Saucony Creek Watershed Restoration: Groundwater Evaluation

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1.0 Executive Summary

The Saucony Creek Watershed is located in northeastern Berks County, in the middle of the “farm belt”. The area is blessed with very fertile soils, a product of the underlying carbonate geology. The soils and karst features produce a high rate of groundwater recharge.

The watershed supports three community drinking water systems including Lyons Borough, Maxatawny Township and the Borough of Kutztown. The largest of these water systems is Kutztown, which serves over 14,000 people, including the students of Kutztown University.

Nitrates in groundwater have long been used an indicator of agriculture pollution, generated from either excess fertilizer or manure. Nitrates are naturally found in groundwater, but at low concentrations. In heavy agriculture areas, nitrates can approach or exceed the drinking water standards of 10 mg/l. The nitrates in the Kutztown raw water were approaching the maximum contamination levels due to agricultural related contamination.

Interest to improve the water quality in the Saucony Creek Watershed was initiated by a desire to protect a freshwater marsh and the need for clean drinking water. Environmental organizations, scientists, and the government went work to improve the water quality of the Saucony Creek Watershed. Many agricultural *Best Management Practices* (BMPs) were installed throughout the watershed, including streambank fencing, cattle crossing, manure storage units, and riparian buffers.

With the guidance of the Berks Nature staff (formerly Berks Conservancy), 13 funding partners have supported the watershed restoration efforts, contributing to 29 individual restoration projects, which were completed by the end of 2016. Funded primarily by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) and the Nation Fish and Wildlife Foundation (NFWF), manure storage units, which greatly reduce nutrient and sediment loading, have helped to manage nearly 270,000 pounds of nitrogen-nitrates annually.

Watershed restoration results were first detected independently, as decreasing nitrates in groundwater was observed in the Kutztown drinking water. The Kutztown wells are tested for nitrates on a quarterly basis and were tracked from 2000 through 2016. From 2000 through 2007, the nitrate concentration was consistently above 8 mg/l. From the end of 2007 through 2014, nitrates were highly variable with only 29% of the samples above 8 mg/l, and the average nitrate concentration of 7.4 mg/l. For the last two years, 2015 through 2016, another downward shift in nitrates was observed, with the average concentration dropping to 6.7 mg/l. This represents a steady trend of decreasing nitrates in the Kutztown drinking water and the Saucony Creek Watershed as a result of agricultural BMPs.

Not only are these agricultural BMPs helping to improve water quality on farms, they are contributing to a more sustainable watershed community. Decreased volume of nutrients and sediments entering the waterways, equates to less treatment costs for public water suppliers and safe drinking water. Reducing excess nutrient loading in the Saucony Creek Watershed, also decreases the nutrient/sediment loads flowing downstream into Lake Ontelaunee, the drinking water source for the City of Reading. Ultimately, clean drinking water and farming practices can work together in a mutual sustainable way. The success measured in the restoration of the Saucony Creek Watershed proves that investments in agricultural restoration does result in water quality improvements and can be utilized as a model in other agriculture intensive watersheds.

2.0 Introduction

The Saucony Creek Watershed has been farmed for over 250 years. The majority of the agriculture land is found in the mid and lower sections of the watershed. While farms exist in the headwaters, they only account for 22% of the land use as compared to over 51% in the lower basin and 66% in the mid-basin. As a result of dense farming, elevated levels of nitrates, were present in the streams and groundwater of the mid and lower portions of Saucony Creek Watershed. The Borough of Kutztown, a major water supplier within the basin, is located in the farming intensive area of the mid-basin. Kutztown's raw water supply had nitrate levels approaching the drinking water *Maximum Contaminant Levels* (MCLs) of 10 mg/l. Nitrates are water soluble and are an indicator of agriculture contamination.

The desire to protect a threaten rare marsh known as the Saucony Marsh and the need for clean drinking water, partners lead by Berks Nature (formerly Berks Conservancy), started to formulate a plan to improve the water quality of the Saucony Creek Watershed. Starting in 2002, funding was secured to start working with farmers to retrofit their farms with environmental friendly infrastructure called *Best Management Practices* (BMPs). The agriculture BMPs are designed to reduce nutrients and sediment loads from entering the waterways. By the end of 2016, partners like USDA Natural Resources Conservation Service (NRCS), National Fish and Wildlife Foundation (NFWF), State and County agencies have worked together to fund and install BMPs on over 20 farms located in the Saucony Creek Watershed. During this time, a significant volume of nutrients were captured and managed on the farms. First fluctuating levels of nitrates were observed, but from 2015 through 2016, the large swings in nitrate concentrations appear to have stabilized and are continuing to trend downward. Through 2007, nitrate levels were approaching the drinking water MCLs. As a result of the watershed restoration activities, nitrates in the groundwater have decreased in concentration.

