restoration in comprehensive fashion.

WATERSHED CHARACTERISTICS

The majority of the CCW is located in Lancaster County and nearly 60% of the watershed land area is used for farming (Figure 1). Although precise statistics are not available for the CCW, Lancaster is Pennsylvania's leading county for agriculture production. With more than 5,600 individual farms operating on approximately 75% of the overall land area, Lancaster County has more than twice the number of farms and over a third more land area used for agriculture than the state's second leading farming county[2].

For context, not only does Lancaster County lead Pennsylvania in the number of total farms, its croplands consistently deliver the state's highest yields (i.e., production per acre) for important commodities including barley, corn, hay, oats, soybeans, and winter wheat. Lancaster County also is Pennsylvania's leading producer of most livestock. Since 2012, the county has accounted for >40% of egg-laying chickens and >30% of meat birds; 17% of the overall cattle herd and 20% of dairy cows; >30% of hogs; and, 7% of sheep in Pennsylvania.

In addition to leading Pennsylvania in overall agriculture land use and livestock population, based on the 2012 census, Lancaster County also has the sixth highest human population (~526,000) of the state's 67 counties. Lancaster County also leads Pennsylvania in terms of pollutant loads that are delivered to the Chesapeake Bay. As reported through the WIP3 process, Lancaster County alone accounts for roughly 20% of Pennsylvania's overall share of nitrogen pollution inputs to the Chesapeake Bay.

[2] In 2016, York County reported 2,170 farms operating on ~45% of the land area (USDA, 2017).

The CCW covers 126 square miles in the Piedmont Physiographic Province of southeastern Pennsylvania that includes a total of 192 miles of mapped stream length. Approximately 40% of the watershed is underlain by carbonate bedrock; the balance consists mainly of gently folded sedimentary and lightly-metamorphosed rock types. The watershed was sporadically intruded by younger igneous dikes.

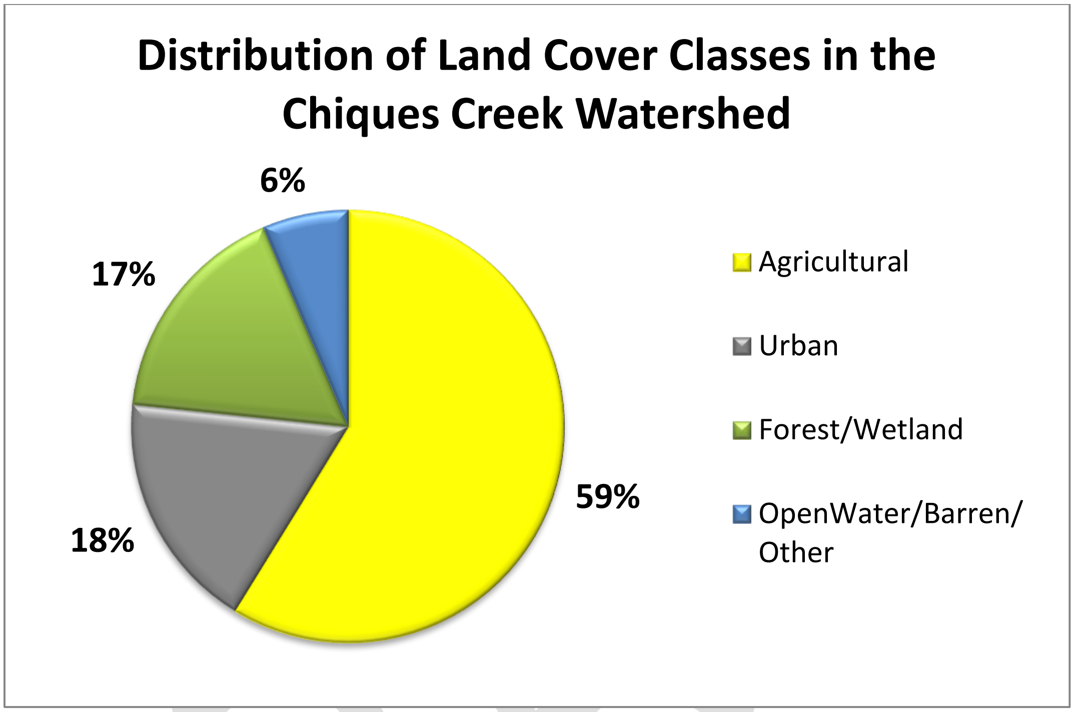

Figure 1. Proportions of the Main Land Cover Types in the Chiques Creek Watershed

Chiques Creek originates on the southern flank of a low, east – west trending ridge in southern Lebanon County. The stream winds generally north to south through a gentle crescent-shaped arc for 31.6 miles predominantly in Lancaster County before making confluence with the Susquehanna River between the historic boroughs of Marietta and Columbia.

The CCW includes three prominent subwatersheds, from east to west: (i) Chiques Creek; (ii) Little Chiques Creek; and, (iii) Donegal Creek. Chiques Creek is the largest subwatershed and accounts for about half (51%) of the total watershed area (65 square miles). Little Chiques Creek makes up 35% and Donegal Creek accounts for the remaining approximately 14% of the overall drainage area. The Donegal Creek subwatershed has the largest proportion of agricultural lands (with over 50% as cropland) and the smallest proportions of natural and developed lands. The Chiques Creek subwatershed has both the largest proportions of natural and developed lands, yet the smallest proportion of agriculture.

Other named streams in the CCW include Dellinger Run, Rife Run, Boyers Run, Brubaker Run, Back Run, and Shearers Creek. Pennsylvania's protected and designated uses within the CCW include High Quality – Cold Water Fishes, Trout Stocked Fishes, and Warm Water Fishes. Most of the protected use High Quality stream reaches occur in Shearers Creek, a headwaters tributary to Chiques Creek with remaining High Quality reaches being unnamed headwater tributaries to Donegal Creek. The mainstems of Donegal Creek and Little Chiques Creek are designated Trout Stocked Fishes waters while most tributaries are designated Cold Water Fishes. Except for Shearers Creek, Chiques Creek and its tributaries are Warm Water Fishes.

For general discussion purposes, the CCW is organized according to four main subwatersheds as follows: (i) Donegal Creek; (ii) Little Chiques Creek; (iii) Upper Chiques Creek (i.e., portion that includes and is upstream of Manheim Borough); and, (iv) Lower Chiques Creek (portion downstream of Manheim Borough to the confluence with Susquehanna River). Figure 2 depicts several prominent landmarks and the distribution of major land cover categories, as well as the four main subwatershed boundaries within the CCW. For purposes of pollutant loading models and BMP opportunities, the CCW is divided into 14 subunits as follows:

Subunit nos. 1-3 comprise Donegal Run;

Subunit nos. 4-8 make up Little Chiques Creek;

Subunit nos. 9-10 form Upper Chiques Creek; and,

Subunit nos. 11-14 cover Lower Chiques Creek.

In Pennsylvania, aquatic life designated uses are defined according to community traits of instream benthic macroinvertebrate (BMI) organisms. Defining aquatic life status for a waterway according to characteristics of its BMI community (note that BMI informally are referred to as "bugs") is relevant and practical because the instream bug community includes members that: (i) are both short- and long-lived; (ii) occupy all available habitat types; (iii) represent various feeding, respiratory, and reproductive strategies; (iv) tend to remain in localized settings; and, (v) are continuously exposed to the conditions of the aquatic environment. BMI assessment begins with standardized collection surveys followed by standard protocols to sort, count, and identify the bugs that are collected. Next, sets of BMI community Indices of Biotic Integrity (IBI) are calculated based on the survey bug data. Finally, the IBI metric score is compared to thresholds for aquatic life attainment that correspond to the type of waterway and season during which the BMI survey occurred. IBI findings are extended from specific BMI survey locations to more broadly categorize the aquatic life status of adjacent stream reaches that exhibit similar physical instream as well as catchment features as the surveyed location. The technical methodology PADEP uses to generate IBI is available at http://files.dep.state.pa.us/Water/Drinking%20Water%20and%20Facility%20Regulation/WaterQualityPortalFiles/Methodology/2015%20Methodology/freestoneIBI.pdf.

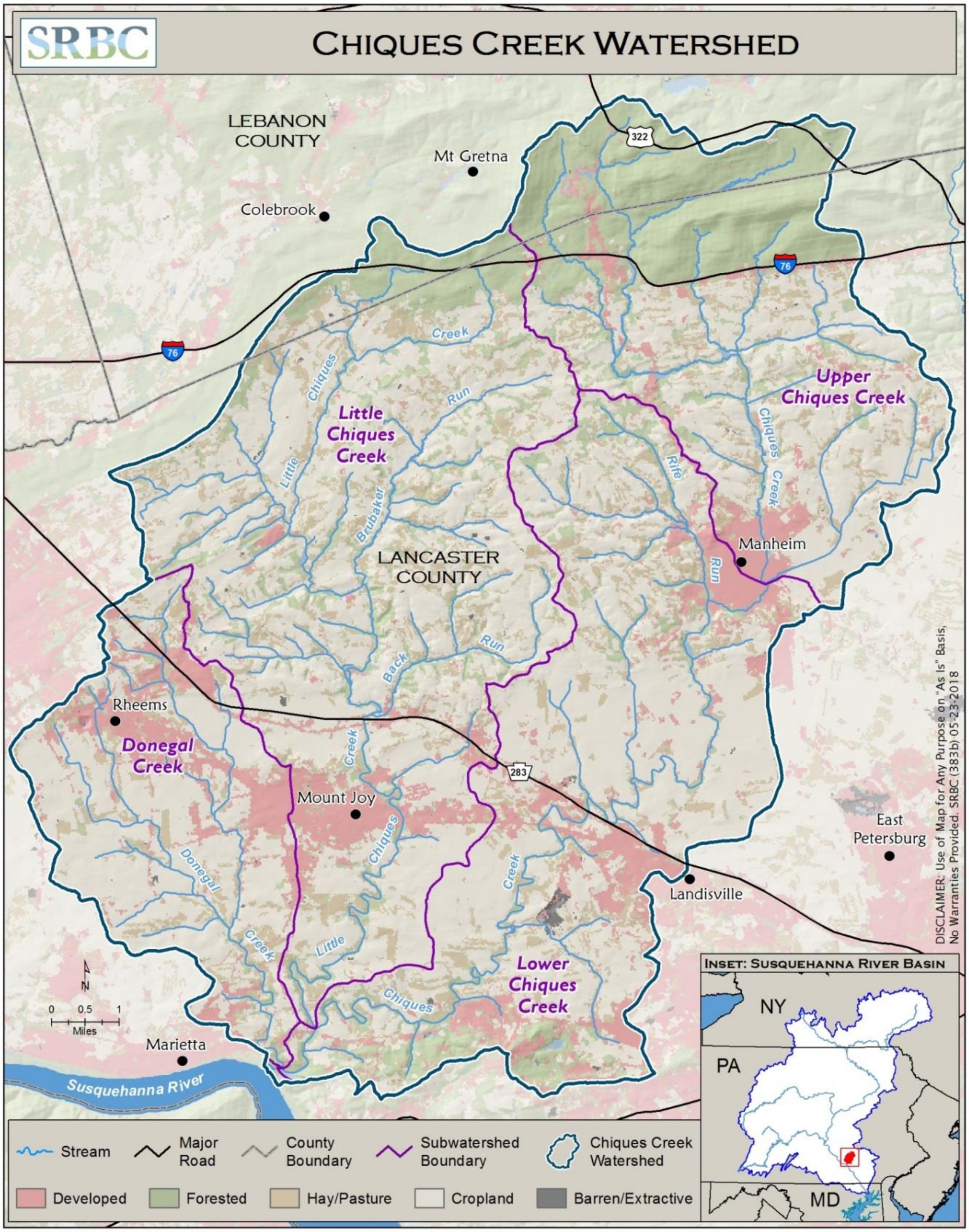

Figure 2. Distribution of Major Land Cover Types and Subwatershed Boundaries in the Chiques Creek Watershed

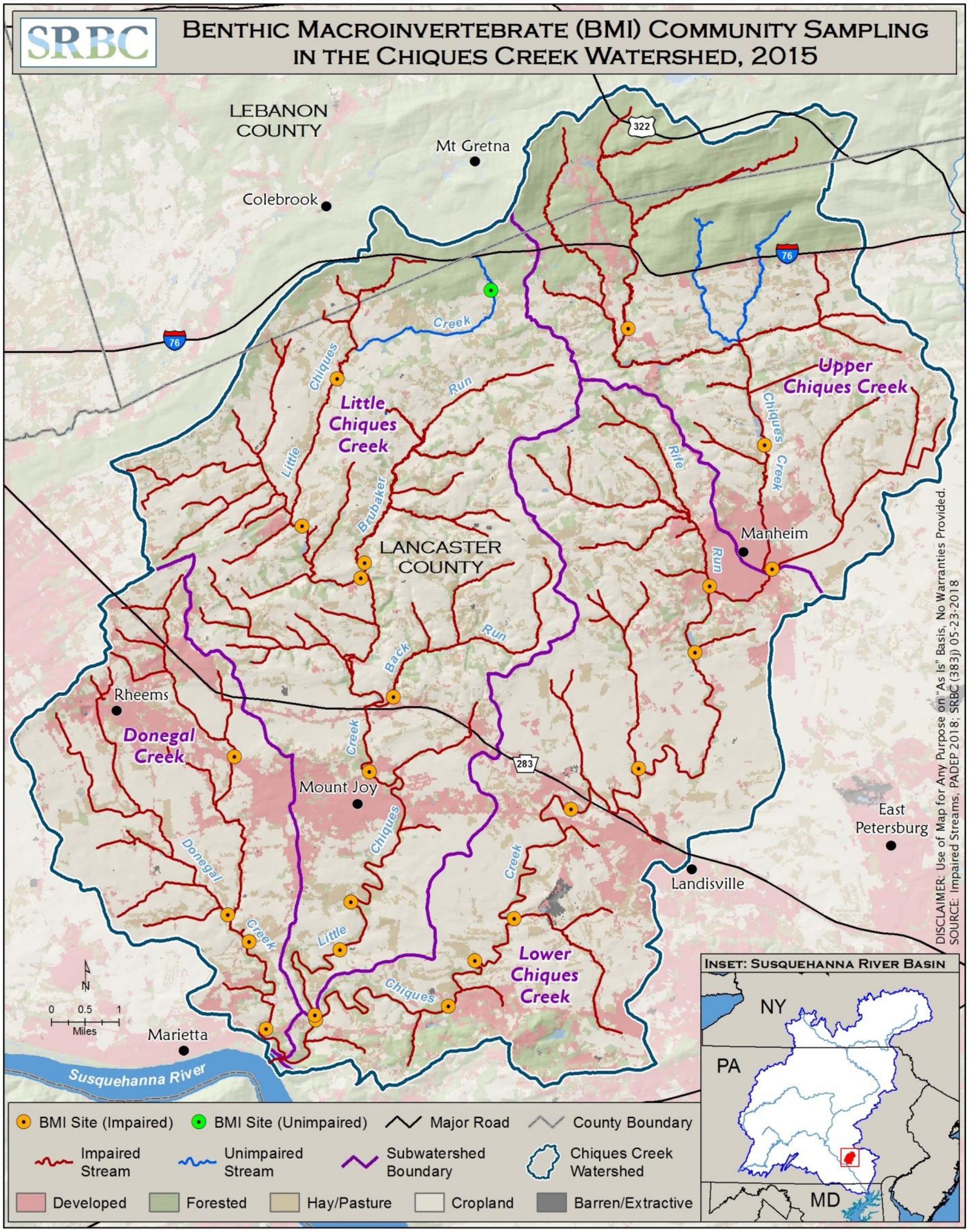

Figure 3. ***Locations of 25 Stream Assessment Stations Surveyed in 2015 and the Corresponding Impaired and Unimpaired Status for All Stream Reaches in the Chiques Creek Watershed Based on the 2015 Survey***

As a result of BMI surveys conducted by PADEP and SRBC biologists throughout the CCW in 2015, the overwhelming majority of stream reaches were classified as *impaired* for aquatic life use. Stream assessment findings are summarized on Table 1 and as indicated, the cause for degradation to the aquatic life community exclusively was attributed to siltation. Detailed listings for each stream reach in CCW as reported in the PADEP Integrated Report are provided in Appendix B.

Table 1. Summary of Aquatic Life Impairment Findings Based on 2015 Stream Assessment for Chiques Creek Watershed

8-Digit Hydrologic Unit Code (HUC): 02050306/Lower Susquehanna River (Area: 2,511 mi^2)				
Named Watershed	**Impairment Source**	**Impairment Cause**	**Length (mi)**	**Designated Use**
Chiques Creek	Agriculture	Siltation	88.0	HQ, WWF
	Urban runoff/Storm sewers	Siltation	40.9	WWF
Little Chiques Creek	Agriculture	Siltation	67.2	TSF
Donegal Creek	Agriculture	Siltation	27.7	HQ, CWF
	Sum for Agriculture:		***182.9***	
	Sum for Urban:		***40.9***	

The total length of aquatic life impairments exceeds the 192-mile total length of mapped streams in the CCW due to overlap in certain reaches by both Agriculture and Urban impairment sources. As a specific cause of impairment, *siltation* refers to the accumulation of mostly fine grain-sized particles on the streambed. The primary outcome of siltation is to limit, and where particularly severe, eliminate habitat niches that are necessary to sustain the full spectrum of a healthy aquatic community.

Excess sediment, not siltation, was emphasized in the Introduction section as the primary pollutant focus for this phase of ARP. For certain, although nuanced differences exist between excess sediment and siltation as stressors for aquatic life, the two are intertwined. For more insight, as a specific cause of impairment, *siltation* compromises the integrity and reduces the overall availability of habitat types that are essential to support all manner of aquatic life. In contrast to the view that a streambed is a sharp division between solid and liquid features, in most healthy streams, the bed materials exhibit lots of size and shape variation that leads to "uneven packing" and plenty of open space between solid pieces. The exchanges of water, matter, and biota that take place within the streambed are vital to healthy functions of the stream environment.

From Lane's 1954 relationship, it is inferred that siltation happens ***wherever in the stream*** the supply (i.e., load) of fine-grained particles exceeds the net capacity (i.e., energy) to transport fine-grained material. For CCW, like many watersheds in the region, a combination of common factors leads to conditions where the build-up of fine-grained sediment in particular stream reaches is likely. The most prevalent contributing factors include: (i) relic mill dams and remnant sediment accumulations related to former mill dams (refer to Figure 4 to see the distribution of known mill dams in CCW); (ii) riparian corridors that lack natural vegetation "buffers," especially buffers that separate plowed cropland from streams; (iii) riparian corridors that do not exclude livestock from entering streams; and, (iv) catchments that efficiently route stormwater from the developed landscape to the waterway.