This study documents the reduction in nitrates found in groundwater at the Kutztown drinking water wells as a result of the BMPs installed in the Saucony Creek Watershed. The Saucony Creek Watershed cleanup has benefits to the downstream Lake Ontelaunee, the drinking water source for the City of Reading. A portion of Reading's drinking water quality (from the Saucony Creek Watershed) has improved due to restoration practices. The larger Maiden Creek Watershed, Reading's entire source water protection area, can be improved by following a similar path in restoration efforts.

3.0 Saucony Creek Watershed

3.1 Location

The study area is located in Berks County, southeastern Pennsylvania as displayed in **Figure 1**. Saucony Creek, a fourth order stream, discharges to the Maiden Creek at Virginville, and is part of the Schuylkill River Watershed. Utilizing the Hydrologic Unit Code classification, the Saucony Creek Watershed is characterized as a Subwatershed with a HUC-12 code of 020402030304. The main focus centers from the Borough of Kutztown upgradient to the headwaters. The Saucony Creek Watershed is shown on the Kutztown, Pennsylvania Untied States Geologic Survey, Topographic 7.5 Minute Quadrangle map.

3.2 History of Land Use

The Saucony Creek region was open to settlement in the 1730's with the transfer of lands from the Native Americans of the Lenni Lenape tribe to the Palatine immigrants from the Middle Rhine region of Germany. The fertile limestone soils produced an agriculture economy that is still going strong in the Saucony Creek Watershed.

Besides agriculture, the other major influence in the Saucony Creek Watershed was the discovery of hematite ore. By the mid-1800's, there were over 100 iron mines in the Maiden Creek area. The glory days for the iron industry lasted from the Revolutionary War through the Civil War. Furnaces were located in Kutztown and Topton. As a result of the iron mines, the East-Penn Railroad was developed in 1857 to connect the mines with the foundries. Many villages including Lyons, Topton, and Bowers were established along the rail line. Another rail line followed the Maiden Creek to service the Moselem Furnace. Virginville, located at the confluence of Saucony and Maiden Creek, was established as a result of this rail line. The railroads were also utilized to transport livestock and produce to Reading and beyond.

Today, land use is predominantly agriculture (51%), followed by forested land (33%) and developed land (16%). The headwaters are mostly forested with a steep terrain. The mid-basin is comprised of agriculture, towns, transportation (roads & rail lines) and a limestone quarry. The lower basin land use is predominantly agriculture with an increase in forested land. The land use for the Watershed is displayed on **Table 1** plus the individual land use percentages of the headwaters, mid-basin and lower-basin.

Table 1: Saucony Watershed – Land Use

Saucony Creek Characteristics	Saucony Watershed	Headwaters	Mid-Basin	Lower Basin
Agriculture Land	51%	22%	66%	51%
Forested Land	33%	69%	10%	38%
Developed Land	16%	10%	24%	10%

3.3 Watershed Characteristics

The Saucony Creek Watershed drains 32 square mile area with approximately 38 miles of streams. The watershed characteristics, stream density and the percentage of carbonate geology are presented on **Table 2** below for the entire watershed plus the headwaters, mid-basin and lower basin areas.

Table 2: Saucony Watershed – Characteristics

Saucony Creek Characteristics	Saucony Creek Watershed	Saucony Creek Headwaters	Saucony Creek Mid-Basin	Saucony Creek Lower Basin
Drainage Area (square miles)	32.4	7.9	14.8	9.7
Stream Length (miles)	38.2	11	7.9	19.3
Stream Density (miles per square mile)	1.2	1.4	0.5	2.0
Carbonate Geology	47%	9%	88%	3%

Of note on **Table 2,** is the decrease in stream density in the carbonate area of the mid-basin. A high percentage of the precipitation infiltrates the ground to provide groundwater recharge.

Saucony Creek flows through three distinct geologic units that shape the watershed characteristics, water quality, and land use. The Pennsylvania Department of Environmental Protection (DEP) has classified Saucony Creek as *Exceptional Value (EV)* waters in the headwater section of the watershed. Only 2% out of the 83,000 miles of streams in Pennsylvania earn the EV status. Saucony Creek is classified as a *Cold Water Fishery (CWF)* through the mid-basin. The drop in water quality is largely due to land use activities, lack of forested land and an increase in population, resulting in more impervious surfaces. By the time the Saucony reaches the Borough of Kutztown, the stream is classified as a *Trout Stocking Fishery (TSF)*. The *TSF* classification remains through the discharge to the Maiden Creek. The stream classifications and the primary geology for the Saucony Creek are presented on **Figure 2**.

3.4 Soils

The mid-basin soils of the Saucony Creek Watershed are composed of silt loams of the Clarkesburg, Duffield and Duffield-Ryder soil series. The soils are weathered from limestone and shale parent material and are well drained. Hydrologic Soils Groups are classified by the NRCS into four potential groups from A to D. Where A's have the smallest potential for runoff (sandy loams) and D's have the greatest potential for runoff (clay loams). The Saucony mid-basin is primarily composed of Hydrologic B soils that are well drained with a low run off coefficient. These soils are classified as prime farmland soils. **Appendix A** contains the NRCS Soil Resource Report for the Saucony Watershed mid-basin.

3.5 Geology

The diverse geology of the Saucony Creek Watershed plays a key role in water quality and landforms of the study area. Bedrock in the headwaters is underlain by pre-Cambrian aged (800 -1,000 million years old) gneiss and lower-Cambrian quartzite of the Reading Prong. The headwaters section is associated with the New England Province geologic setting. The remaining watershed is associated with the Great Valley section of the Valley and Ridge Province.

The Great Valley rock formations were formed in quiet seas on a shallow marine shelf that subsided regularly for millions of years. The subsidence resulted in sediment deposits in the thousands of feet thick. These very fine grain sediments formed the dolomite and limestone formations of the Lehigh Valley sequence that are exposed in the mid-basin of the Saucony Creek Watershed. The carbonate formations can be seen on **Figure 3.** The deposition occurred from 500 million to 440 million years ago. Towards the end of this depositional period, a transition occurred from the carbonates to the shale deposits of the Jacksonburg through Hamburg rock units. The lower Saucony Basin is underlain by the Jacksonburg Formation, Martinsburg Formation and the Hamburg Sequence. This transitional deposition period is evident in the change of topography from the broad carbonate valley to the lower basin defined by rolling hills of moderate relief.

Water in the headwaters start in the crystalline gneiss where the Saucony Creek will drop a total of 880 feet in elevation from the headwaters to the discharge point at Virginville. A majority of this total change in elevation occurs in the headwater area, where Saucony Creek drops 700 feet.

3.6 Groundwater

The movement of groundwater through an aquifer is largely dependent on the characteristics of the underlying geology. As groundwater moves through the mid-basin, seven unique geologic formations are encountered before the Saucony Creek enters the lower basin. Although these geologic formations have their own characteristics, they are all carbonate rock, composed either of dolomite or limestone. Collectively, the carbonate geology of the mid-basin shares similar characteristics that controls the movement of groundwater.

As noted in **Table 2**, although the drainage area is largest in the mid-basin, the stream density is significantly lower than the headwaters, or the lower basin. That means precipitation is infiltrating the soils at a high rate with minimum runoff. This is the direct result of the silt loam soils and the carbonate geology karst features, such as closed depressions and sinkholes.

Karst is a landform developed by the dissolution of rocks such as dolomite and limestone. Acidic water starts to dissolve cracks and bedding planes in the rock. As time goes on, the dissolution features get bigger and start to connect. As the conduits get larger, more water is infiltrated into the ground surface. In time, a drainage network develops, and large amounts of water can be transported through the karst network. As seen in the Saucony Watershed, streams disappear only to reemerge some distance downstream. Another example of the existing karst conditions is Crystal Cave, a popular attraction located in the Saucony Creek Watershed.

Carbonate aquifers can yield very high-producing wells; several in the area produce over 1,000 gallons per minute. On the downside, a sinkhole does not have filtering capacity from soil, and the water has the potential to travel quickly through the karst conduits to a water supply well. As the result of the geology in the Saucony Creek Watershed, the aquifer is very sensitive to land use practices and susceptible to pollution.

Fracture traces and lineaments are vertical fractures in the underlying geology that are expressed on the land surface. Geologists map these features from aerial photographs and satellite images. These features can transport large volumes of water and are used to locate high producing wells. These fractures are also important for locating potential sources of contamination in groundwater. **Figure 3** displays fracture traces and lineaments for the Saucony Creek Watershed as mapped by the Pennsylvania Bureau of Topographic and Geologic Survey. These fractures are denser in the mid-basin. The fractures also extend beyond the watershed boundaries and aid in groundwater flow between watersheds in the Great Valley Section. A number of these vertical fractures extend to the Kutztown Borough Farm from a far distance.