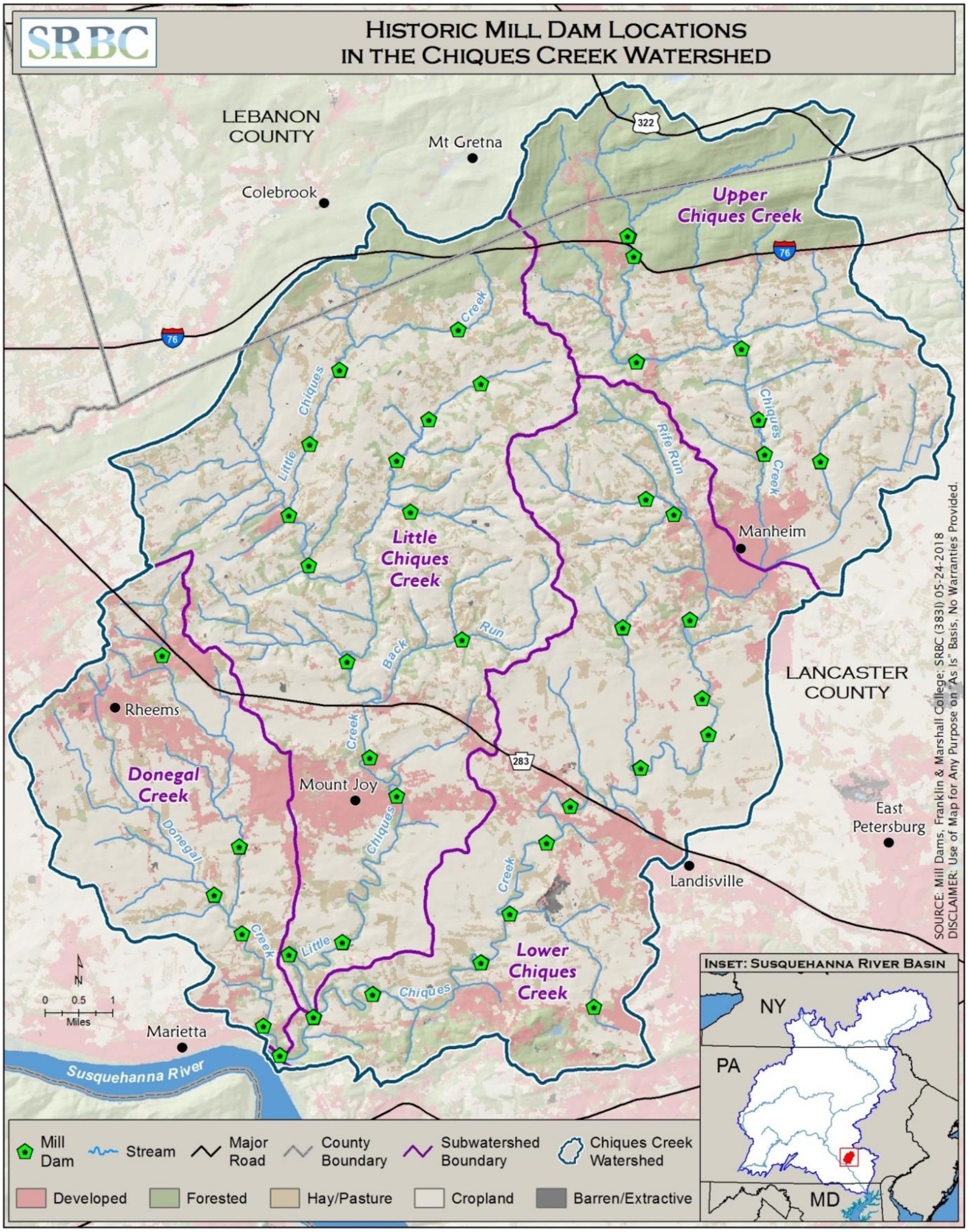

Figure 4. Locations of 42 Known Mill Dams in the Chiques Creek Watershed (Walter and Merritts, 2008)

APPROACH FOR ALTERNATIVE RESTORATION PLAN

This phase of ARP for the CCW emphasizes reducing excess sediment pollution to address corresponding siltation impacts to aquatic life. The initial ARP phase is focused on sediment pollution because impacts due to "sediment pollution" profoundly affect aquatic communities and thereby mask contributions of other pollutants. A subsequent phase of ARP for the CCW specifically will address nutrient (e.g., total nitrogen (TN) and total phosphorus (TP)) pollution.

The pilot project design for ARP in the CCW was anchored to coordination and accountability by a core set of resource trustee organizations (e.g., a steering committee) that included: (i) PADEP; (ii) PSU–Agriculture and Environment Center (AEC); and, (iii) SRBC.

Among the steering committee's major activities were the following:

- Held a stakeholder engagement session (January 2015);
- Developed an assessment and monitoring plan for the watershed and completed aquatic life-based assessments (through summer 2015);
- Installed a network of continuous instream monitoring (CIM) stations in 2016 to collect water quality indicator (WQI) data;
- Established a set of stakeholder work groups and facilitated a schedule of regular, ongoing meetings related to (ongoing):
    - Municipal NPDES permit requirements for municipal separate storm sewer system (MS4) management;
    - Non-regulatory urban/suburban stormwater issues;
    - Agricultural NPS management; and,
    - Steering committee/scientific-technical capacity issues.
- Developed a geospatial database of ~550 BMP opportunities within CCW;
- Through a National Fish & Wildlife Foundation (NFWF) grant, AEC:
    - Held 9 farmer outreach events/workshops between 2015-2018;
    - Established a $75,000 subaward "buffer bonus" program;
    - Special outreach visits to certain 'priority farms' to encourage adoption of conservation practices;
    - Conducted 5 urban stormwater outreach events/workshops, including an Inspection and Maintenance Training workshop for municipal employees;
    - Created a Municipal Stormwater Toolbox with educational material resources and a shared on-line calendar of MS4 events;
    - Provided at no-cost >280 trees to landowners for riparian buffer plantings;
    - Furnished Volunteer Conservation Corps labor to assist 2 projects with riparian buffer plantings;
- Coordinated with related efforts led/undertaken by others, including:
    - The aforementioned Chiques Creek Flood Resiliency project;
    - Historic mill dam and associated legacy sediment mapping and modeling actions performed by Franklin & Marshall College and the Water Science Institute;

- Removal of barriers to aquatic life movement fostered by American Rivers; and,
- Various community and stakeholder engagement events held in the watershed such as:
  - Chiques Creek Watershed Alliance's Water Expo;
  - Homeowner stormwater awareness workshops; and,
  - Multiple farmer outreach events.

Development of this ARP was predicated upon the inclusion of sector stakeholders who have local knowledge, experience, and influence and who were involved in an iterative process with the steering committee. Additionally, high levels of technical and regulatory experience also were infused into this process. It is the iterative approach with community stakeholders that principally distinguishes this ARP from the prior TMDL. Because of collaboration and coordination with stakeholders, the database of BMP opportunities is expected to represent a high proportion of viable, implementable practices and projects. The approach to ARP described above is expected to result in a more durable and lasting commitment to pollution reduction throughout the watershed than was afforded by past efforts. Moreover, this ARP was developed in recognition for the WIP3-based perspective that requires Lancaster County to generate and sustain overall momentum in order for Pennsylvania to achieve its pollutant load reduction targets within the goal of restoring Chesapeake Bay.

Many of the nonpoint sources (NPS) of sediment pollution in the CCW are encompassed by existing regulatory frameworks; therefore, mechanisms to facilitate and ensure the implementation of this ARP will draw upon such frameworks as relevant. The following regulatory mechanisms are emphasized herein:

- Pennsylvania Clean Streams Law and specifically Chapter 102: Erosion and Sediment Control requirements – an Ag E&S plan is required to be implemented where plowing and/or tilling, including where conservation (a.k.a. no-till) activities disturb >5,000 ft^2 and where animal heavy use areas (AHUA) disturb >5,000 ft^2;
- National Pollutant Discharge Elimination System (NPDES) authorization for construction activities is required for earthwork that disturbs >1 acre. Within the NPDES construction authorization, permittees are required to develop and implement an Erosion and Sediment Control (ESC) plan and a post-construction stormwater management plan (PCSM); and,
- NPDES stormwater discharges from Municipal Separate Storm Sewer Systems (MS4) – MS4s that discharge stormwater to the Chesapeake Bay Watershed and/or that discharge stormwater to local surface waters that are impaired for sediment are required to develop and implement pollutant reduction plans (PRP) designed to achieve a minimum 10% sediment loading objective.

ASSESSMENT AND MONITORING

In 2015, SRBC and PADEP staff began instream data collection in the CCW to characterize baseline aquatic resource conditions and establish a network of monitoring stations in the watershed to evaluate the effects of water quality improvement practices and projects expected to be undertaken. BMI community metrics, WQI, select aqueous chemistry parameters, stream discharge, stream habitat assessment, and other scientific measurements have and continue to be collected as part of a coordinated, ongoing, and long-term strategy to evaluate aquatic resource conditions in the CCW.

Aquatic Life Assessment

As discussed above, in 2015, SRBC and PADEP surveyed BMI community assemblage at 25 sites (Figure 3) to formally re-assess the Aquatic Life Use (ALU) status of stream reaches within CCW. BMI-based community assessment is the primary means PADEP uses to assess stream conditions with findings that are based on IBI scores. For more information about Aquatic Life assessments, in 2017 PADEP produced ***Looking Below the Surface***, an informative story map available at https://www.depgis.state.pa.us/macroinvertebrate/index.html.

Coincident with each of the 25 BMI surveys, the WQI parameters pH, temperature, dissolved oxygen (DO), specific conductance (SpC), and turbidity were measured using direct-read sensors. Additionally, stream discharge was calculated based on incremental stream velocity measurements collected using an acoustic-based flow meter coupled with the cross-sectional wetted channel geometry. Water samples also were collected at each of the 25 sites and subsequently were analyzed by a PADEP-certified laboratory for pH, alkalinity, biochemical oxygen demand (BOD), total suspended solids (TSS), ammonia (NH_3), nitrite (NO_2), nitrate (NO_3), and phosphorus (as total recoverable form or TP).

Of the 25 sites that were assessed for ALU status in 2015, 24 scored "Impaired" and just one site scored "Attaining."

Ongoing Monitoring Strategy

BMI Community Surveys

Beginning in 2018 and annually thereafter, BMI will be collected at a subset of at least 20% of the 25 stations surveyed in 2015 as one component of the long-term monitoring strategy to assess instream conditions as the restoration plan for CCW unfolds across time. It is useful to reassess the BMI community within a fixed station network on an ongoing basis to amass and analyze information about the overall structure and condition of this key aquatic taxa component through time; however, the macroinvertebrate community improvements likely will lag years behind the implementation of practices and projects that reduce sediment and nutrient pollution in CCW. The BMI community response depends on a multitude of dynamic and interactive factors including landscape conditions, instream habitat traits, aquatic species' population cycles, and climate conditions.

In addition to annual BMI surveys within at least 20% of the network of benchmark sites sampled in 2015, beginning in 2018, BMI surveys also were conducted at select, targeted locations that correspond to specific areas with focused implementation of BMP and/or where prominent stream restoration, dam removal, or other significant projects are imminent and the evaluation of supplemental BMI datasets may enhance scientific insights regarding restoration of

CCW. For supplemental BMI surveys, decisions regarding re-surveys will be determined case-by-case.

Continuous Instream Monitoring (CIM)

CIM is 21st Century technology that enables high-resolution (i.e., time scale) WQI data sets to be developed cost-effectively. High-resolution WQI data sets (e.g., pH, temperature, DO, SpC, and turbidity) provide scientists with unprecedented opportunities to seek and detect sensitive signals of changing conditions in aquatic resources. Moreover, certain WQI parameters may be correlated with grab aqueous chemistry sample results to develop models that, when coupled to continuous discharge records, provide estimates for pollutant loads.

Since 2016, PADEP and SRBC have deployed a total of six CIM stations within CCW. Two CIM stations are operated by SRBC that report "real time" results on a publicly-available website, part of SRBC's Remote Water Quality Monitoring Network (RWQMN) program. CIM stations are visited monthly to calibrate and service the equipment, as well as measure stream discharge. Additionally, SRBC's RWQMN stations each serve as anchor points for a broad array for scientific data/information collection that includes: quarterly water sample collection and laboratory analyses; annual BMI surveys; development of stage – discharge regression relationships; and, compilation of a wide array of landscape attributes for the contributing catchment.

SRBC's real-time CIM data are accessible at https://mdw.srbc.net/remotewaterquality/data_viewer.aspx.

For more information about the RWQMN program and to download available CIM, water sample, and biologic data associated with RWQMN stations, see https://mdw.srbc.net/remotewaterquality/index.htm.

Overall Watershed Pollutant Loads and Trends

The USEPA Chesapeake Bay Program's nontidal water quality monitoring program (a.k.a. non-tidal network or NTN) began in 2004 as means to estimate nutrient and sediment loadings from the Bay region's rivers and streams into Chesapeake Bay. The NTN program encompasses more than 125 active stations (> 25 of which are located in the Susquehanna River Basin) that apply standardized and rigorous sample collection protocols. Data furnished by the NTN program serve as the primary basis to estimate pollutant loads and trends throughout the Bay watershed as well as to inform continued evolution of the model suite that serves as the principal pollutant-reduction planning and management tool for the Chesapeake Bay TMDL. For more information regarding the NTN program, see https://www.chesapeakebay.net/what/programs/chesapeake_bay_quality_assurance_program/quality_assurance_nontidal_water_quality_monitoring.

Although not formally integrated into the Chesapeake Bay Program's NTN, beginning in April 2018, SRBC initiated a sample collection program for a station located near the mouth of Chiques Creek (Figure 5) that adheres to the NTN program protocols and methods. SRBC is committed to long-term monitoring at this station to provide the basis for assessment of overall pollutant loads and trends for CCW.

Data Applications

In an ongoing manner, SRBC, PADEP, and other scientists will evaluate available datasets for various signals indicative of change.

Ongoing Water Quality Data Management, Analyses, and Documentation

On an annual basis beginning in 2019, SRBC will coordinate with PADEP and other ARP steering committee partners, as well as the Lancaster County Conservation District, PADEP Southcentral Region staff who administer/oversee BMP-relevant programs, and others to compile, evaluate, and synthesize data sets and information pertinent to this ARP. SRBC will develop a document or comparable web-based “deliverable product” (e.g., StoryMap) that summarizes findings. Included in this activity, SRBC will furnish updates to the BMP opportunities database on a semi-annual basis.

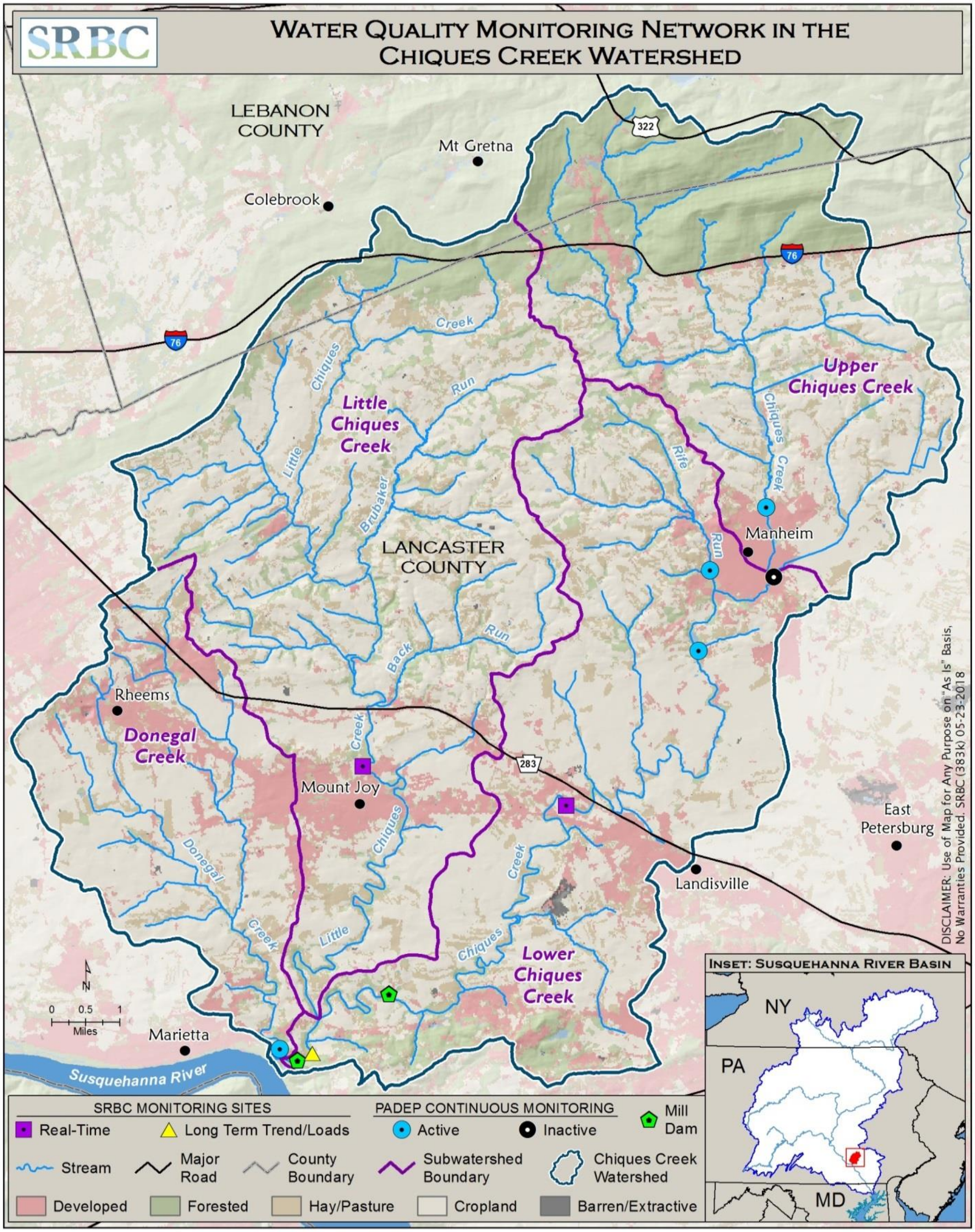

Figure 5. Locations of Primary Water Quality Monitoring Equipment and/or Recurring Activities

DERIVATION OF WATER QUALITY TARGETS FOR SEDIMENT

The focus for the initial phase of ARP is SS reduction because the main stressor effects to BMI associated with elevated sediment loadings (i.e., siltation, altered flow, and excess turbidity) tend to mask other stressor impacts including nutrient pollution. The approach to derive a SS water quality target for the CCW is applicable throughout the Susquehanna River Basin.

In the past and pursuant to conventional TMDL development projects, impaired watersheds were compared to similar unimpaired “reference” watersheds to obtain water quality targets supportive of SS and/or nutrient pollutant load reductions. Given the size of the CCW and especially given the extents of agriculture and developed land use in the CCW, no comparable unimpaired watershed exists within the Commonwealth or even within the Mid-Atlantic region; therefore, the following approach was used to develop a sediment loading target, expressed on a unit area basis as yield.

The ARP target was developed from water quality loads estimated by United States Geological Survey (USGS) from NTN monitoring stations located in the SRB portion of the Chesapeake Bay Watershed (data source: https://cbrim.er.usgs.gov/loads_query.html). Mean annual load estimates that were primarily based on the period 2005-2006 through 2015, inclusive were used to derive water quality targets; although, approximately 15% of the stations used for SS were based on a shorter period; i.e., 2010 through 2014.