3.7 Watershed Groundwater Withdrawals

Groundwater withdrawal and recharge calculations are based on the Source Water Protection (SWP) Zone III area for the Kutztown Borough Wells. This is the area that contributes water to the Borough wells as delineated in the Northeast Berks County Wellhead Protection Plan. The Zone III SWP area covers 20.5 square miles and is shown on **Figure 6**. Using stream flow regression equations for a dry year of one-in-ten year recharge rate (90% of years will have more precipitation), the basin has 0.509 million gallons of groundwater available per day per square mile. Based on the area that contributes water to the Kutztown wells, the basin has 10.4 million gallons per day (mgd) available.

Permitted groundwater withdrawals in the Saucony includes the three community water systems of Kutztown, Lyons Borough, and Maxatawny Township, plus East Penn Manufacturing and the New Enterprise Quarry (formerly Eastern Industries Quarry). Groundwater usage for the Kutztown Borough Wells average 0.68 mgd, which represents 6.5% of the available groundwater. Lyons, Maxatawny, and East Penn Manufacturing account for 0.33 mgd or 3.2% of the groundwater. The largest groundwater withdrawal source is New Enterprise Quarry. From 2011 through September of 2015, the quarry has averaged an estimated 5.5 mgd of groundwater withdrawal or 53% of the available water in a one-in-ten year recharge rate. The quarry is permitted to dewater at a maximum rate of 5,000 gallons per minute (gpm) or 7.2 mgd. The quarry has submitted a permit application to DEP to increase their withdrawal rate. As shown on **Figure 4**, the groundwater pumped from the quarry through a pipeline is discharged to Saucony Creek after bypassing the Kutztown Borough Wells. This pipeline was installed in 2006.

Collectively taking all of the permitted groundwater withdrawal sources, the average daily groundwater withdrawal within the Kutztown SWP area is 6.51 mgd or 62.6% of the available groundwater during a dry year.

4.0 Kutztown Borough Water

The Kutztown Borough Farm is located on the southeast side of the Borough along a railroad spur as outlined in **Figure 5**. In the early 1900's, the Borough officials had the foresight to purchase the farm for their community water supply. The parcel is located along the confluence of the Saucony Creek and an unnamed tributary that drains 6.7 square miles of the eastern portion of the mid-basin. Saucony Marsh, a significant natural resource, overlaps a portion of the Kutztown Borough Farm. Four community drinking water wells are located on the Kutztown Borough Farm property.

4.1 Well Construction

The Kutztown wellfield is an interesting mix of four groundwater wells, ranging in depth of less than 50 feet to over 500 feet (**Table 3**). The wells are constructed as open-rock wells with steel casings set to a depth of approximately 50 feet below ground surface. The boreholes of the three highest producing wells of approximately 500 gallons per minute (gpm), penetrate what DEP categorize as a semi-confined aquifer. This means that while the well is pumping, a portion of the water can be entering the borehole from the unconfined water table above or even the ground surface. All of the wells drilled in the semi-confined aquifer are classified by DEP as "groundwater under direct influence of surface water" (GUDI). Basically, the water quality of a GUDI well can fluctuate following a precipitation event. Example includes a rise in turbidity due to sediment or a spike in bacteria. As a result, GUDI wells require special treatment before the water can be delivered to the customers. These wells are more susceptible to surface water contamination and land use practices. As a result, Kutztown operates a water filtration and treatment facility.

Table 3: Kutztown Well Data

Well Number	Well Depth (ft)	Casing Depth (ft)	Pumping Rate (gpm)	Aquifer Type	Under the Influence of Surface Water	Date Drilled
Well #1	37	30	536	Semi-confined	Yes	<1930's
Well #2	50	47	490	Semi-confined	Yes	1930's
Well #3A	506	33	120	Confined	No	1980's
Well #4	195	28	565	Semi-confined	Yes	1960's

4.2 Kutztown Water Use

The Borough of Kutztown's water distribution system serves people residing in the Borough, students and faculty of Kutztown University, and small number of residences located in Maxatawny Township. In total, the Borough provides drinking water for 14,200 customers. All four of the groundwater wells are located on the Borough Farm property. The Borough serves water to Kutztown University, which can be challenging, depending if the University is in session or not. The average water production when the University is in session is 660,000 gallons per day (gpd) and 500,000 gpd out of session.

4.3 Drinking Water Parameters

In order to ensure that a community's drinking water supply is safe to consume, the DEP has a rigorous set of drinking water parameters to analyze at a set frequency. The analytical results of the sampling is presented in a report called the Consumer Confidence Report (CCR). The CCR is made available to the public and can usually be found on the water systems website.

Based on the available analytical database for community drinking water systems, the compound nitrate (NO3-) was selected to best represent groundwater impairment from agriculture activities. Nitrates in groundwater can be found at relatively low concentrations, but in areas of intense farming, nitrate concentrations can approach or exceed the safe drinking water standards. The U.S. Environmental Protection Agency (EPA) has set the maximum contaminant level for nitrate at 10 mg/l, due to health concerns for infants and pregnant women. Nitrates can have a negative effect on the body's ability to carry oxygen in the bloodstream, known as Methemoglobinemia or "Blue Baby" condition. Infants can starve for oxygen in their bloodstream, causing their skin to turn blue. In some instances although rare, Methemoglobinemia can be fatal. Additionally, medical studies are linking nitrates/nitrites to health concerns including cancer and birth defects.

4.4 Source Water Protection

The U.S. Congress developed an important statute in the 1970's to protect human health by maintaining clean drinking water. As the Safe Drinking Water Act (SDWA) matured, the EPA started to develop a program for community water systems to focus on methods to keep their water sources clean, before the water treatment process. In 1992, the Borough of Kutztown was awarded an EPA Wellhead Protection (WHP) Demonstration Grant to assist EPA in developing this new national Program. This pilot study was one of the first in the nation. The SDWA Act was amended by the U.S. Congress in 1996, which included the SWP Program. Today's Source Water Protection Plans, got their start in Kutztown and the Saucony Creek Watershed.

In the mid-2000's, Kutztown reached out to the Borough of Lyons and Maxatawny Township, who also operate community water systems in the Saucony Creek Watershed, to create the Northeast Berks County, Wellhead Protection Plan. This study was funded by a grant through the Pennsylvania DEP. In 2008, the Wellhead Protection Plan was approved by DEP and measures were put into effect to protect the drinking water for over 15,000 people in the Saucony Creek Watershed. Following approval of the SWP Plan, Kutztown Borough started to work with Berks Nature to implement the SWP management initiatives. Since the community water wells are located on a working farm, owned by the Borough, it was ideal location to establish agriculture BMPs. Following the creation of a Conservation Plan, BMPs were implemented, including vegetative and woody buffers, vegetated swales, managed crop rotation and no-till farming practices. Through the SWP initiative, the theme, "Drinking Water Quality is Everyone's Responsibility" and the Borough Farm BMPs are still being used today, to educate the family farmers of the area.

5.0 Agriculture Best Management Practices

Agriculture in the Saucony Creek Watershed includes many small family owned farms that produce both crops and livestock. Agriculture producers are important to the Saucony Watershed, but also to Berks County as a whole. The 2012 Census of Agriculture has Berks County ranked third in the State for both crops and livestock production. Due to the leadership of the Berks County Department of Agriculture, Berks County is ranked third in the nation for Agricultural Land Preservation with 700 farms, and close to 70,000 acres dedicated to producing a sustainable food supply for generations to come.

The following sections describe the BMPs and the numerous conservation partners that have worked creatively together to restore the Saucony Creek Watershed.

The first agricultural BMPs were initiated in 2002 with Berks Nature and the Tulpehocken Chapter of Trout Unlimited installing over 9,000 feet of streambank cattle exclusion fencing. Since the initial farm restoration project, at least 13 partners have joined forces for a concentrated effort to restore the watershed. All of the projects listed in this study have been installed in the Kutztown's Source Water Protection Zones. Additional agricultural BMPs, downstream from the Kutztown Borough Farm, have been completed in the lower Saucony Basin. These projects are not included in this study because the area does not contribute to Kutztown's groundwater drinking supply.

The Saucony Watershed Restoration Timeline includes the date, location, BMPs and funding partners is contained in **Appendix B**. The timeline also includes the amount of nutrients (nitrogen) captured per farm in waste storage. The location of the farms and completion date of the BMPs and the Source Water Protection Zone III are displayed on **Figure 6**. The Source Water Protection Zone III is the watershed area that has the potential of contributing water to the Kutztown wells.