To derive pollutant water quality targets, the following underlying assumptions apply:

- Biological assessment findings are attributable to SS/nutrient pollution;
- Load reduction will foster biological functions to respond in restorative manners; and,
- Driving factors of biological integrity are encompassed by the measured/presumed-similar conditions in the attaining and impaired watershed.

The following approach was used to derive the water quality target for CCW:

i. Calculate descriptive statistics and plot a histogram of the average annual estimates of SS yield based primarily on recent 10-year datasets derived by USGS/USEPA for 27 NTN monitoring stations distributed throughout the SRB;

ii. Within the 27 NTN monitoring stations, identify the subset of stations that meet screening criteria for catchment area <500 mi^2 and <25% total stream length impairment due to non-attainment for aquatic life (n = 6);

iii. Identify an inflection point in the overall average annual SS yield data set below-which includes the entire subset of NTN monitoring stations identified in the preceding; i.e., screening, step; and,

iv. Subtract 10% from the inflection point average annual yield, as an uncertainty factor.

Figure 6 below is a histogram of ~10-year annual average SS yields for the 27 NTN stations in the SRB. Values for the subset of 6 NTN stations that met the above-mentioned screening criteria are specified in the histogram by red circle symbols. The dashed gray line emphasizes the position and corresponding SS yield value for the inflection point (~560 lb SS/ac-yr), below-which all stations met the screening criteria. Upon application of a 10% uncertainty factor, *the annual SS yield target is defined as 500 lb SS/ac-yr*.

In concept, the NTN-based approach to develop an SS yield target value described herein is transferable across a geographic and land use spectrum. Moreover, this non-biometric indicator method furnishes consistency with PADEP's BMI community assemblage-based stream assessment findings. Additionally, the approach relied upon a uniform 10-year pollutant dataset developed according to the rigorous and consistent quality assurance protocols established by USGS/USEPA for its Chesapeake Bay NTN stations.

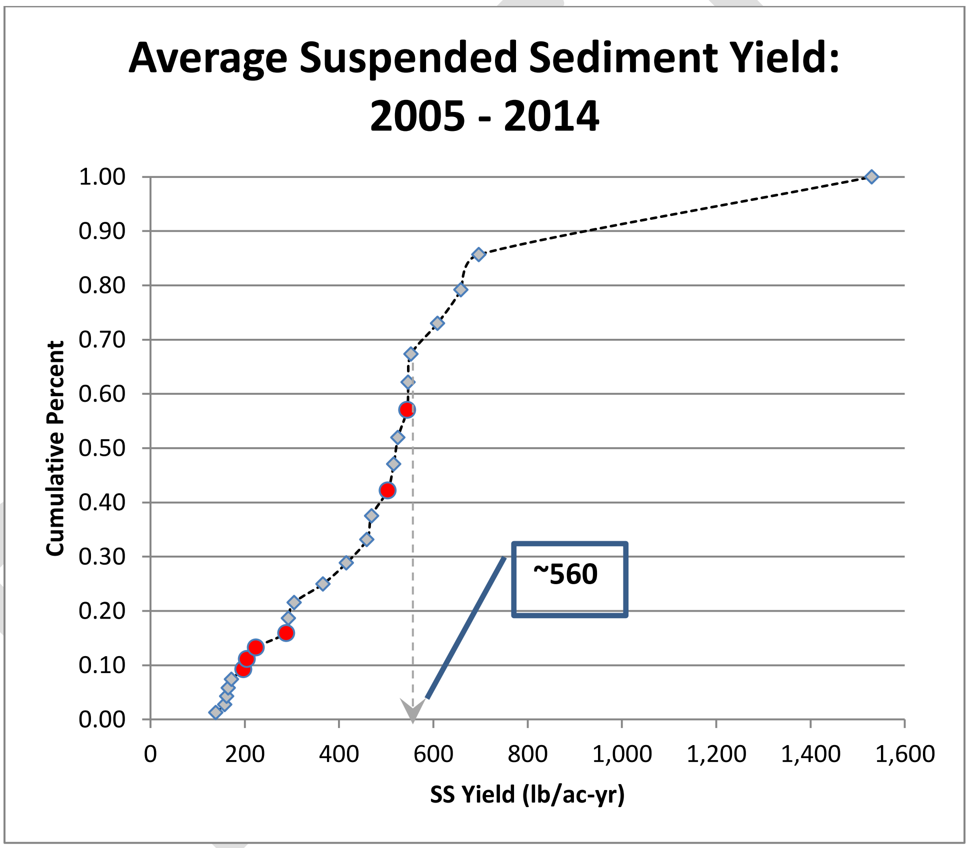

Figure 6. Histogram of Estimated Average Annual Yield for Suspended Sediment at 27 Non-Tidal Network Monitoring Stations in the Susquehanna River Basin (Inset charts depict NTN stations similarly for total nitrogen and total phosphorus. Red circles distinguish the 6 NTN stations that fulfilled screening criteria for drainage area size (<500 mi^2) and fraction of stream impairment attributed to siltation (<25%). Average annual yields are based on 10-years from 2005 – 2014.)

ESTIMATING POLLUTANT LOAD

A pollutant's ***load*** refers to the mass transported by streamflow past a location in a certain duration. To compare pollutant amounts from different watersheds more readily, the load is divided by the watershed area to standardize output in terms of ***yield***. Unless specified differently, load and yield as used herein refer to pollutant mass moved per year. Load and yield are reported as the amount of a substance that originates from the entire watershed upstream of the measurement location, and intuition may create the perception that the water-borne mass of a substance gets delivered uniformly from within the watershed. In reality, watershed processes are highly variable in space and time; therefore, proper interpretations drawn from load and especially yield reflect overall average conditions for a watershed rather than specific or explicit details about local parts of a watershed.

Sediment pollutant loads under baseline conditions and for various proposed improvement scenarios were estimated using the MapShed Watershed (MapShed) model version 1.5, in MapWindows form (Evans and Corradini, 2016). MapShed's core watershed simulator evolved from the Generalized Watershed Loading Function (GWLF) model developed by Haith and Shoemaker (1987). MapShed's lead developer furnished extensive model support to the Steering Committee.

MapShed's core parts include: (i) a pre-processor used to manipulate GIS data, weather input files, and other information pertinent to creating the input files that drive MapShed's watershed simulation model; (ii) the Generalized Watershed Loading Function – Enhanced (GWLF-E) watershed simulation algorithm; (iii) a BMP simulator module to evaluate pollutant-reducing scenarios; and, (iv) a graphic user interface (GUI) that facilitates interactions with MapShed for input and output.

MapShed is considered to be a combined distributed and lumped parameter watershed model. MapShed's surface loading module is *distributed* in the sense that the model allows multiple land use/cover scenarios, although each land use/cover area is treated as homogenous in regard to basic attributes. MapShed models sub-surface loading as a *lumped parameter* by tracking both the unsaturated and saturated zone water balances across the entire watershed without differentiating land use/cover. MapShed is a continuous simulation model that uses daily time steps for weather input data to simultaneously maintain multiple sets of water balance calculations. Daily water balance components are accumulated, integrated, and tracked according to pollutant source and transport processes, and output is reported as monthly sediment and nutrient loads.

MapShed simulates sediment and nutrient load contributions, attenuation, and transport to streams according to average coefficients assigned to: (i) land cover categories; (ii) as specifically reported and/or estimated according to various input source types (e.g., manure, point discharges, septic systems); (iii) groundwater – surface water interface (GSI); and, (iv) streambank erosion. The BMP simulator module relies on pollutant reduction efficiencies and coefficients that were mostly developed for use in the *Chesapeake Assessment Scenario Tool* (CAST) model. MapShed includes an empirically-derived streambank erosion routine that is related to average monthly streamflow and the following five watershed traits: (i) percent developed land; (ii) average soil erodibility factor; (iii) livestock density; (iv) average watershed slope; and, (v) average runoff coefficient (curve number) for the watershed.

Although MapShed is operated using a GIS interface, the model does not distribute pollutant loads to specific source locations within a watershed. And importantly, much of the input data are provided at county-scale without finer resolution. With MapShed, there is no spatially-explicit routing from a source to a point at which load is estimated. Instead, MapShed calculates and sums weighted average loads based on categorical input information and corresponding default and/or user-defined coefficients. Next, MapShed factors attenuation losses for each categorical compartment and time step. Finally, MapShed partitions and re-distributes the remaining loads among a series of surface and subsurface sources.

Seasonal variation is considered by GWLF-E through various processes. As mentioned, daily time steps are the inputs for weather data used in water balance calculations. The model also specifies daylight length for each month as part of its evapotranspiration calculation. MapShed parameters also consider typical manure application seasons and recognize specific seasonal aspects of various crop types. More detailed information about MapShed and GWLF-E can be found on the software's webpage at http://www.mapshed.psu.edu/.

For modeling purposes, the CCW was divided into 14 distinct subunits to facilitate scenario development at more spatially-concise scales. Note that subsheds 1 through 3 inclusive comprise the Donegal Creek drainage; subsheds 4 through 8 make up Little Chiques Creek; subsheds 9 and 10 are Upper Chiques Creek, and, subsheds 11 through 14 form Lower Chiques Creek.

The MapShed model output assigns pollutant loads to various sources and land cover types. For the entire CCW, MapShed estimated an annual sediment load rate of approximately 70.4 million pounds. Distributed evenly across the ~126 mi^2 (~80,700 ac) CCW, the baseline average sediment yield is approximately 875 lb SS/ac-yr. The MapShed-apportioned sources for annual sediment load are summarized below.

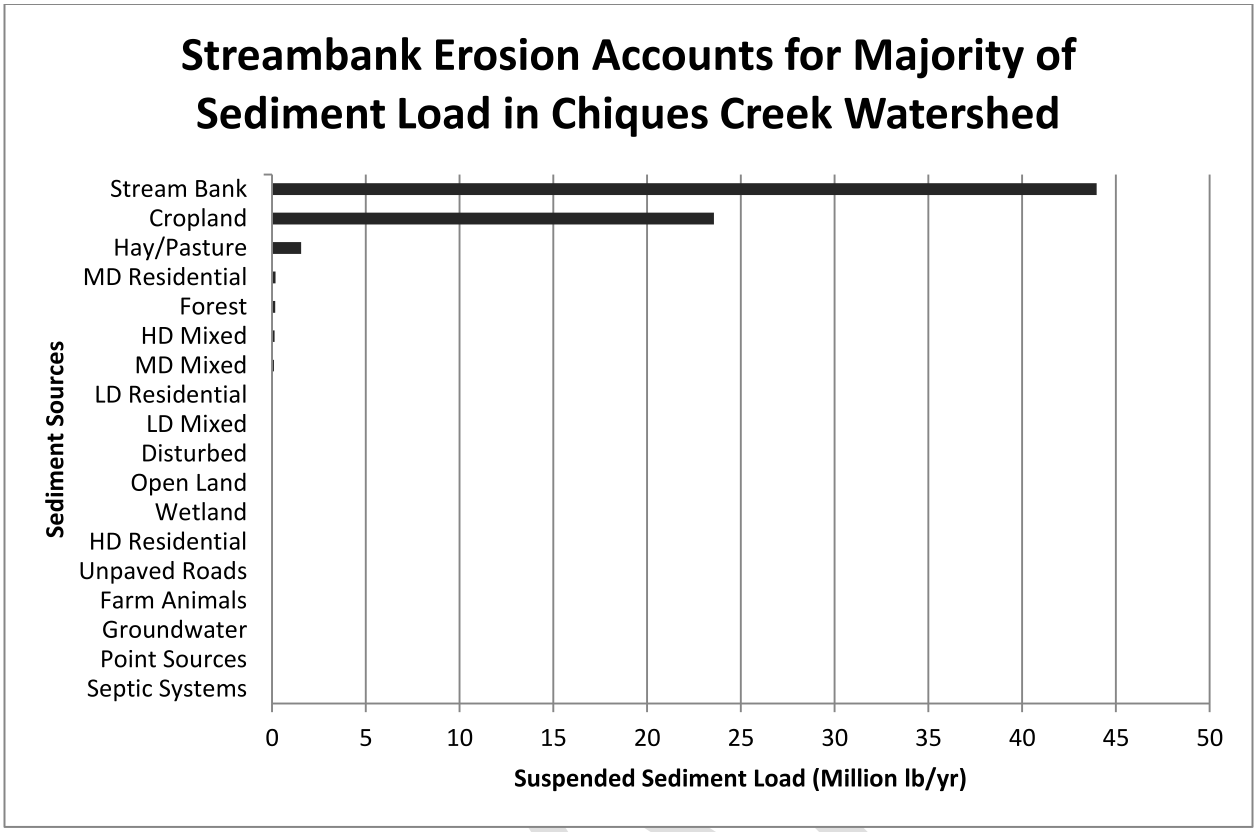

Figure 7. Ranked Annual Sediment Loads Estimated by MapShed According to Source Type

As depicted in Figure 7, the highest individual sediment loading source in CCW is streambank erosion, which accounts for more than 60% of the estimated total annual load. Note that sediment loading attributable to *streambank erosion* includes a variety of erosion sources/processes that occur between the banks of a stream. When combined, the estimated loads from streambank erosion, cropland, and hay/pasture account for > 98% of the watershed's annual sediment load. Figures 8 and 9 illustrate the corresponding relative sediment load and yield estimates, respectively, for each of the 14 MapShed subunits.

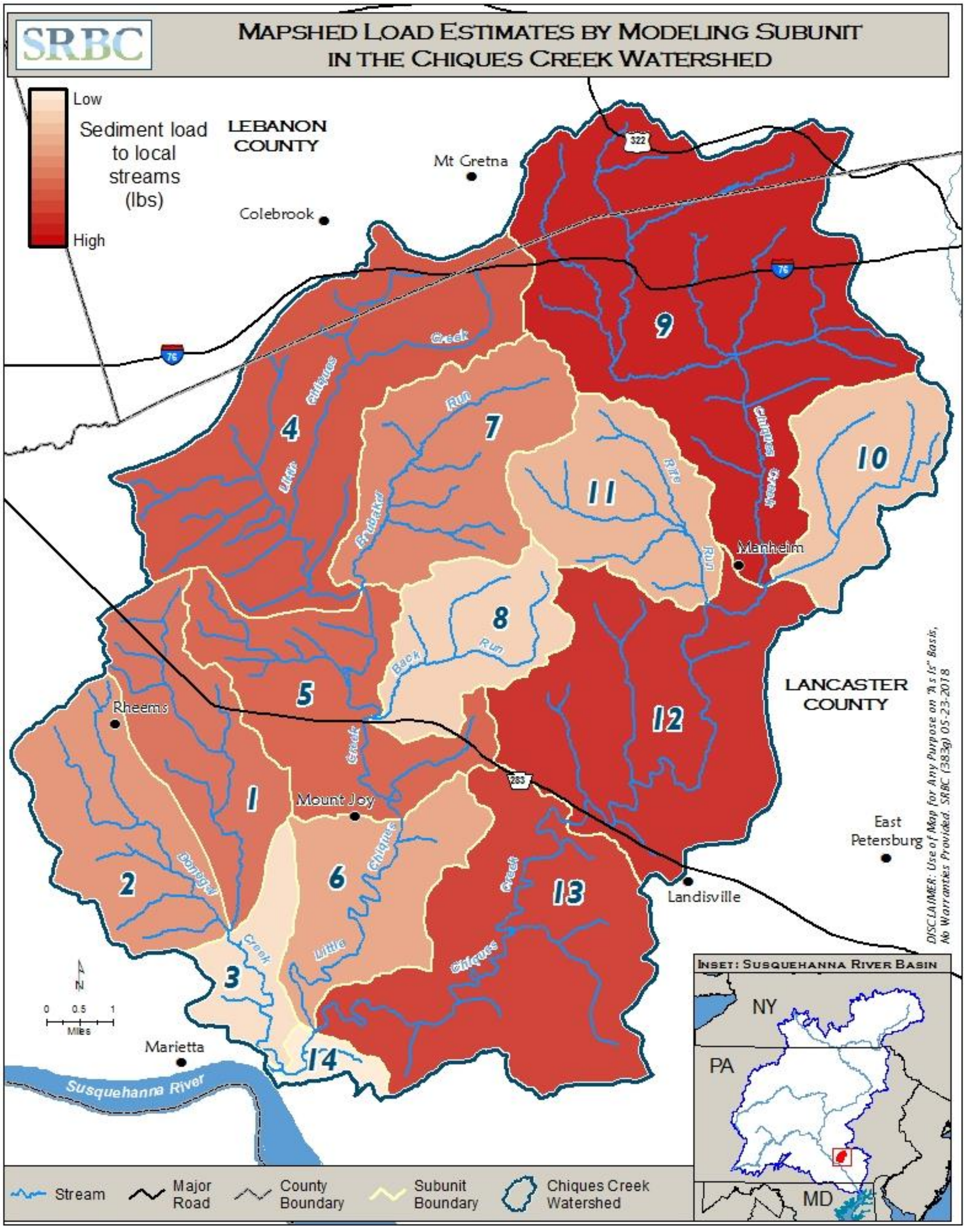

Figure 8. Sediment Load for each MapShed Subunit (Darker tone refers to higher sediment load. Load refers to total sediment output in streams and expressed as lbs/yr.)