A large number of dedicated conservation partners have teamed together to install BMPs on the individual farms. Partners include non-profit organizations, government organizations and water restoration funds that are a mix of government and private partnerships. The USDA NRCS and NFWF have been very active in the watershed. The one constant in all of the farm restoration projects is Berks Nature. The following is the list of conservation partners who have been actively involved in funding and participating in the farm BMP projects:

- **Berks Nature**

- **Friends of the Saucony Creek Marsh**
- **Maiden Creek Watershed Association**
- **Trout Unlimited, Tulpehocken Chapter**
- **Kutztown University**
- **USDA-Natural Resources Conservation Service (NRCS)**
- **National Fish and Wildlife Federation (NFWF)** with major support from the William Penn Foundation
- **PA Department of Conservation & Natural Resources (DCNR)**
- **PA Department of Environmental Protection (DEP)**
- **Berks County Conservation District**
- **Berks County**, Agricultural Land Preservation Program, Department of Agriculture, and the Planning Commission
- **Schuylkill River Restoration Fund** with support from Exelon-Limerick Generating Station, the Philadelphia Water Department, Partnership for the Delaware Estuary, and other donors
- **Berks Watershed Restoration Fund**, a local grant source that offers financial assistance to Berks County agriculture producers for nutrient planning and project cost-share. This fund was originally created by staff from Spotts, Stevens and McCoy and Berks Nature through a grant from William Penn Foundation. Local supporters to the fund include Kutztown Borough, Reading Area Water Authority (RAWA), Western Berks Water Authority (WBWA), and Saucony Creek Brewing Company

The strategy used in selecting the individual farm projects was to initially concentrate the efforts on the farms surrounding the Kutztown Borough Farm and the properties immediately upstream, particularly with stream footage along the Saucony Creek and the tributaries. The second phase was to concentrate on farms generating the most nutrients throughout the mid-basin and headwaters. These projects were selected based on the sensitive nature of the carbonate geology, and the cumulative nutrient impacts. In most cases, multiple BMPs were selected based on the individual needs of the farm to maximize the management of nutrient and sediment runoff. The majority of agricultural BMP projects were completed in conjunction with NRCS using their Environmental Quality Incentive Program (EQIP) for ranking, inventory and evaluation, engineered designs, and construction oversight. In total, 29 farm restoration projects have been completed in the mid-basin and headwaters of the Saucony Creek Watershed, with an additional two projects scheduled for completion in 2017.

As a result of the Saucony Creek Watershed restoration strategy, the NRCS designated the Saucony Creek Watershed with, the National Water Quality Initiative (NWQI) status. Only priority watersheds are selected for the NWQI designation where farm conservation projects will produce the greatest water quality improvement. This is an important award for a watershed as it provides funding for farm conservation projects. The Maiden Creek Watershed, of which the Saucony Creek is a subwatershed in, has also obtained the NWQI designation status. Other funding-partnership initiatives followed, including the William Penn Foundation's Delaware River Watershed Initiative (DRWI) for improving water quality in targeted watersheds. The Maiden Creek Watershed was included as a priority watershed in the Middle Schuylkill cluster, focusing on agricultural restoration. The Maiden Creek Watershed also received the NRCS, Regional Conservation Partnership Program (RCPP) status. The RCPP is a source of funding for locally driven projects with public-private partnerships that improve the nation's water quality. All of these partnerships and watershed designations were critical for restoration work performed on the private farms.

The NRCS programs have recognized the importance of carbonate aquifers, and have elevated them as a priority when evaluating grant applications. This priority ranking is attributed to the work performed in the Saucony Creek Watershed and other carbonate watersheds within the Valley and Ridge Province of eastern Pennsylvania.

While the NRCS, NFWF and Berks Nature have been discussed as key contributors, the success of the watershed restoration would not have been possible without the contributions of the 13 individual conservation funding partners. It is typical for multiple funding sources to be used on each farm restoration project. As an example, for a $100,000 farm restoration project, NRCS generally provides two-thirds of the funding and most farmers require assistance to cover the remaining $33,000. The supplemental funding such as the Berks and the Schuylkill Watershed Restoration Funds is critical in the gaining final approval to implement the farm projects. Without the flexibility of the supplemental funds, a majority of the individual projects would not have been initiated.

5.1 Kutztown Borough Farm

Following the development of the Northeast Berks County, Wellhead Protection Plan, Berks Nature was awarded a DEP grant in 2008 to develop a Farm Conservation Plan and install BMPs on the Kutztown Borough Farm. The DEP grant was utilized to buffer the Kutztown wells from the on-site agricultural activities and use the BMPs as a demonstration project. This demonstration project was used to show local farmers how BMPs can be used to assist agricultural production and support clean water. The following agricultural BMPs were installed on the Borough Farm:

- 13.9 acres of vegetated filter buffer on previously tilled cropland,

- 5.6 acres of riparian forest buffer on previously tilled cropland with planting of 1,430 native trees and shrubs,
- 975 feet of vegetated filter swale,
- In addition to the DEP grant, a Conservation Plan on the neighboring farm was developed and implemented and a 20-year lease was negotiated between the Borough of Kutztown and Saucony Meadows, LLC, to establish a riparian forest buffer of 195 native trees and shrubs, replacing the 1.2 acres of mowed lawn. The neighboring farm Conservation Plan was instrumental in protecting the Saucony Marsh (15.4 acres), a rare freshwater marsh as a Wildlife Area; it converted Cropland Fields (4.8 acres) to permanent Filter Buffer Strips. Another Wildlife Area (4.4 acres) was formed by installing streambank fencing.