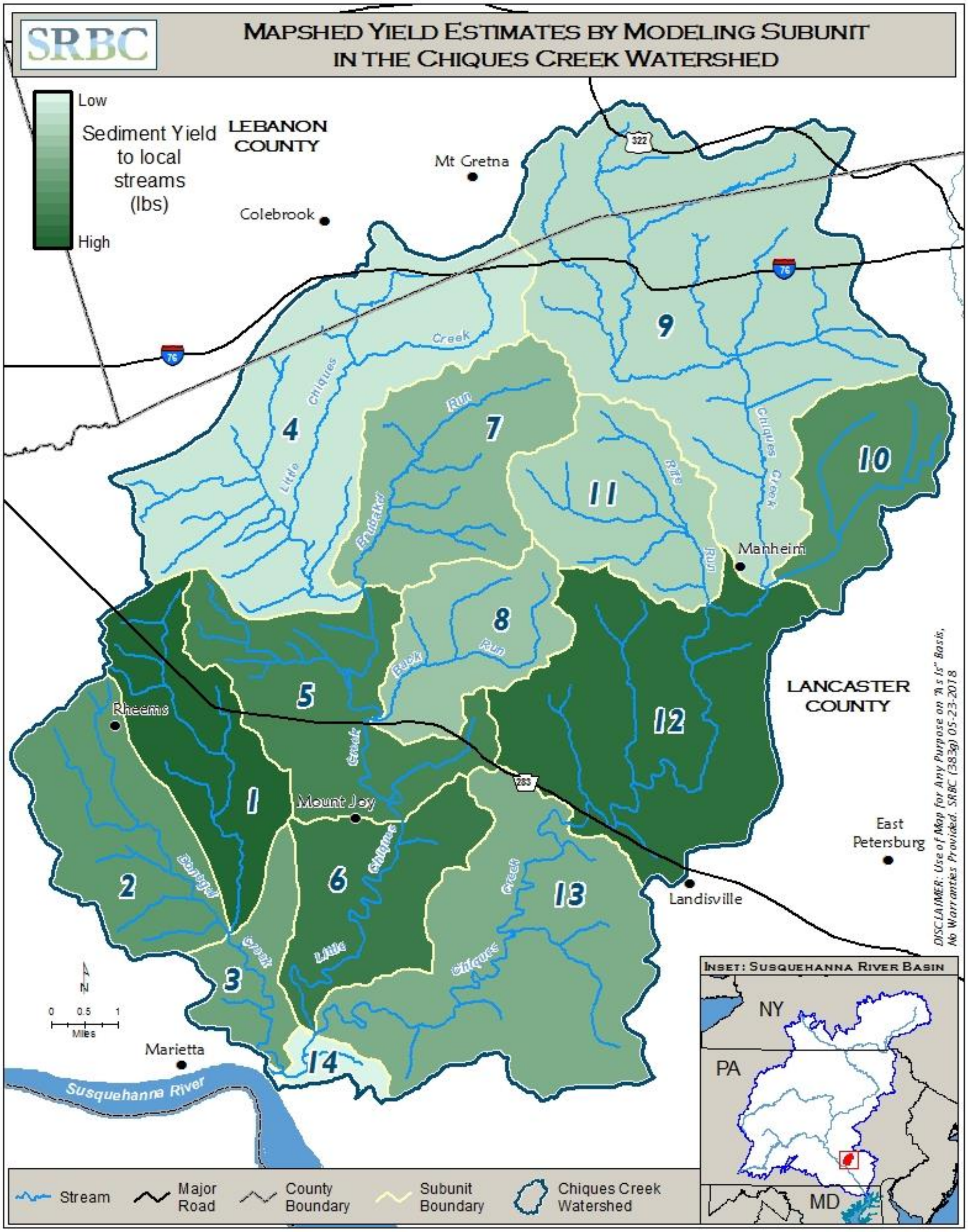

Figure 9. Sediment Yield for Each MapShed Subunit (Darker tone refers to higher sediment yield. Yield refers to sediment output in streams normalized for watershed area and expressed as lbs/ac-yr.)

EQUAL MARGINAL PERCENT REDUCTIONS

MapShed was used to estimate the baseline SS load for the CCW as ~70.4 million (M) pounds. The target load for CCW was estimated as ~40.3 M lb, requiring a ~30.1 M lb reduction. In terms of yields (i.e., load evenly distributed throughout the ~80,700 ac CCW), the baseline is ~875 lb SS/ac-yr and the target is ~500 lb SS/ac-yr, or ~43% reduction from baseline.

Both the baseline and target SS load estimates encompass the entire ~80,700 acre watershed; however, in terms of pollutant reduction, not all pollutant sources can be reduced (e.g., natural settings such as forests and wetlands). Equal Marginal Percent Reduction (EMPR) is a regulatory tool for smoothing pollutant load reductions proportionately among the *controllable sources* in a watershed. The controllable sediment sources in the CCW are considered to be Agriculture land cover (e.g., Hay/Pasture and Cropland) and the Developed land uses (Low, Medium, High both Residential and Mixed). Based on the combined area of Agricultural and Developed land cover types, the controllable source area is approximately 96.5 mi^2 or ~76.5% of the total CCW area. By distributing the ~30.1 M lb sediment load reduction needed to meet the overall target across just the ~61,800 controllable acres, the *controllable target yield equates to ~400 lb SS/ac-yr or ~54% reduction from baseline*.

As depicted in Figure 7, MapShed estimated that the source for more than 60% of the CCW SS load was due to streambank erosion. While MapShed does not directly assign streambank erosion to particular land cover categories, MapShed simulates streambank contributions according to an empirical Lateral Erosion Rate (Evans et al., 2003):

Equation 1: $LER = aQ^{0.6}$ where, **Q** is mean monthly stream discharge and **a** is an empirically-derived erosion potential constant developed through multiple linear regression modeling.

The erosion potential constant **a** in Equation 1 is comprised of five watershed parameters and **a** is dominated (~10X factor greater than next contributing parameter) by the proportion of developed land in the watershed. Developed lands in CCW account for 18% of the overall area and 23% of the controllable land area. To relate streambank erosion to controllable land cover types, ~85% of the streambank load was allocated among the controllable land cover categories, with Developed lands receiving approximately half the streambank load. Although Developed lands account for less than one quarter of the controllable source landscape, the LER subroutine is heavily weighted to the proportion of developed lands, a consequence of the highly efficient transfer of storm flows into streams attributable to intentional and unintentional stormwater routing mechanisms.

Appendix C contains an EMPR calculation for the entire CCW. The EMPR process was used to estimate, by major subwatershed, the sediment load reductions needed from controllable land cover types to meet the overall target yield for CCW. Table 4 summarizes the controllable sediment load reductions and includes the relative contributions from each major subwatershed, as well as the relative overall contributions expected from controllable sources in the Agriculture and Developed sectors.

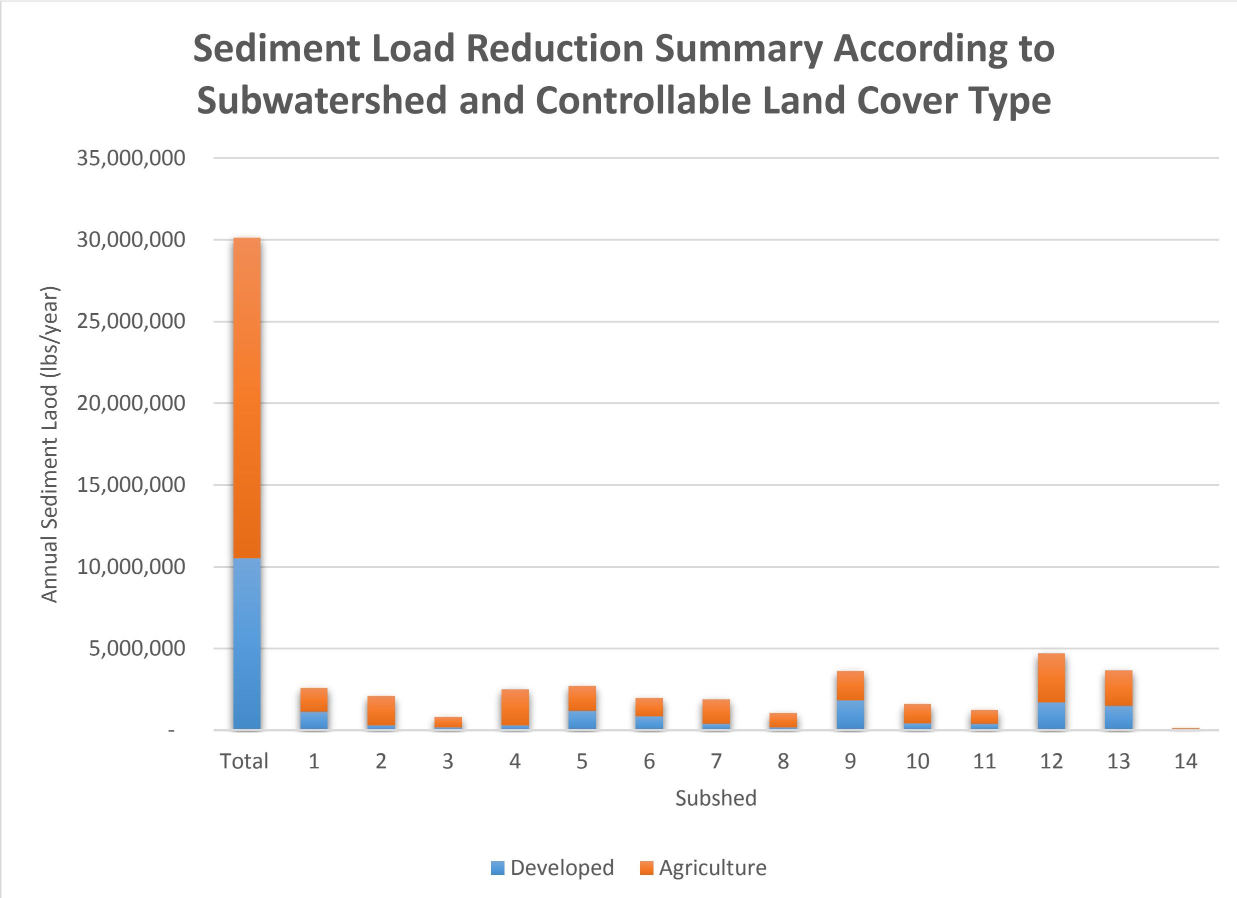

Figure 10. Sediment Load Reductions from Controllable Land Cover Types within Chiques Creek Watershed Subsheds

Based on the sediment mass reductions summarized in Figure 10, 65% of load reductions needed to meet the water quality target in CCW are expected to come from the Agricultural landscape and 35% from Developed settings. Sediment reductions from controllable sources in subwatershed 14 account for less than 1% of the overall load reduction needed in CCW (smallest contribution), whereas subwatershed 12 controllable sources are expected to contribute 16% of the overall reduction needed for CCW (largest portion).

Municipal Separate Storm Sewer System (MS4) Municipalities

Communities within CCW that have an MS4 permit were required by PADEP to submit a Pollution Reduction Plan (PRP) in 2018 that identifies their strategy to reduce SS load by 10% during the course of their 5-year MS4 permit cycle. As part of this plan, each municipality has a defined Urbanized Area (UA) footprint for which they must reduce SS load by 10% (more information can be found at http://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater/Pages/default.aspx).

There are nine MS4 municipalities in the CCW. Figure 11 summarizes the EMPR-derived sediment reductions needed according to controllable land cover types for each MS4 jurisdiction. Although most MS4 jurisdictions include some agricultural land cover types, the MS4 settings tend to be dominated by developed land cover and as such, the largest sediment loading source (hence reduction) required from each municipality is attributed to developed lands. While it can seem counter-intuitive that highly developed and primarily impervious surfaces act as sources of SS in waterways, the primary factor relating developed land cover to SS pollution is attributed to the intentional as well as unintentional, very efficient features that drain stormwater from developed landscapes. In general, the main "source" of SS that originates from developed landscapes comes from excessive energy due to faster rate and higher volume of stormwater that enters waterways and thereby scours, erodes, and re-mobilizes material from stream beds and streambanks.

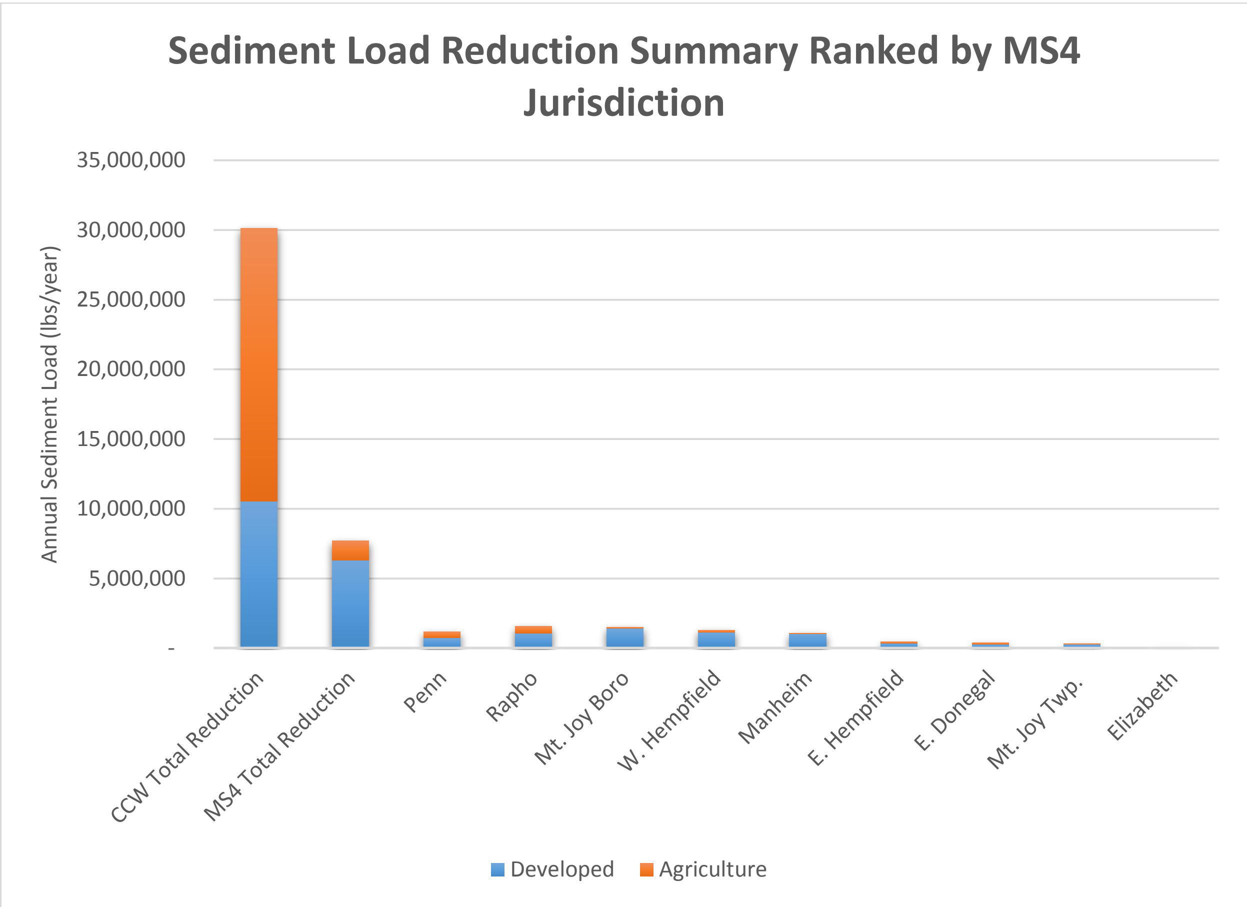

Figure 11. Sediment Load Reductions from Controllable Land Cover Types within Chiques Creek Watershed Municipalities as Percent of Load

In sum, the MS4 jurisdictions are accountable for ~28% of the overall sediment load reduction needed in CCW. Rapho Township has the largest individual load reduction share for a MS4 jurisdiction and accounts for ~5% of the total sediment load reduction needed for the CCW overall. For every MS4, the developed controllable land cover type is expected to furnish the largest share of sediment reduction.

BEST MANAGEMENT PRACTICE (BMP) OPPORTUNITIES

Since 2015, many interested stakeholders have met to recommend, inventory, and discuss the viability of potential BMP opportunities within the CCW. Key input came from municipal representatives, local farmers, private consultants, Lancaster County Conservation District, Alliance for the Chesapeake Bay, Chesapeake Bay Foundation, PADEP, SRBC, and AEC. Through a collaborative exchange, more than 550 distinct BMP opportunities have been identified (Figure 12; Table 2). The set of BMP opportunities identified to date is not comprehensive in that the practices and projects largely reflect a few categorical types, most of which have existing systematic frameworks and that the stakeholder partnership recognizes will facilitate:

i. Actions that effect sediment as the dominant pollutant source type;
ii. Development of repeatable/scalable approaches and engagement with broad spectrum of landowners; and,
iii. By implementing the majority of these core opportunities, the sediment load reduction necessary to achieve the water quality target for the CCW is expected.

The list is extensive, but it is not exhaustive and potential projects can and are expected to be added, edited, or removed. BMP opportunities were entered into a GIS database that is meant for use as a planning tool and is expected to be adaptively–managed throughout the restoration effort timeline. The BMP opportunities represent a pool of practices and projects that, based on MapShed forecasts, is more than adequate to reduce baseline SS load in CCW to levels that are capable of supporting a healthy aquatic system.

As shown in Table 2, the most common overall project type in the database is riparian buffer with more than 285 opportunities identified that collectively encompass approximately 95 linear stream miles in CCW. As a BMP, a riparian buffer is a permanent corridor of naturalized vegetation that is situated adjacent to a watercourse (perennial, intermittent, or ephemeral). Riparian buffers are compatible with most land use settings. For a variety of reasons, but especially owing to the overall level of deforestation in Lancaster County, implementation of RFB is prioritized over grassland buffers for CCW.

The BMP database contains more than 40 individual streambank fencing project opportunities that in sum, account for more than 25 linear miles of streambank protection. As a BMP, streambank fencing is a simple and effective way to improve water quality in agricultural settings. Fencing excludes livestock from the riparian corridor which in turn: (i) minimizes bank destabilization that may result from excessive hoof traffic and grazing pressure; (ii) eliminates substrate disturbance and sediment resuspension caused by farm animals entering streams; and, (iii) eliminates animal waste deposition streamside and directly into waterways. In addition to water quality benefits, excluding livestock from stream corridors also minimizes opportunities and incidents involving injury and disease.

As a BMP, stormwater basin retrofit projects are applicable in developed landscapes. The BMP opportunities database includes 75 basin retrofit projects that collectively receive stormwater contributions from 1,600 acres. Conventionally, stormwater basins were designed to collect and detain storm runoff for brief periods in order to reduce peak streamflow from storm events. The term "retrofit" applies to any among a suite of enhancements implemented in existing basins that are designed to add or improve pollutant filtering and/or transformation processes or that are designed to increase storage volume, increase retention time, or ultimately eliminate discharge to a stream. Examples of retrofit amenities include modifications to outlet control structures that increase storage volume and/or slow retention time, removal of concrete low-flow channels, replacement of manicured turf with naturalized meadow or wetland vegetation, soil/substrate addition or amendment (e.g., sand) that promotes filtration and pollutant transformation, and installation of measures that promote infiltration or groundwater recharge.

A bioswale is a vegetation-lined stormwater conveyance feature. As with stormwater basins, various retrofit amenities can be implemented into existing bioswales that enhance pollutant reduction and/or reduce the rate and volume at which storm runoff is conveyed to stream channels. Common bioswale retrofits include replacement of manicured turf with naturalized meadow or wetland vegetation, soil/substrate addition or amendment (e.g., sand) that promotes filtration and pollutant transformation, and installation of measures that promote infiltration or groundwater recharge. The BMP opportunities database has more than 30 bioswale retrofit projects with combined runoff received from more than 950 acres.

Floodplain restoration projects are applicable in urban and agricultural landscape settings. Floodplain restoration is appropriate for stream reaches in which the channel is incised or the floodplain was buried by additions of fill or accumulation of sediment as occurs in dam-impounded reaches. Where floodplain function is well integrated with the stream, the typical flows that determine stream channel form and substrate conditions generally have about a one-year recurrence interval. In such settings, flows that exceed the one-year recurrence frequency enter the floodplain and thereby reduce the overall kinetic energy within the channel (and thereby diminish in-channel scour/erosion). Moreover, the fraction of flood water that departs the channel enters the floodplain and transports SS as well as particulate and dissolved nutrients, some of which is filtered, transformed, or otherwise sequestered in the floodplain. The CCW BMP opportunities database includes more than 40 projects that account for 20 linear miles of stream restoration potential. The effectiveness of a given floodplain restoration project to reduce downstream flood severity and to improve water quality generally increases where the accessible floodplain area is relatively compared to the drainage area.