The SWP project on the Kutztown Borough Farm, established the theme that is still used today: "*Drinking Water Quality is Everyone's Responsibility*". Two keystones for any successful community and local economy are quality local food and quality local drinking water. Kutztown Borough and Berks County are blessed with both high-quality water and food production. Encouraging, investing, and participation in agriculture BMP projects strengthens the local farming communities, while protecting high-quality drinking water supplies.

5.2 Saucony Creek Watershed: Best Management Practices

In response to high level of nitrates in the Kutztown Borough drinking water wells and surface waters of the Saucony Creek, Berks Nature and partners secured funding to install BMPs designed to prevent nitrogen, phosphorous, pathogens and sediment from reaching the surface water, stormwater, and groundwater, particularly in the vulnerable carbonate geologic section. NRCS was key in selecting the appropriate BMPs from a full suite of program practices including, but not limited to the following:

- liquid manure storage (dairy manure and/or barnyard run-off),
- dry manure storage (stacking sheds and bedded pack facilities),
- decommissioning of failed practices (failed earthen lagoons and/or failed or inadequate storages),
- stormwater controls (rain gutters, lined outlets, collection boxes, grassed waterways, level spreaders, etc.),
- barnyard controls (curbing, etc.),
- silo controls (leachate collection and transfer to storage),
- milkhouse controls (waste collection and transfer to storage),
- manure transfer,

- grazing regimes (grazing fencing; stabilized animal walkways & streambank fencing),
- covers crops,
- watershed buffers (riparian & wetland buffers).

The primary means for selecting the appropriate agricultural BMPs are approved Conservation and Nutrient Management Plans. These plans detail the capture, storage, management and the recycling of nutrients by the crops grown on the acreage farmed by the owner/operator.

Berks Nature, a 501(c)3 land trust, also employs the complementary strategy of land protection of forested lands in headwater areas. The basic premise is to keep water clean by protecting forests and establishing agricultural BMPs, where forest cede into agricultural zones. Forests provide natural chemical and biological buffering/filtering components and are a critical part of the Saucony Creek restoration strategy. By working in unison with the numerous agriculture BMPs established downstream, clean water flowing from the headwaters reinvigorates the downstream portions of Saucony Creek. Berks Nature has been involved in four land preservation projects in the Saucony Creek headwaters, totaling more than 500 acres. **Figure 7** shows the forested land use pattern of the headwaters and the agriculture land use of the mid-basin.

5.3 Nutrient Reduction

The Conservation and Nutrient Management Plans with supporting BMPs are designed to control excess nutrients and sediment from entering waterways, including groundwater. The amount of the nutrients and sediments can be calculated per BMP on a pounds per year basis. For this study, pounds of nitrogen managed per year was calculated, based on the following time periods: 2002-2007, 2008-2014, and 2015-2016. Each of these time periods had roughly the same number of new agriculture projects. Several of the farms had BMPs installed on a phased approach that spanned more than one of the time segments. From the 2002-2007 time frame, 10 agriculture conservation projects were completed. These agricultural BMPs included grazing regimes, land preservation, headwater projects, and barnyard controls.

From 2008-2014, 10 conservation projects were completed, many with NRCS assistance. It was during this period that BMPs were installed on the Kutztown Borough Farm and surrounding upgradient farms. A majority of the projects involved manure storage controls, which have a large impact on reducing excess nutrient runoff. By the end of 2014, BMPs accounted for 184,700 pounds of nitrogen was being managed on an annual basis.

The final time period of 2015-2016 had nine projects completed during the past two years. While multiple types of BMPs were installed, most projects included manure storage infrastructure. The agriculture restoration projects completed during this period controlled an additional 84,900 pounds of nitrogen per year.

For the accumulation of Saucony Creek Watershed restoration projects completed through 2016, nearly 270,000 pounds of nitrogen is being managed. Nitrogen, phosphorous, pathogens and sediment are being controlled by the BMPs installed on the Saucony Creek Watershed since 2002.