Floodplain restoration is accomplished by removing fill material or accumulations of legacy sediment as well as through targeted lowering of bank height that facilitates flood water access to off-channel riparian corridor remnant stream channels, wetlands, and other depression features. An alternative approach to floodplain restoration that may be appropriate for incised channels occurs through placement of coarse streambed material and other features that aggrade (raise) the streambed profile such that overbank flooding events better match the annual storm flow recurrence.

A total of nearly 10 miles of streambank stabilization was identified with 30 project opportunities in CCW. As a water quality BMP, streambank stabilization minimizes or prevents pollutant loading contributions from actively eroding banks that occur during high flow events. Note that streambank armoring is not a qualifying water quality BMP; rather, use of grading, re-vegetation, and log sill features are examples of appropriate stabilization approaches.

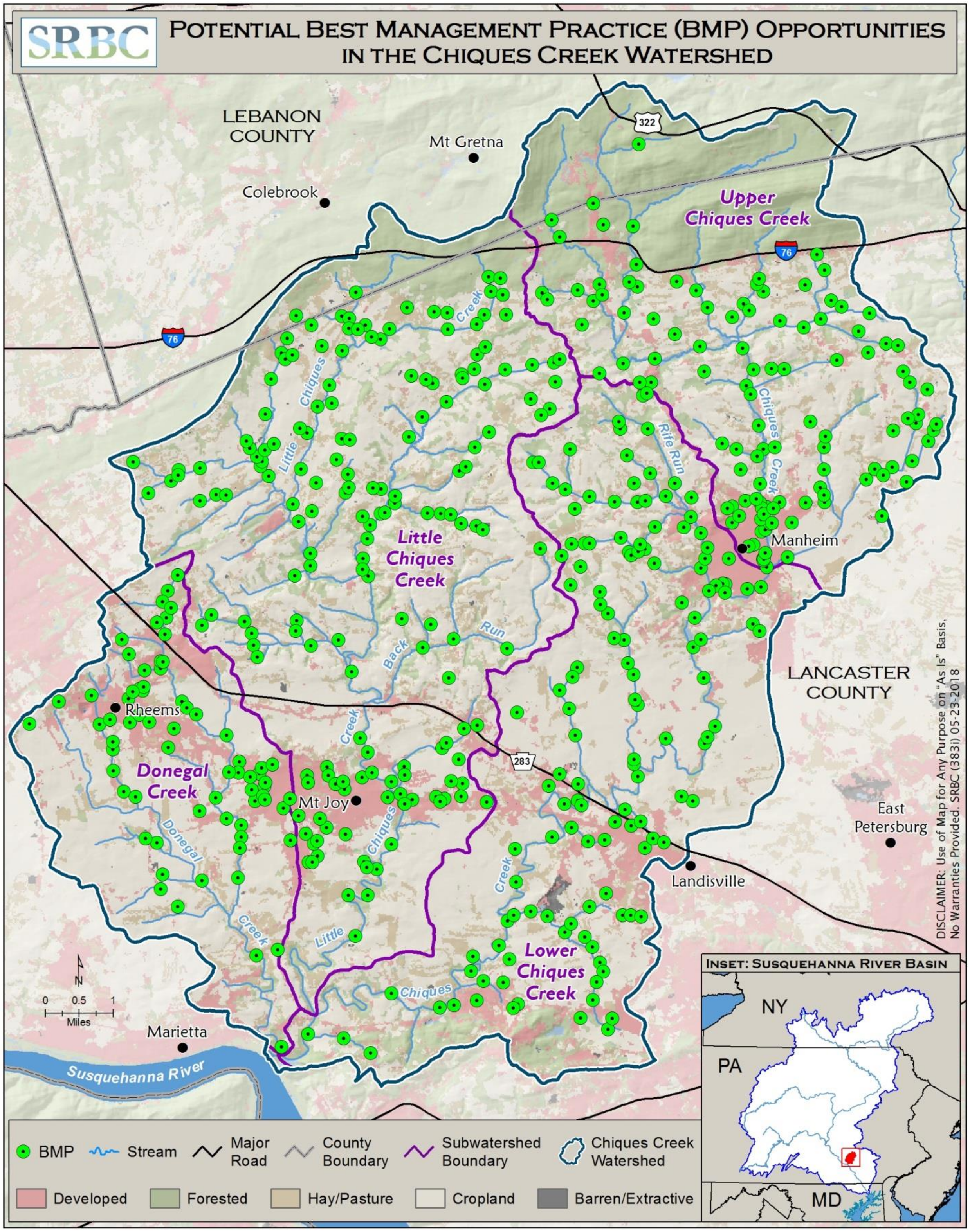

Figure 12. Mapped Locations for Database of Potential BMP Opportunities Identified in Chiques Creek Watershed

Table 2. Summary of Potential Best Management Practices identified for Chiques Creek Watershed

Subshed	Riparian Buffer		Pasture Management		Streambank Fencing		Streambank Stabilization	
	# of Projects	Total Length (ft)	# of Projects	Area (acres)	# of Projects	Total Length (ft)	# of Projects	Total Length (ft)
Donegal	32	47,777	1	8	1	678	7	13,475
Little Chiques	118	202,617	2	16	16	53,729	17	28,048
Upper Chiques	65	108,422	4	26	13	41,088	5	11,481
Lower Chiques	71	146,054			13	49,227	8	16,572
Totals	286	504,870	7	50	43	144,722	37	69,576

Subshed	Floodplain Restoration		Barnyard Runoff Control		Stormwater Retrofit		Bioswale Retrofit	
	# of Projects	Total Length (ft)	# of Projects	Area (acres)	# of Projects	Area (acres)	# of Projects	Area (acres)
Donegal	1	1,200	2	5	27	108	4	113
Little Chiques	11	26,699	4	6	25	987	8	612
Upper Chiques	17	49,937	5	13	6	284	6	151
Lower Chiques	14	27,891	3	4	17	233	15	92
Totals	43	105,727	14	28	75	1,612	33	968

Subshed	Bioinfiltration		Nutrient Separating Box		Pervious Pavement	
	# of Projects	Area (acres)	# of Projects	Area (acres)	# of Projects	Area (acres)
Donegal			1	99		
Little Chiques	2	33	1	44		
Upper Chiques	11	112			2	2
Lower Chiques	4	129				
Totals	17	274	2	143	2	2

BMP Estimated Costs

Scenario costs were generated using a mix of stakeholder input as well as unit price estimates provided for Pennsylvania in the Chesapeake Assessment Scenario Tool model; i.e., CAST. The costs shown in Tables 3 and 4 are intended to be used for broad planning purposes only; actual costs fluctuate due to a variety of factors. As indicated below, certain practice and project types include operation and maintenance (O&M) as well as opportunity costs, whereas others do not. Moreover, each BMP includes an estimated lifespan from which the total annualized cost was derived.

Table 3. Planning Unit Cost Estimates for BMP Types from CAST

BMP Type	Lifespan (yr)	Capital Cost	O/M Costs	Opportunity Cost	Total Annualized Cost	Units
Riparian Buffer	75	$ 2,929.92	$ -	$ 139.64	$ 157.35	$/acre
Pasture Management	15	$ 194.87	$ 2.00	$ -	$ 20.77	$/acre
Streambank Fencing	10	$ 1,685.83	$ 52.00	$ 139.64	$ 277.07	$/acre
Streambank Stabilization	20	$ 500.00	$ -	$ -	$ 25.00	$/ft
Floodplain Restoration	20	$ 500.00	$ -	$ -	$ 25.00	$/ft
Barnyard Runoff Control	15	$ 5,890.00	$ -	$ -	$ 567.19	$/acre
Stormwater Retrofit	38	$ 8,881.57	$ 257.05	$ 552.13	$ 811.12	$/acre
Bioswale Retrofit	50	$ 9,614.18	$ 313.93	$ 507.71	$ 865.94	$/acre
Bioinfiltration	25	$ 11,814.45	$ 183.06	$ 761.56	$ 1,059.02	$/acre
Nutrient Separating Box	20	$ 22,000.00	$ 450.00	$ -	$ 1,550.00	$/unit
Pervious Pavement	20	$ 100,994.00	$ 3,610.00	$ 50,000.00	$ 14,220.12	$/acre
Cover Crops	1	$ -	$ 33.33	$ -	$ 33.33	$/acre
Conservation Tillage	1	$ -	$ -	$ -	$ -	$/acre
Ag E&S Plans	10	$ 15.00	$ -	$ -	$ 1.94	$/acre

Table 4. Planning Annualized Costs of BMP Implementation from CAST

	Total Annualized Cost	Amount	Annualized Cost
Riparian Buffer	$ 157.35	1159	$ 182,372.12
Pasture Management	$ 20.77	50	$ 1,038.50
Streambank Fencing	$ 277.07	696	$ 192,779.44
Streambank Stabilization	$ 25.00	69576	$ 1,739,400.00
Floodplain Restoration	$ 25.00	105727	$ 2,643,175.00
Barnyard Runoff Control	$ 567.19	28	$ 15,881.32
Stormwater Retrofit	$ 811.12	1612	$ 1,307,525.44
Bioswale Retrofit	$ 865.94	968	$ 838,229.92
Bioinfiltration	$ 1,059.02	274	$ 290,171.48
Nutrient Separating Box	$ 1,550.00	143	$ 221,650.00
Pervious Pavement	$ 14,220.12	2	$ 28,440.24
Cover Crops	$ 33.33	17005	$ 566,769.98
Conservation Tillage	$ -	6184	$ -
Ag E&S Plans	$ 1.94	25415	$ 49,305.68
Total			**$ 8,076,739.13**

COMBINED BENEFIT OPPORTUNITIES

As part of a comprehensive watershed management philosophy, there is value and interest in the identification of project opportunities that bundle benefits for multiple objectives and stakeholder perspectives. As mentioned, flood-prone settings in and near Manheim Borough became the focus of a partnership between PADEP, SRBC, USACE, Manheim Borough, and Penn Township that overlapped in time with the broader ARP efforts in CCW. As part of the Chiques Creek Flood Resiliency Study, sophisticated high-resolution hydraulic and hydrologic models were developed for the mainstem of Chiques Creek from the headwaters to south of Manheim Borough (e.g., mostly within the Upper Chiques Creek subshed defined herein for

ARP purposes). One outcome of the Flood Resiliency Project was identification and subsequent evaluation of multiple locations in terms of both flood mitigation and water quality improvement implications. For about a dozen such settings, BMP opportunities are listed in the ARP geodatabase and corresponding sediment reduction estimates were quantified using MapShed. Such projects appear in the BMP database under the "Floodplain Restoration" and "Streambank Stabilization" categories. For more information about the Flood Resiliency Study, refer to the full report (SRBC and USACE, 2018).

In addition to flood resiliency projects, there are various activities that could fulfill multiple stakeholder priorities, including water quality improvement, and thereby leverage interest, resources, and alliances. Such combined benefit opportunities include: (i) hazard mitigation projects (i.e., repetitive flood damage); (ii) open space restoration, conservation, and preservation; (iii) dam safety and removal of barriers to aquatic life movements; (iv) groundwater recharge; and, (v) potable source water protection activities.

IMPLEMENTATION SCENARIOS

Based on practice and project opportunities identified in the geodatabase to date, multiple pathways are available to reduce sediment pollution load in CCW to the aquatic life-based water quality target. This section illustrates through a step-wise graphic approach, the effect on load reduction achieved through implementation of four key BMP scenarios in CCW. It is noteworthy that the BMP opportunities database is not exhaustive in terms of BMP types or specific opportunities and as such, the scenarios presented below are recognized to illustrate possible pathways for reaching the water quality target, rather than an absolute prescription. It also is noteworthy that, while designed with emphasis on reducing sediment pollution in CCW, specific BMP scenarios presented herein adhere to recommendations developed by stakeholder work groups as part of the WIP3 process underway to reduce nutrient pollution delivered to Chesapeake Bay. And although the scenarios are described as step-wise iterations, implementation of particular practices/projects need not adhere to the sequence presented herein.

The charts and corresponding discussions in this section pertain to the following set of scenarios:

1. ***Regulatory Compliance:*** Implementation of commitments submitted by MS4 permit-holders in CCW and reductions commensurate with 90% participation of applicable agriculture Conservation Plans.
2. ***Implementation of BMP Opportunities:*** Implement the specific practices/projects contained in the CCW geodatabase, except for those identified above as MS4 commitments and except for projects identified as Stream Restoration.
3. ***Soil Health Management:*** Increase adoption of healthy soil management practices in agricultural settings consistent with messages contained in Pennsylvania in the Balance, Harnessing Agriculture's Culture of Stewardship as a Solution to Clean Water (PSU-AEC, 2017).
4. ***Stream Restoration:*** Implementation of Stream Restoration projects identified in the BMP opportunities database, including projects contained in the Chiques Creek Flood Resiliency Study (SRBC and USACE, 2018).

The following charts depict the baseline sediment load and iterative load reductions forecast using MapShed for each scenario outlined above. Sediment load is expressed as the overall watershed area-weighted average, or yield, in units of pounds per acre per year (lb/ac-yr). The SS target yield of 500 lb/ac-yr is indicated. Loads and reductions are presented according to the four subsheds introduced previously. By convention, each chart uses gray bars to represent the baseline sediment yield and colored bars represent the reductions associated with each specified scenario. The final chart in this section shows composite effects for all four scenarios in the CCW.

Figure 13 shows the baseline yield conditions for the 14 subwatersheds in CCW.

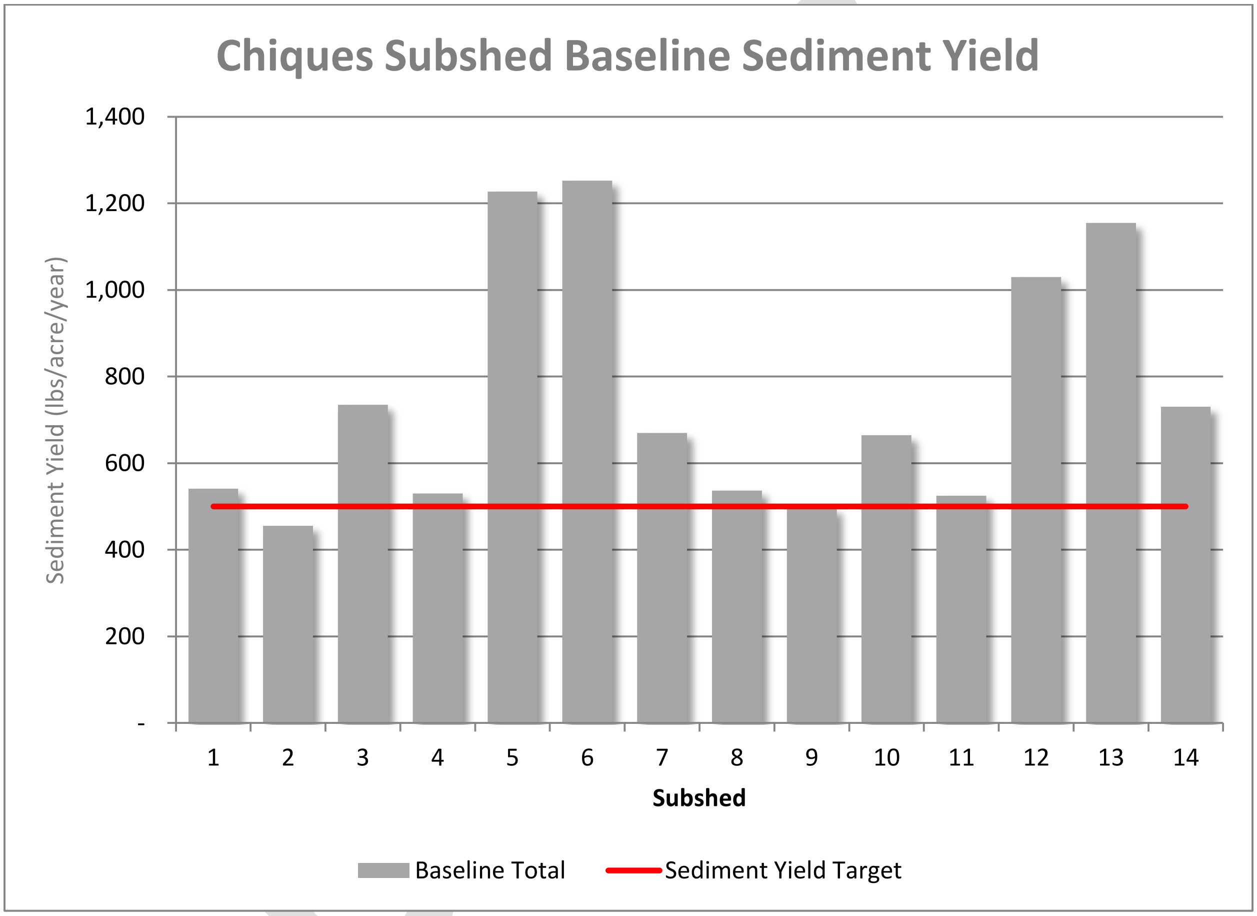

Figure 13. Baseline Sediment Yield by Subshed (Load reductions for each subshed are shown; the overall CCW load reduction is ~31%.)

Scenario No. 1 – Regulatory Compliance

In September 2017, all municipalities with an MS4 Permit requirement submitted their PRP for 10% sediment, 5% phosphorus, and 3% nitrogen load reductions to PADEP for review. For more information and specifics about this process, see http://www.dep.pa.gov/Business/Water/CleanWater/StormwaterMgmt/Stormwater/Pages/default.aspx. The BMPs for these planned reductions must be in place by September 2023.

Additionally, increasing compliance to 90% of the available acreage to have a written Ag E&S Plan is depicted in Figure 14 as part of the Compliance scenario. The 90% written Ag E&S compliance is consistent with Chesapeake Bay TMDL WIP3 draft scenario developed by the WIP3 Agriculture Work Group for consideration by Pennsylvania's WIP3 Steering Committee in 2019. Note that Pennsylvania's commitments pursuant to WIP3 require implementation of practices, projects, and an overall strategy by 2025 that reduce nutrient and sediment loads into Chesapeake Bay commensurate with goals for a healthy Bay ecosystem.

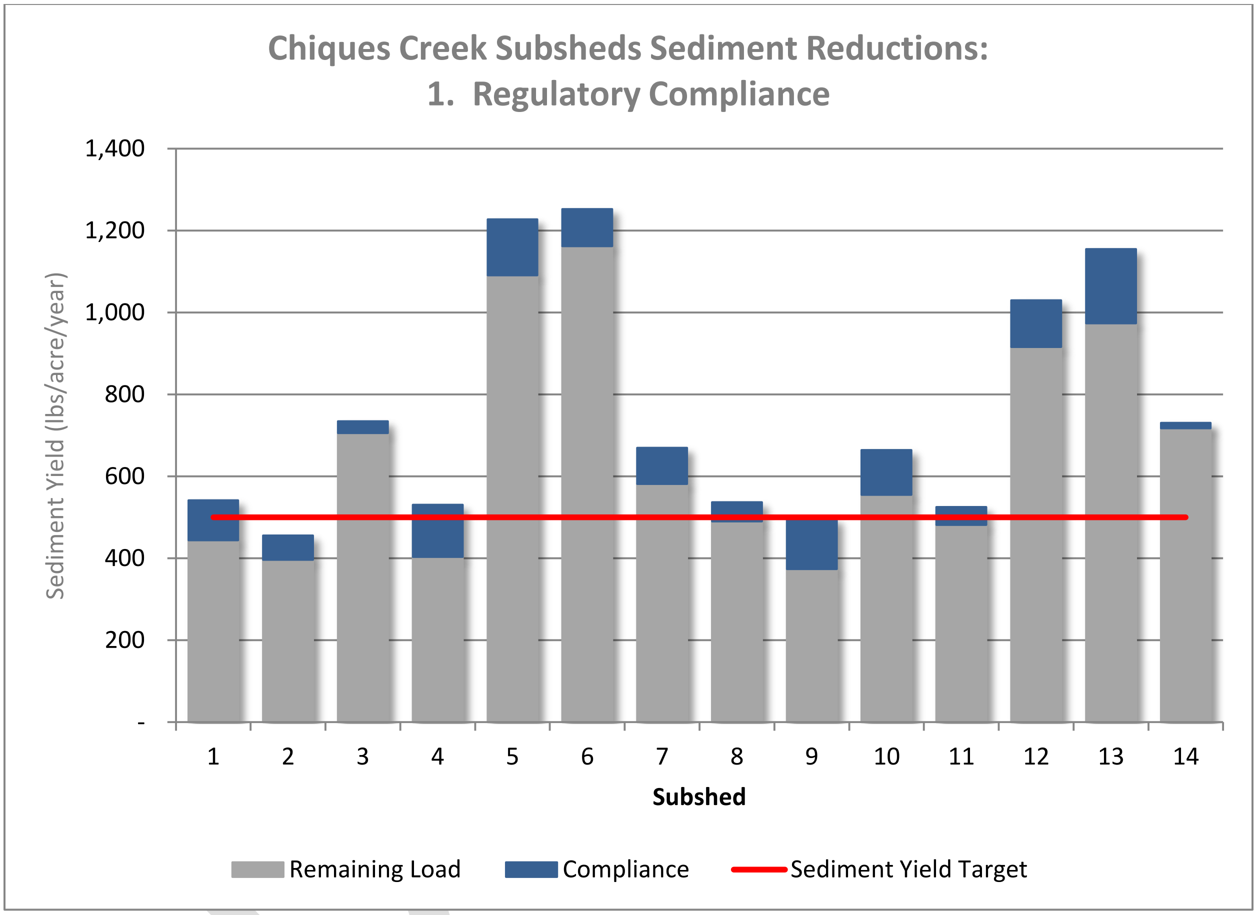

Figure 14. Scenario No. 1 – Sediment Reductions Associated with Regulatory Compliance (MS4 pollution reduction plan compliance and 90% participation in agriculture erosion and sediment control plans. Implementation of Scenario No. 1 is expected to reduce sediment load by 5% for CCW.)

<u>Scenario No. 2 – Implementation of BMP Opportunities</u>

The CCW BMP Opportunities database currently includes approximately 550 unique BMP opportunities. Figure 15 illustrates the potential sediment reductions for all BMPs except for the above-listed MS4 PRP reductions as well as Streambank Stabilization/Floodplain Restoration project opportunities which are presented as Sediment Reduction Scenario No. 4. The majority of BMP opportunities in Scenario No. 2 are installation of riparian forest buffers and streambank fencing projects implemented in agricultural settings.

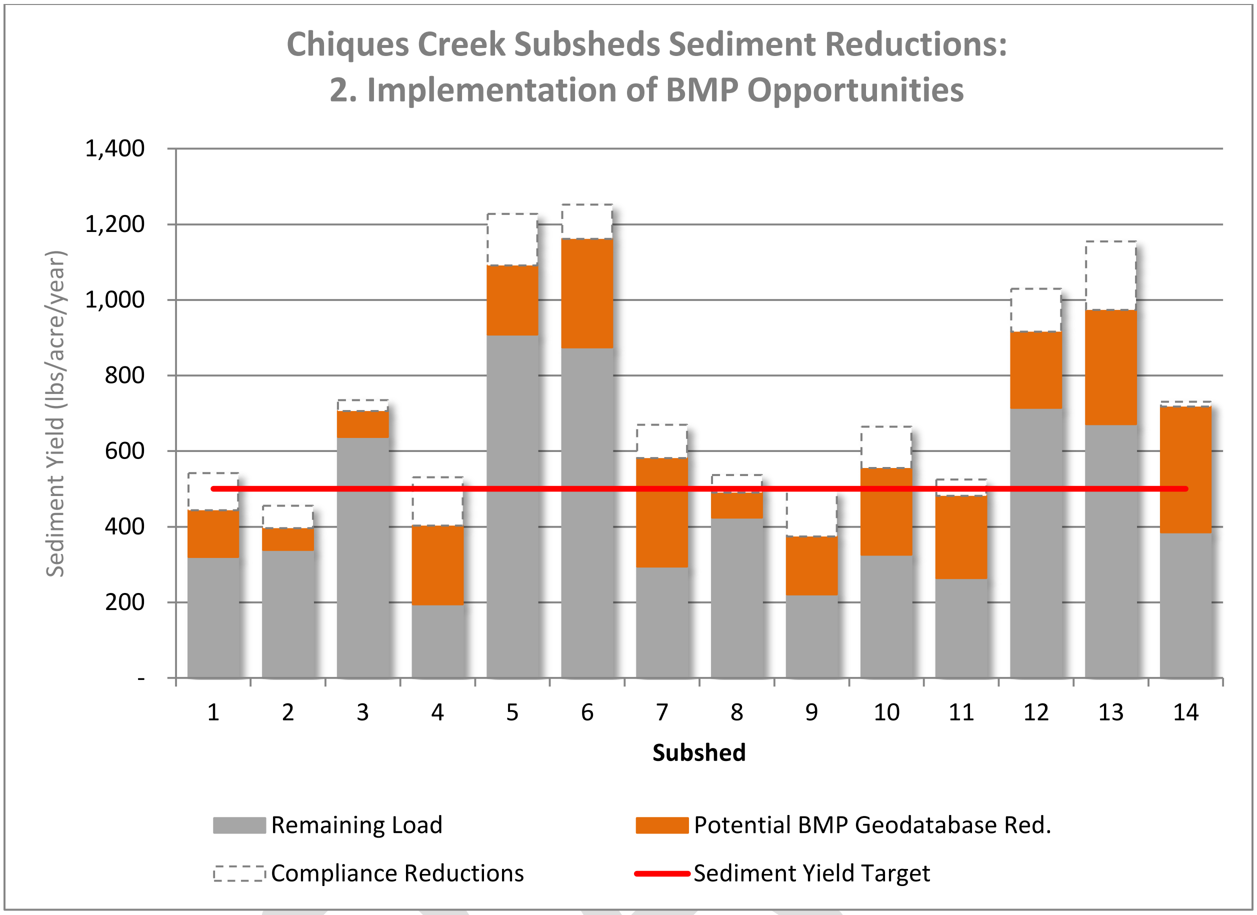

Figure 15. Scenario 2 – Sediment Reductions from Implementation of BMP Opportunities

Scenario No. 3 – Soil Health Management

In addition to the specific BMPs identified through the stakeholder effort, there are other BMP and projects that have significant sediment reductions. Cover Crops and Conservation Tillage are two other common BMPs that were modeled to evaluate potential sediment reductions across the watershed. Both cover crops and conservation tillage were modeled to encompass 75% of available agriculture lands. Figure 16 shows the sediment reductions forecast with these Soil Health Management practices in place.

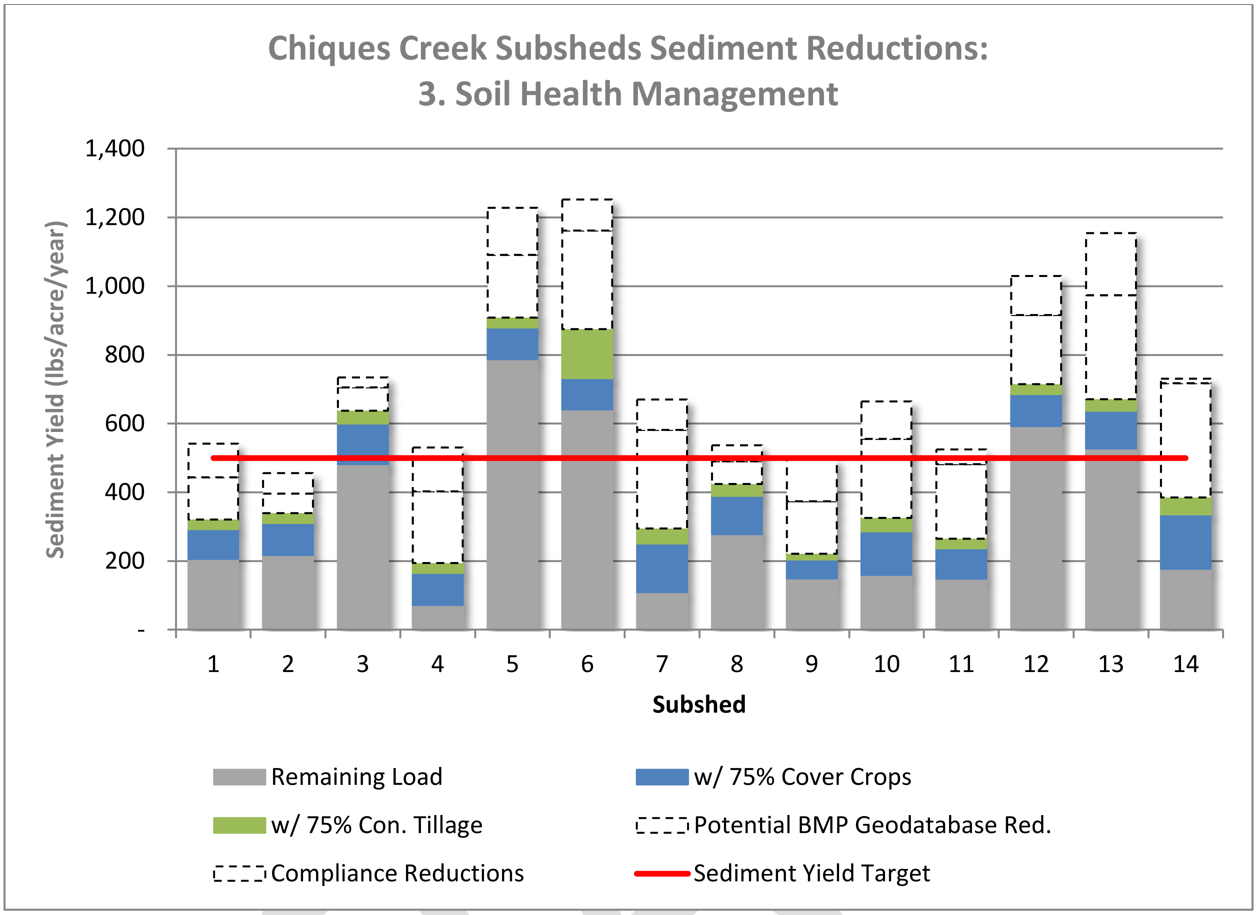

Figure 16. Scenario 3 – Sediment Reductions for Adoption of Soil Health Management Practices (75% adoption of cover crops and conservation tillage. Implementation of Scenario No. 3 is expected to reduce sediment load by 22% for CCW.)

Scenario No. 4 – Stream Restoration

The last category of BMP opportunities identified through the stakeholder effort was stream restoration. These projects vary from streambank stabilization to floodplain restoration and all such projects were modeled through the PADEP-recommended unit reduction method guidance for PRP development; i.e., using a default value of 115 lb SS reduction per linear foot of each project. Figure 17 illustrates the potential sediment reduction from these projects identified to-date based on application of the default methodology.

Note that the Chesapeake Bay Program's Expert Panel process for BMP evaluation related to Stream Restoration projects can be found at https://www.chesapeakebay.net/channel_files/18983/attachment_b1--urban_stream_restoration_panel_final_report_12062012.pdf.

This served as the foundation for PADEP's recommended stream restoration default pollutant-reduction values, also advocated for the use of several protocols to estimate the actual pollutant-reduction outcome of specific projects. The use of expert panel-recommended "protocols" necessitates certain skill sets and requires supplemental resources beyond the basic suite of assumptions used to estimate generic, planning-level sediment (and nutrient) reductions; however, the likelihood is that application of expert panel-recommended protocols will result in actual pollutant load reductions that exceed the default efficiency-based estimates furnished using MapShed. Furthermore, the Chiques Creek Flood Resiliency Study (SRBC and USACE, 2018) identified multiple Stream Restoration project opportunities with potential flood mitigation and water quality improvement benefits.

The implementation of Scenario No. 4 delivers significant sediment reductions, ranging from 17% for Lower Chiques Creek to nearly 50% for Upper Chiques Creek. Recall that estimates of sediment reduction for Stream Restoration projects were derived based on application of a conservative, default credit approach, rather than application of protocols advocated by CAST Expert Panel that are expected to furnish more realistic as well as "deeper" pollutant reductions compared with the default planning approach.

As shown in Figure 18, the overall CCW sediment reduction significantly eclipses the target yield when all four scenarios are bundled together, providing evidence that multiple pathways as well as price points exist for CCW to achieve sediment loading reductions expected to facilitate healthy aquatic communities.

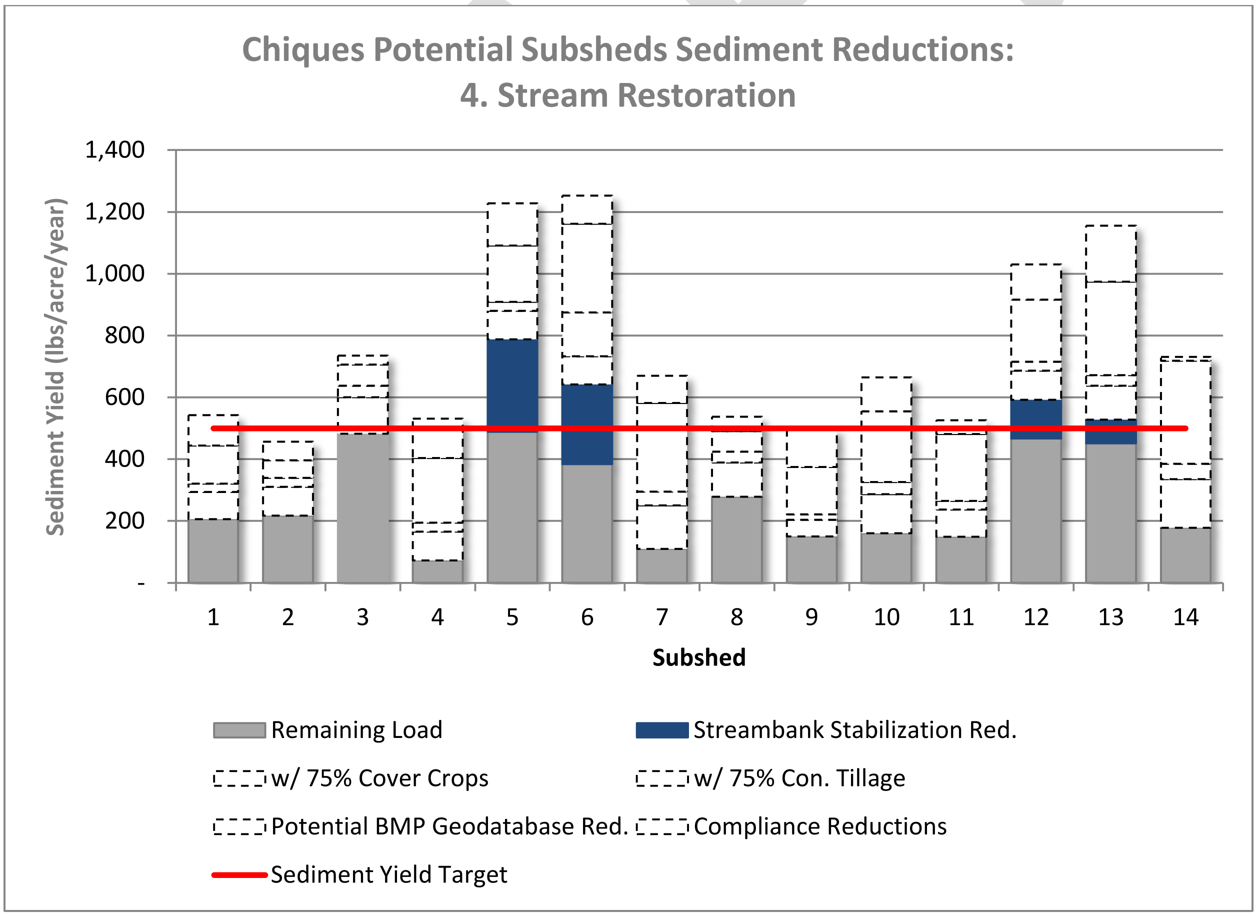

Figure 17. Scenario 4 – Sediment Reductions for Stream Restoration Projects

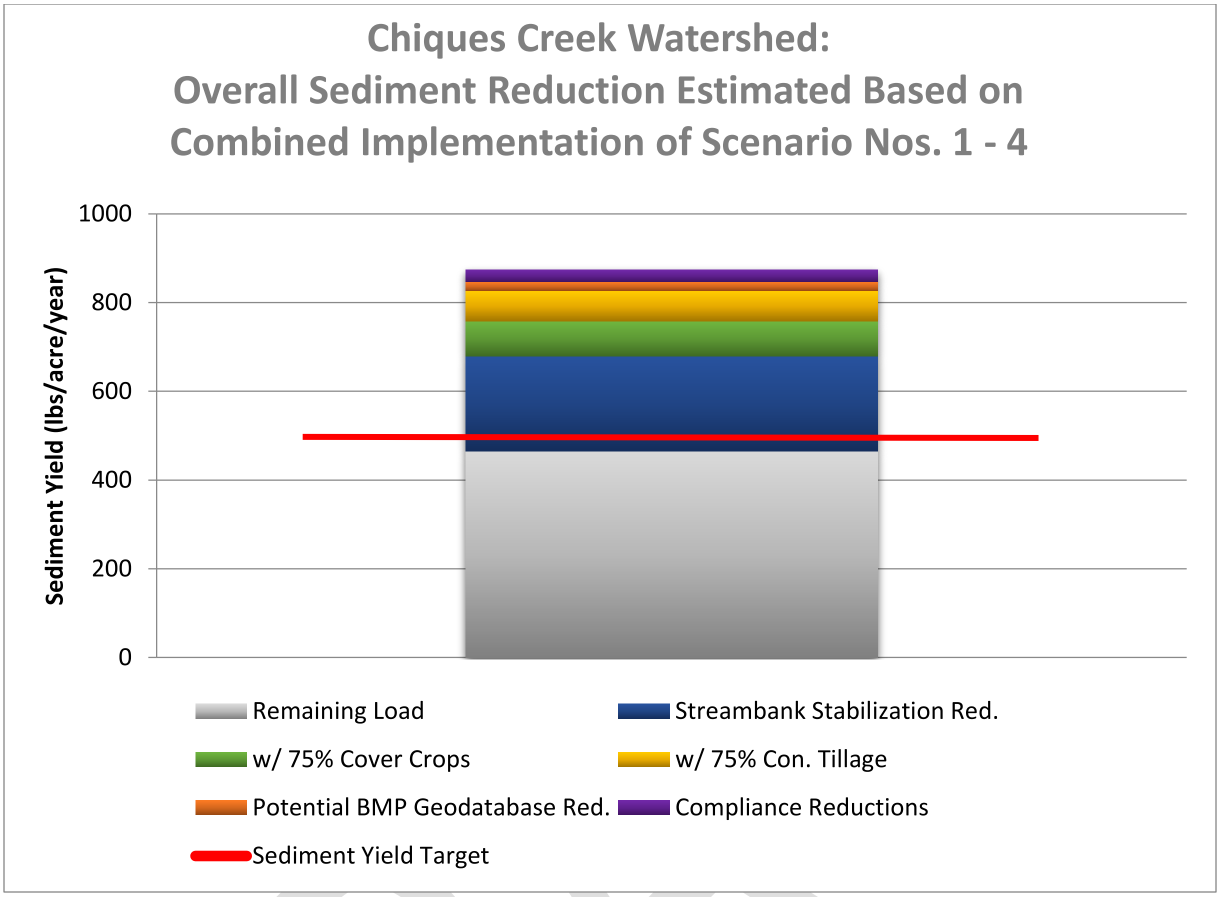

Figure 18. Overall CCW Sediment Reductions Based on Implementation of Scenarios 1 through 4

As indicated in Figure 18, complete implementation of the four scenarios discussed herein reduces sediment loading in CCW well below the target yield that is expected to support healthy aquatic life in the watershed. Of note, the BMP opportunities database provided herein is limited to several BMP types that were selected based on stakeholder and steering committee input as well as prominent agricultural-sector approaches that are being incorporated into WIP3. Although the BMP opportunities offered are considered appropriate, achievable, and adequate to restore aquatic life functions, there is acknowledgement that other BMP practice and project types may be as or more effective in terms of pollutant reduction, cost, pace of implementation, rate of aquatic health recovery, as well as benefits other than water quality related.

FUNDING OPPORTUNITIES

As noted above, the estimated costs provided in this ARP are broad approximations and properly considered for planning purposes only. In particular, the unit cost approach used herein varied in terms of whether operation and maintenance or opportunity costs were incorporated and moreover, the projected lifespans are subject to debate. Moreover, Scenario Nos. 1 through 3 were estimated to achieve the aquatic life-based target yield in both the Little Chiques Creek and Upper Chiques Creek subsheds.

Most of the project opportunities identified in the BMP opportunities database belong to riparian corridor, agriculture management, and stormwater basin retrofit categories. Riparian corridor stewardship, especially the establishment of stream side buffers, as well as agriculture management including livestock exclusion fencing, are parts of well-established and even growing programs and funding/technical assistance is readily available through agencies that include U.S. Department of Agriculture (USDA), PA Department of Conservation and Natural Resources (PADCNR), and PADEP. And in 2018, the Chesapeake Bay Foundation (CBF) announced its Keystone Ten Million Trees Partnership, a collaborative effort that is committed to planting 10,000,000 new trees in Pennsylvania's priority landscapes by the end of 2025 (http://www.cbf.org/how-we-save-the-bay/programs-initiatives/keystone-ten-million-trees-partnership.html).

BMP projects specified through MS4 permits (e.g., part of Scenario No. 1/Regulatory Compliance) have corresponding funding mechanisms such as PADEP grants and municipal revenue sources already committed. In general, the funding and other resources required to implement BMP projects can originate from a variety of sources and methods. PADEP, SRBC, AEC, and other organizations are committed to ongoing efforts to support and partner with the interested stakeholders to obtain funding for implementation of BMP in CCW. Moreover, as prefaced earlier, Lancaster County is at the forefront of WIP3-related initiatives and as such, pollution reduction efforts and activities in CCW are expected to benefit from the attention and resources devoted to Chesapeake Bay TMDL compliance.

The CCW ARP steering committee, along with other stakeholder leaders, compiled the list below as a partial inventory of grants and other funding sources.

a. Growing Greener – PADEP
    i. Program to support restoration of impaired (polluted) streams
    ii. Statewide, focused on priority watersheds (recoverable)
    iii. Addresses: agriculture, urban stormwater, stream restoration
    iv. Annual application process (spring/summer) thru PADEP
    v. Non-profits eligible (municipalities, conservation district, watershed orgs, etc.)
    vi. 15% match required
    vii. 3-4 years to implement the project

b. Commonwealth Financing Authority (CFA) watershed restoration grants program – Department of Community and Economic Development (DCED)
    i. Same as GG above (statewide, same issues, 15% match, project length)
    ii. For profit businesses also eligible
    iii. Apply through DCED

c. Conservation Reserve Enhancement Program (CREP) – USDA/DEP
    i. Focused on restoring/protecting lands bordering streams
    ii. 10-15 yr contracts to remove lands from production and put into natural vegetation

iii. Funding provided to landowners for annual rental payments and installation of conservation practices (fencing, tree planting, etc.)

d. Chesapeake Bay funding – PADEP/Conservation District
   i. Addressing nutrients and sediment coming from ag operations
   ii. Will include urban stormwater in the near future
   iii. Funding provided to landowner through the conservation district to install conservation practices
   iv. Landowners required to provide match monies

e. Resource Enhancement and Protection (REAP) Program – Soil Conservation Service
   i. Addressing nutrients and sedimentation coming from ag operations
   ii. PA tax credit provided to landowners to install conservation practices and to purchase certain farm equipment designed to reduce nutrient and sediment loss
   iii. Provides tax credit for 50% to 75% of cost of the practice or equipment
   iv. First come, first served
   v. $150,000 lifetime max for the program

f. NRCS EQIP program – USDA NRCS
   i. To address resource concerns on farms (primarily nutrients/sediment)
   ii. Provides incentive payments to landowners for implementing conservation practices
   iii. Enter into EQIP contract to install practices determined to be needed to address soil, water, animal, and air concerns

g. Nonpoint Source (319) funding – PADEP
   i. Only available to select priority small watersheds with restoration plans
   ii. Provides funding to nonprofits to address impaired stream reaches
   iii. Addresses: agriculture, urban runoff, and stream restoration
   iv. No match required for practices implemented
   v. Must have small watershed determined by PADEP to be a priority for this funding source and must develop a plan outlining practices needed to clean up the stream

h. National Fish and Wildlife Funding program – NFWF

i. Private Sector Dollars – Various

j. PENNVEST Nonpoint Source funding – PENNVEST

SCHEDULE FOR IMPLEMENTATION AND STAKEHOLDER ENGAGEMENT

This ARP addresses siltation as the overwhelming source of aquatic life impairment in CCW. A subsequent phase of ARP, expected to be developed in 2020, will address excess nutrient pollution in CCW.

As indicated by the scenarios presented previously, several pathways that reduce siltation pollution commensurate with healthy aquatic resources are available, even within a watershed that is as profoundly impaired as CCW. To achieve healthy aquatic resources will require ambitious and sustained efforts to coordinate and implement practices and projects throughout the watershed. And while it is recognized and expected that restoration and full recovery of CCW will require uncertain, perhaps decades-long timelines, two initial phases for BMP implementation are outlined below that are expected to guide pollution-reduction efforts during the first few years. These two phases are described separately; however, it is expected that individual projects within each phase will be carried out simultaneously.

Part I – Compliance Framework: 2018-2023

Part I is intended to focus on the Regulatory Compliance scenario presented above and is expected to roll-out during the 5-year horizon that corresponds with the MS4 NPDES permit cycle. Regulatory Compliance in this sense is specifically directed at implementation of the MS4 PRP commitments as well as preparation and implementation of Ag E&S plans. Support and resources for farmers to obtain their written Ag E&S plans is offered within CCW and Lancaster County, through the WIP3 process and other partners, Several municipalities have adopted, or are considering, ordinances that tie new permit authorizations to Ag E&S plans. The 90% Ag E&S plan objective set forth in this ARP exceeds the WIP3 timeline goal for 90% Ag E&S plan compliance by 2025.

While Part I is estimated to account for a modest ~3% sediment load reduction overall in CCW, Part I does establish multiple positive trajectories for ARP in that MS4 jurisdictions will gain and solidify experience with respect to implementation of pollutant reduction projects, O&M, regulatory interaction, and public participation. Furthermore, Ag E&S compliance puts in place a mechanism for broad engagement with the agricultural sector across CCW, thereby providing opportunities for stakeholder outreach and engagement consistent with goals and objectives contained in Scenario Nos. 2 (especially stream corridor stewardship) and 3 (soil health management), as well as the next ARP phase and the WIP3 process.

Part II – BMP Implementation and Soil Health Management: 2018-28

Part II emphasizes the BMP opportunities summarized by Scenario No. 2 above, with particular focus on establishing riparian buffers, livestock exclusion from streambank settings, and retrofitted stormwater management items, plus adoption of soil health management practices for 75% of cropland. Much of Part II is expected to be instrumental under the next ARP phase and also aligns with the WIP3 process. Pursuant to WIP3, by 2025, Pennsylvania's strategic framework to achieve Chesapeake Bay TMDL pollutant reductions must be in place. Pivotal pieces of both CCW ARP and WIP3 approaches rely on RFB and soil health management to exert substantial roles in pollutant reductions both within CCW and for Chesapeake Bay.

EVALUATION OF PROGRESS

As part of the ARP, it is important to monitor and evaluate progress to demonstrate that efforts by stakeholders are making positive change and, if necessary, to inform decisions where adjustments may be warranted. ARP progress in CCW will be evaluated as a two-pronged approach that includes tracking the implementation of projects/adoption of practices and assessing instream observations.

BMP Tracking

Projects in the existing BMP inventory as well as regulatory compliance goals will be tracked through coordination with stakeholders in CCW, representatives in PADEP regulatory programs, and affiliates in Lancaster County working to implement WIP3 initiatives. On an ongoing basis, SRBC will update the BMP opportunities database in terms of tracking project completions, identifying opportunities considered no longer viable, and integrating new projects and new opportunities. SRBC will furnish updates to PADEP's TMDL section on a quarterly basis, as well as announce progress summaries and database updates via CCW-dedicated web portal, as well as relevant social media platforms.

Instream Observation Assessment

As mentioned, varied scientific efforts are underway to monitor the waters of CCW and such efforts will continue and are expected to expand for the foreseeable future in order to facilitate detecting signs of improvement in water quality, habitat, and stream health. SRBC's real-time CIM stations will remain at the two locations shown in Figure 6 through 2025 at least. As mentioned, SRBC's CIM stations anchor ongoing data collection activities well beyond WQI parameters.

In addition to its real-time CIM stations, SRBC is committed to long-term data collection consistent with NTN protocols near the mouth of Chiques Creek in order to develop sediment and nutrient datasets suitable to calculate overall CCW pollutant loads and evaluate trends. Based on current and foreseeable resources, SRBC is committed to long-term monitoring at this location and we note that typically at least 10 years of NTN monitoring is necessary to assess pollutant trends.

SRBC also is committed to continued BMI surveys within the network of 25 stations surveyed in 2015 as well as other locations where such data may furnish insights about implementation of specific BMP.

In conjunction with CIM station, NTN protocol monitoring, and BMI surveys, SRBC will undertake additional instream observations and coordinate with PADEP and other stakeholders in CCW to evaluate scientific data with objective to discern changes in pollutant loading status, aquatic community assemblage, as well as habitat conditions. Such activities are expected to include:

- Correlating turbidity with SS concentrations.
- Generating Intensity – Duration – Frequency statistics for turbidity and evaluating for signs of change through time.
- Quantifying streamflow and precipitation and assessing hydrographic and runoff ratio response based on BMP implementation.
- Quantifying substrate habitat traits and bank erosion/stability.
- Evaluation of BMI community response.
- Stream respiration analysis.

Annual Summary Report

SRBC will compile and summarize the findings obtained for approaches outlined above that track BMP implementation as well as instream scientific measures into an annual technical progress summary that will be distributed to ARP steering committee, CCW stakeholder leaders, and other interested parties.

Stakeholder Engagement

For this and the subsequent ARP phase to successfully reduce pollutant loads in CCW and ultimately recover healthy aquatic life communities will require sustained commitment, interest, and actions by a broad base of stakeholders. SRBC acknowledges a key leadership role and responsibility to garner and sustain momentum for this ARP and our partnership with PADEP provides a contractual mechanism that solidifies our continued commitments. In addition to SRBC's contract with PADEP, our agency is committed to various water science, stakeholder relationship, and ecosystem stewardship priorities that compel us to apply various Commission resources in CCW alongside and additional to, PADEP's direct contract requirements.

Consistent with SRBC's commitments to ongoing stakeholder coordination, BMP database management, instream data collection, and preparation of technical summary information, our agency will launch and manage a web page via srbc.net that is dedicated to the CCW ARP pilot project. SRBC's CCW web page will provide the following:

- Links to key ARP-related documents and information;
- Interface with real-time CIM stations;
- Calendar of ARP-related events;
- Stakeholder contacts and links; and,
- BMP opportunities database and quarterly progress-tracking.

In addition to a CCW-dedicated web page, SRBC also will manage a dedicated social media platform designed to facilitate stakeholder and public outreach and engagement.

CONFORMITY WITH ELEMENTS OF WIP

This ARP conforms with the nine elements USEPA requires for WIP as follows:

1. Defined causes and sources of aquatic life impairment.

   Aquatic life impairment is caused by siltation for ~95% of the CCW stream length with sources due to Agricultural (182.9 of 192 miles) and Developed Land (40.9 of 192 miles).

2. Estimated current sediment pollutant loads, a target sediment load expected to foster recovery of healthy aquatic communities, and corresponding pollutant load reductions expected for the various controllable pollutant sources. Additionally, the principal categorical sources of sediment as well as land cover types associated with such sources within each of four subwatersheds are identified.

The current overall sediment load for CCW is estimated at ~70 M pounds per year. The target sediment load expected to foster recovery of the healthy aquatic community is ~48 M pounds per year. To meet the aquatic life-based target load, the individual subshed sediment load reductions range from 24 to 40% of existing baseline. Of the ~29 M pounds/year sediment reduction needed to achieve the target in CCW overall, ~19 M pounds will come from Agricultural settings and ~ 10 M pounds will be controlled via management and projects directed at Developed lands. The main sources of sediment pollution in the CCW are cropland losses (~1/3) and streambank erosion (~2/3).

3. Management measures needed to achieve load reductions.

   This ARP presents 4 scenarios, that if fully implemented, are capable of reducing existing sediment load for CCW by more than the aquatic life-based target. In addition to fulfilling the sediment reductions proposed herein, the scenarios are consistent with prominent elements of the WIP3 approach. The BMP strategy contained herein is based predominantly on combinations of regulatory compliance (MS4 PRP commitments for the current permit cycle and agricultural E&S plan development & implementation), riparian ecosystem stewardship, and soil health management. In addition to the aforementioned practice and project types, substantial sediment reductions are afforded by stream restoration projects, including streambank stabilization.

   Of note, the BMP opportunities presented in this ARP are capable of achieving greater sediment load reduction than is forecast to meet the aquatic life-based target.

4. Conservative estimates of the associated costs to achieve sediment pollutant load reductions developed for this plan and sources of technical and financial assistance that will be relied upon to implement this ARP.

   A local stakeholder-vetted, spatially-explicit and dynamic database that currently lists > 550 individual BMP opportunities with estimated pollutant-reduction contributions as well as planning-level associated costs for each BMP is offered. This BMP database provides a pool of practice types and projects that offer multiple pathways to achieve the load reductions estimated in this ARP. Moreover, BMP opportunities presented herein are acknowledged to encompass only a select variety of category types and stakeholders are encouraged to identify and implement BMP that fulfill the load reduction outcome developed herein, whether or not the projects appear in the current BMP database.

5. Description of information/education components that will be used to enhance and inform public understanding of the project and encourage their ongoing support and participation in selecting, designing, and implementing management measures.

   The CCW ARP steering committee and local stakeholders already implement several activities that educate and inform members of the public about pollution-reduction and clean water enhancement measures. Moving forward, SRBC will be responsible for launch and maintenance of a CCW ARP-dedicated webpage that provides information and resources related to this (siltation) and the next (nutrient enrichment) phase of ARP. The web page will include key documents, stakeholder contact information, calendar of events, access to real-time and other monitoring data, as well as a summary about BMP *progress and opportunities. In addition to a dedicated webpage, SRBC also will manage a social media platform that offers more day-to-day information, announcements, and a forum to exchange ideas.*

6. A schedule for implementing management measures identified in this ARP.

   The next ARP phase (nutrients) is expected to be developed in 2020. BMP implementation is underway currently and the expectation for this ARP phase is that regulatory compliance (e.g., MS4 PRP commitments and Ag E&S plans) will be completed during the next 5 years. In accordance with WIP3, Pennsylvania's strategies for compliance with Chesapeake Bay TMDL pollution reduction targets must be in-place by 2025 and by design, much of the practices and projects identified in this ARP also are prominent features of WIP3. As such, the predominant share of BMP opportunities identified to date (i.e., RFB and livestock exclusion from riparian corridor projects) are expected to be implemented during the next 5 to 10 years.

7. A schedule of interim, measurable milestones for determining whether the management strategy and BMP implementation pace is commensurate with this ARP.

   The primary measurable milestones associated with this ARP are two-fold; the first measurable milestone will be progress toward BMP implementation, especially items identified as Scenario Nos. 1 through 3. The second measurable milestone will be instream observations. As discussed, the BMI community response is expected to take decades to recover to healthy stream assessment status, but SRBC and other scientific partners will perform ongoing data collection and evaluation activities with objective to discern evidence of improving conditions in terms of water quality, habitat, and biometric indicators. SRBC will compile and prepare an annual summary of activities, findings, and interpretations related to measurable milestones.

8. A set of criteria that will be used to determine whether loading reductions are being achieved over time and sufficient progress is being made towards attaining water quality targets and, if not, the criteria for determining whether this ARP warrants revision.

   As mentioned, in regulatory context, aquatic life assessment is based on BMI community metrics that are expected to lag, perhaps by decades behind the adoption of practices and implementation of projects. Moreover, the CCW lacks a robust baseline dataset capable of serving to analyze trends for the watershed. In 2018, SRBC initiated monitoring commensurate with NTN protocols and we expect that between 5 and 10 years of data collection will enable evaluation of pollutant trends. As interim measures of progress toward the pollutant-reduction targets, SRBC and PADEP will analyze and evaluate CIM data with emphasis on sensitive signals of improvement including shifts in stream hydrographs (i.e., reduced peak rate/volume associated with storm flows), runoff ratios, turbidity profiles, substrate habitat quality, and streambank erosion rates.

9. A monitoring strategy to evaluate the effectiveness of BMP implementation through time, measured against the criteria established in element no. 8 above.

As part of an annual progress synthesis and summary, SRBC will convene steering committee and stakeholders to discuss possible triggers that warrant adjusting the ARP approach.

CONCLUSIONS

The CCW ARP is a pilot project that is unfolding in one of Pennsylvania's most challenged watersheds. The CCW lies in the state's most productive agricultural setting and is among the state's least forested regions.

In order to restore aquatic life communities in local waterways, current elevated sediment loads need to be reduced by nearly 50% to achieve a target water quality level expected to support healthy aquatic ecosystems. Through this ARP process, the primary sources of sediment, as well as nutrient pollutants are: cropland, pasture, eroding streambanks, and livestock, as well as high levels of nutrients in soil and groundwater due mostly to former land use practice.

With general buy-in from a cross-section of local stakeholders, the ARP steering committee developed a database with more than 550 separate BMP opportunities. Most of these opportunities derive from a few common project and practice types – many of which have existing programmatic and/or structural frameworks for technical and financial assistance. Moreover, by implementing the majority of identified BMP (exclusive of Stream Restoration), sediment load reduction necessary to achieve the target water quality level is predicted.

The timeline to implement projects needed to achieve sediment load reduction is uncertain; however, it is acknowledged that the time required to restore aquatic life communities could well take decades. The seemingly long time for watershed recovery should be viewed in the context of current magnitude of degradation, widespread lack of forest cover, natural cycles needed for soil/groundwater attenuation, duration for riparian forest buffer maturation, as well as the biologic processes required for life to recruit and colonize the watershed.

REFERENCES

Ator, S.W., J.D. Blomquist, J.W. Brakebill, J.M. Denis, M.J. Ferrari, C.V. Miller, and H. Zappia. 1997. Water quality in the Potomac River basin, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia, 1992–96. Circular 1166. US Geological Survey, Reston, Virginia.

Evans, B. and K. Corradini. 2016. MapShed Version 1.5 Users Guide; Penn State Institutes of Energy and the Environment, The Pennsylvania State University; University Park, PA. 144 pp.

Evans, B., S. Sheeder, and D. Lehning. 2003. A spatial technique for estimating streambank erosion based on watershed characteristics; Journal of Spatial Hydrology 3: 1-13.

Haith, D. and L. Shoemaker. 1987. Generalized watershed loading functions for stream flow nutrients; Journal of American Water Resources Association 23: 471-478.

Lane, E.W. 1954. The importance of fluvial morphology in hydraulic engineering; Hydraulic Laboratory Report No. 372, United States Department of the Interior Bureau of Reclamation; Denver, CO. 21 pp.

Lothrop, J.C., D.L. Lowery, A.E. Spiess & C.J. Ellis. 2016. Early Human Settlement of Northeastern North America; PaleoAmerica, 2:3, 192-251.

Penn State University (PSU) Agriculture Environment Center (AEC). 2017. Farmers need to give stream space. Pennsylvania in the Balance: Harnessing Agriculture's Culture of Stewardship as a Solution to Clean Water, p. 28.

Sheeder, S. and B. Evans. 2007. Estimating nutrient and sediment threshold criteria for biological impairment in Pennsylvania watersheds; Journal of American Water Resources Association 40: 881-888.

Susquehanna River Basin Commission (SRBC) and United States Army Corps of Engineers (USACE) Baltimore District. 2018. Chiques Creek Flood Resiliency Study; prepared with a grant from Pennsylvania Department of Environmental Protection (PADEP) under the Federal Floodplain Management Services Program. 757 pp.

United States Department of Agriculture (USDA). 2017. 2016-2017 Agricultural Statistics Annual Bulletin – Pennsylvania; National Agricultural Statistics Service, PA Field Office. 76 pp.

Walter, R. and D. Merritts. 2008. Natural streams and the legacy of water-powered mills; Science 319: 299-304.

Wischmeier, W. and D. Smith. 1965. Predicting rainfall – erosion losses from cropland east of the Rocky Mountains, Guide for selection of practices for soil and water conservation; Agriculture Handbook No. 282, Agricultural Research Service – USDA in cooperation with Purdue Agricultural Experiment Station, 49 pp.

APPENDIX A

CCW WITHDRAWAL RATIONALE AND TMDL/TMDL ALTERNATIVE PROPOSAL

Chiques Creek appeared on Pennsylvania's 1996 303(d) List of Impaired Waters (List) as being impaired by nutrients from agricultural sources. The impairment was modified as part of the 1998 List to also include siltation from agriculture. The Chiques Creek Watershed TMDL for phosphorus and sediment was developed by Pennsylvania Department of Environmental Protection (DEP) and approved by the United States Environmental Protection Agency (EPA) on 4/9/2001 and was one of the first TMDLs completed in partial fulfillment of EPA's Consent Decree requirements. While the original TMDL adequately included the known regulated dischargers and sources of impairment at the time, it has several major deficiencies that render it ineffective as any sort of planning tool for pollutant reduction purposes in present day.

Therefore, DEP is proposing that the current Chiques Creek TMDL be immediately withdrawn and the waterbodies in the Chiques Creek watershed returned to Category 5 in the integrated report with updated sources and causes. Based on DEP's current resources and funding, March 2016 is the current target date by which the withdrawn TMDL will be replaced by a TMDL for nutrients and sediment or an alternative approach that will be more comprehensive in its geographic extent, more accurate in its characterization/inclusion of all sources, and provide a management tool for both point and nonpoint sources in the watershed. At that time, the listing placement can be reevaluated to determine the most appropriate category for the Chiques Creek Basin waters.

STATUS OF CURRENT TMDL(s)

Since the Chiques Creek TMDL approval, the WLAs included in the original TMDL have been fully implemented (i.e., dischargers are in compliance with the requirements of the 2001 TMDL). Further reductions requirements in accordance with the Chesapeake Bay TMDL have also been instituted and three waste water treatment plants (WWTPs) have already upgraded their facilities. These new requirements are not accounted for in the existing TMDL.

The larger issue still remains that many dischargers were not assigned WLAs, nor were stormwater sources that are now NPDES permittees. Implementation of the nonpoint source (NPS) portion of the TMDL has not been overly successful as there was no stakeholder involvement in its development and no plan to follow the TMDL with funding targeted to NPS BMP implementation. This proposed pilot remedies both of those flaws with a more intensive public engagement effort along with DEP/EPA grant program coordination during development of the watershed plan.

The remainder of this document will provide more specific updates on the implementation status of both point and nonpoint sources along with details for the proposed-alternative approach for the restoration of Chiques Creek Watershed or, as necessary, revised TMDL.

ISSUES IN CURRENT TMDL

Assessments

The Chiques Creek TMDL (2001) has some major deficiencies that not only make implementation impossible, but are so major in scope that a revision to resolve the problems on an expedient timeframe is not feasible. The current health of the streams in the watershed and existing sources/causes of impairments must be understood in order to properly revise the TMDL. Any revision of the TMDL should also address the entire geographical extent of the watershed, but evaluate water quality on a subwatershed basis that helps guide implementation efforts.

The last assessments in the Chiques Creek Watershed were performed in 1997. The assessments were not done using the ICE protocol which is currently the method used today. The advantage of the ICE protocol is that it is quantitative and can be used to demonstrate incremental progress in waterbody health. The prior methodology used a pass/fail outcome that did not lend itself to measuring progress using comparisons to previous surveys. DEP proposes a complete reassessment of the Chiques Creek watershed using the ICE protocol to get a new baseline. Additionally, DEP would initiate a monitoring effort that would include collection of continuous instream data (CIM), water chemistry, and periphyton. This work is slated to begin in the fall of 2014 and continue through the summer of 2015.

NPDES Permits

Certain existing NPDES discharge permits were not provided WLAs in the original TMDL. These permits must be renewed and there are no WLAs in the existing TMDL to accommodate them. Additionally, dischargers would need to be addressed by extending the geographical revisions to be more inclusive of the entire Chiques Creek Watershed as discussed later in this proposal.

The Municipal Separate Storm Sewer System (MS4) permittees in the Chiques Creek watershed (≈12) did not receive WLAs and are not required to plan for pollutant reductions from their outfalls. The 2001 TMDL was also developed prior to the James Hanlon memorandum of November 22, 2002, “Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Requirements Based on Those WLAs.” Simply moving the loads around and updating the existing TMDL to include these permittees is not an option as the 2001 model did not include a streambank erosion component; therefore, no sediment in that TMDL was attributed to urbanized areas. Revising the TMDL will entail a remodeling effort to better characterize the contributions to the watershed sediment load from MS4s through bank and channel degradation.

Nonpoint Sources

In the years following the establishment of the existing TMDL, several initiatives and projects were undertaken to address nonpoint source (NPS) inputs to the system. There was a Chiques Creek Watershed Alliance formed around 2001. This group did a watershed-wide stream assessment with Growing Greener funds in 2002 and also received Growing Greener funding for stream restoration work in Mummau Park and on Rife Run. After several years of dormancy, the group has been reformed and have a new joint NFWF/Growing Greener grant to do another stream restoration project on Rife Run with work schedule to begin in the summer of 2015. The group has also been active in organizing educational/outreach events such as farm shows, watershed expos, watershed nights, creek stomps, stream cleanups and tree plantings.

Other work has been done in the watershed, though not affiliated with the Chiques Creek Watershed group. For example, a Little Chiques Creek Rivers Conservation Plan was created in 2005, streambank and fish habitat improvement work was done in 2007 on Shearers Creek, along with several feasibility studies aimed at a combination of pollution and flood control. Several municipalities, including Rapho Township and Mount Joy Borough, have been active in the basin both in terms of participation in many of the activities mentioned above along with on-site BMPs at their offices.

In the proposed Chiques Creek alternative approach, in collaboration with stakeholders, DEP will take a much more coordinated and targeted approach to NPS BMP implementation. Chiques Creek is being considered for designation as a priority watershed under the state’s Growing Greener Program. This state funded program provides grant monies to support watershed restoration activities in areas defined by the Department as priority watersheds for implementation. The Growing Greener Program allocates approximately $20.0 million a year for watershed restoration activities. The Department is likewise considering a portion of the Chiques Creek Watershed as a focal area for agricultural compliance assessment and support. Being selected as one of these focal areas initiates on the ground assessment by state program staff of every farm in the area to ensure that they are meeting agricultural compliance obligations established through state and federal laws and therefore appropriately protecting the water resources in the area. These focused efforts in the watershed can greatly enhance restoration activities in the Chiques Creek watershed and significantly shorten the timeframe needed to restore impaired stream reaches within this watershed.

Geographic Extent

The entire Chiques Creek Watershed consists of four HUC 12 subwatersheds. The Chiques Creek TMDL captured two of the four subwatersheds comprising the mainstem of Chiques Creek from its headwaters to a point in the watershed (≈ $65mi^2$ TMDL approved in 2001) above the confluence of Chiques Creek with Little Chiques Creek (≈ $45mi^2$ with no current TMDL) and Donegal Creek (≈ 17 mi^2 TMDL approved in 1999). DEP proposes the TMDL Revision or alternative approach for Chiques Creek be more comprehensive and include new assessments for Little Chiques and Donegal Creek (Figure 1). Donegal Creek has had a lot of BMP implementation activity, some post-TMDL but predominantly before the TMDL was completed. New assessments in this watershed may provide a basis for delisting Donegal Creek. The assessment findings will appear on Pennsylvania's 2016 IR. In order to properly understand both the point and nonpoint source contributions at a manageable scale for implementation, the Chiques Creek Watershed will be broken into even smaller subwatersheds.

PATHWAY FORWARD

The assessment work is slated to begin in the fall of 2014 and continue through the summer of 2015. A detailed plan for assessment, monitoring, and sampling can be found in Appendix A. DEP and SRBC will partner in the monitoring effort, the exact division of responsibilities is still being worked out. SRBC will coordinate all workgroups including scheduling/facilitation of meetings. SRBC will also take the lead in the TMDL/TMDL Alternative development process and act as the point-of-contact for Chiques Creek stakeholders. An initial stakeholder engagement meeting will be held in January 2015. This group will consist of representatives from all sectors and will be the core of what is envisioned to be a steering committee. EPA will be represented on the Steering Committee and will provide guidance to ensure that the Alternative Implementation Strategy meets all necessary criteria. Data collection, as discussed in Attachment A, will commence in spring 2015 and continue through the summer. Parallel to the data collection efforts and after several (monthly) meetings with the steering committee members, several workgroups will be formed. These groups will represent the major stakeholder interests (nonpoint source/agriculture, MS4s, WWTPs) and also a technical (modeling) workgroup. The goal is to have a new TMDL Alternative/Chiques Creek Watershed Implementation Strategy for meeting newly derived endpoints in place by March 2016.

SUMMARY

DEP is proposing to withdraw the existing Chiques Creek TMDL and replace it with a revised TMDL or TMDL Alternative. Either resolution will be guided by additional data collection, modeling, and analysis work and engage stakeholders from all sectors. At this point, the Chiques Creek TMDL (2001) is no longer an effective vehicle to affect point or nonpoint source pollutant reductions in the watershed. The watershed has not had an aquatic life use assessment in approximately 15 years; meanwhile, assessment methods and sources of impairment in the growing area have changed dramatically. Additionally, many current NPDES dischargers were not included in the original TMDL. These discharges must be included in a comprehensive TMDL/TMDL Alternative for the entire watershed (Chiques, Little Chiques and Donegal Creeks) that addresses the current sources/causes of impairment as determined by new, watershed-wide, aquatic life use assessments. This comprehensive approach will take a considerable amount of time and also require a complete remodeling of the watershed; however, this is the only way to determine nutrient/sediment load reductions required for Chiques Creek to meet water quality standards.

Based on the ineffectiveness of the existing TMDL, the obstacle that the current TMDL poses in the implementation and renewal of current permits, and the time required to complete the work necessary to replace it with a quality TMDL/TMDL Alternative, DEP requests approval of the withdrawal of the Total Maximum Daily Loads (TMDLs) Development Plan for Chiques Creek Watershed (2001) and the impaired waters returned to Category 5 while an appropriate replacement is prepared.

APPENDIX B

INTEGRATED REPORT: CHIQUES CREEK WATERSHED

Assessment ID:	Stream Name:	Assessed Use:	Status:	Category:	Impairment Source:	Impairment Cause:	Date Listed:	HUC:	HUC Name:	Reachcode:	COMI
19371	Back Run	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306001261	57462
19371	Back Run Unnamed To (ID:57462867)	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306004616	57462
19371	Brubaker Run	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306001267	57462
19371	Brubaker Run Unnamed To (ID:57462559)	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306001270	57462
19375	Chiques Creek	Aquatic Life	Impaired	5alt	Agriculture	Nutrients	1997	02050306	Lower Susquehanna	02050306000201	57464
19376	Chiques Creek	Aquatic Life	Impaired	5alt	Agriculture	Siltation	1998	02050306	Lower Susquehanna	02050306000206	57463
19376	Chiques Creek	Aquatic Life	Impaired	5alt	Urban Runoff/Storm Sewers	Siltation	2016	02050306	Lower Susquehanna	02050306000208	57462
19379	Chiques Creek Unnamed To (ID:57464345)	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306004790	57464
19379	Dellinger Run	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306001258	13362
19379	Dellinger Run Unnamed To (ID:57462727)	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306004605	57462
19365	Donegal Creek	Aquatic Life	Impaired	4a	Agriculture	Nutrients	2016	02050306	Lower Susquehanna	02050306000417	57463
19365	Donegal Creek	Aquatic Life	Impaired	4a	Agriculture	Organic Enrichment/Low D.O.	2016	02050306	Lower Susquehanna	02050306000417	57463
19365	Donegal Creek	Aquatic Life	Impaired	4a	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306000417	57463
19365	Donegal Creek	Aquatic Life	Impaired	4a	Agriculture	Suspended Solids	2016	02050306	Lower Susquehanna	02050306000417	57463
19368	Donegal Creek Unnamed To (ID:57464155)	Aquatic Life	Impaired	4a	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306004764	57464
19370	Little Chiques Creek	Aquatic Life	Impaired	5alt	Agriculture	Nutrients	1998	02050306	Lower Susquehanna	02050306000218	57463
19371	Little Chiques Creek Unnamed To (ID:57463307)	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306004659	57463
19376	Rife Run	Aquatic Life	Impaired	5alt	Agriculture	Siltation	1998	02050306	Lower Susquehanna	02050306001255	13362
19376	Rife Run	Aquatic Life	Impaired	5alt	Urban Runoff/Storm Sewers	Siltation	2016	02050306	Lower Susquehanna	02050306001255	13362
19376	Rife Run Unnamed To (ID:57462579)	Aquatic Life	Impaired	5alt	Urban Runoff/Storm Sewers	Siltation	2016	02050306	Lower Susquehanna	02050306004595	57462
19379	Shearers Creek	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306004536	57461
19379	Shearers Creek Unnamed To (ID:57461799)	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306001251	57461
19371	Shells Run	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306001274	57462
19371	Shells Run Unnamed To (ID:57462667)	Aquatic Life	Impaired	5alt	Agriculture	Siltation	2016	02050306	Lower Susquehanna	02050306004601	57462

APPENDIX C

EQUAL MARGINAL PERCENT REDUCTIONS

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) between the appropriate contributing nonpoint sources. The five major steps identified in the spreadsheet are summarized below:

1. Calculation of a TMDL based on impaired watershed size and unit area loading rate of the target reference condition.

2. Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.

3. Actual EMPR Process.

    a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of the EMPR.
    b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

4. Calculation of total loading rate of all sources receiving reductions.

5. Summary of existing loads, final load allocations, and percent reduction for each pollutant source.

Step 1:	TMDL Total Load				Step 2:	Adjusted LA = (TMDL total load - MOS) - uncontrollable						
	Load = loading rate in ref. * Acres in Impaired					5078.59	5079					
	5642.88											
	SEDIMENT LOADING											
Step 3:		Non-MS4 Daily Average Load	Load Sum	Check	Initial Adjust	Recheck	% reduction allocation	Load Redu	Initial LA	Acres	Allowable Loading Rate	% Reduction
	Hay/Past.	1089.98	8968.33	good	1090	ADJUST	0.13	435.97	654.01	956.30	0.68	40%
	Cropland	2295.43		good	2295	3385	0.27	918.12	1,377.31	2013.90	0.68	40%
	Developed	5582.91		bad	5079		0.60	2031.32	3,047.27	1149.10	2.65	45%
	Streambank			good	0		0.00	0.00	0.00			#DIV/0!
	Total	8968.33			8464		1.00		66013.17	4119.30		
Step 4:	All Ag. Loading Rate	0.68										
Step 5:		Acres	Allowable (Target) Loading Rate	Final LA	Current Loading Rates	Current Load	% Red.					
	Final Hay/Past. LA	956.30	0.68	654.01	1.14	1089.98	40%					
	Final Cropland LA	2013.90	0.68	1377.31	1.14	2295.43	40%					
	Developed	1149.10	2.65	3047.27	4.86	5582.91	45%					
	Streambank			0.00		0.00	#DIV/0!					
	Total			5078.59		8968.33	43%					