This study utilized the Pennsylvania Nutrient Management Act 38 Program's, Technical Manual methods for computing the unit mass calculations for nitrogen captured by the farm BMPs. Additional details for the nutrient unit mass calculations are provided in **Appendix C** along with pictures of the BMPs.

6.0 Groundwater Quality Assessment

The following sections describes how nitrates move through aquifers and their impact on the Kutztown raw drinking water quality. The final section discusses the outcomes of the Saucony Creek Watershed restoration efforts. Although this report focuses on the groundwater aspects of watershed restoration, it is best to view a watershed as *One Water,* with surface water and groundwater viewed as a single dynamic system for protecting drinking water.

6.1 Nitrates in Groundwater

Nitrogen is the most abundant element in the atmosphere (78%). Atmospheric nitrogen has little value to plants unless converted by either biological or physical processes to nitrates. Nitrogen-nitrate is an essential element for plants, including turf grass (lawns) and agriculture crops. Bacteria in the soil converts the nitrogen to nitrates which can be absorbed through the plant's root structure. Excess nitrates not absorbed by plants will be leached through the soil horizon to the water table. Nitrates are highly soluble and once they reach the water table, they are readily transported through the watershed by groundwater. Nitrogen-nitrate is utilized in large quantities as a fertilizer for lawns, gardens and crop applications.

Nitrates can also occur from the decomposition of animal or human waste. This biological process is the reason that manure is a good source of nutrients for crops when efficiently applied. When nitrates exceed background levels, it is a good indicator of a source of pollution, either from fertilizers, manure or malfunctioning septic systems.

6.2 Kutztown Borough Farm: Nitrate Results

In accordance with DEP's drinking water monitoring requirements, the Kutztown Borough Water Department has been collecting water quality samples from the Borough wells for years. During this time period, nitrate concentrations have been analyzed on a quarterly basis by a certified laboratory. Per DEP sampling requirements, the water analyzed for nitrates is representative of the four active Kutztown wells. In other words, the sample results are representative of the aquifer that is the source of drinking water for the Borough. The nitrate data utilized for this report starts in the year 2000, two years before the Saucony Creek Watershed restoration activities were initiated. The 17 years of data provides a long-term view of the nitrate trends in the Saucony Creek Watershed.

The 68 individual nitrate sample results from the Kutztown wells are displayed on **Figure 8** as mg/l. The overall nitrate concentration patterns can be viewed in three separate segments. From 2000 through 2007, 80 percent of the samples were above 8 mg/l. During these eight years, the nitrate levels were consistent with the average concentration ranging from 8.0 to 8.4 mg/l. Due to the consistency of the nitrate results, seasonal variability and precipitation had little influence over the nitrate concentrations in the Kutztown wells. As a result of the nitrate concentrations approaching the *Maximum Contaminant Level* (MCL) of 10 mg/l, Kutztown Borough installed denitrification equipment in the water treatment plant. The water treatment process ensures that the finished water served to the customers meet all of DEP's water quality standards.

Starting in the last quarter of 2007 after six years of watershed restoration, fluctuations in the quarterly nitrate concentrations started to transpire. From 2008 -2014, only 29% of the sample results were above 8 mg/l. The yearly nitrate average ranged below 8 mg/l for the first time, with concentrations of 7.0 to 7.9 mg/l. It was during this time frame, that the Kutztown Borough Farm *SWP* measures were implemented on the Borough Farm property and surrounding farms. By the end of 2014, a total of 20 agriculture watershed conservation projects were completed within the Saucony Creek Watershed. During the final observation segment, 2015-2016, nitrates continued to decline with an average result of 6.7 mg/l. The following is the average nitrate concentration for the three observation periods.

- 2000-2007: Nitrate Concentration – 8.2 mg/l
- 2008-2014: Nitrate Concentration – 7.4 mg/l
- 2015-2016: Nitrate Concentration – 6.7 mg/l

By the end of 2016, an additional nine agriculture watershed restoration projects were completed, bringing the total to 29 projects. **Figure 9** displays the average of the four nitrate sample results per year and the high and low individual values for each year. The declining nitrate trends are evident.

6.3 Watershed Restoration Results

Groundwater starting in the headwaters of the Saucony Creek Watershed first encounters two community drinking water systems, the Lyons Borough (PWSID #3060096) system and the Maxatawny Township Municipal Authority (PWSID #3060013) system. These community water systems rely on groundwater for their drinking water and are located upgradient from the Kutztown wells. The nitrate levels of these water systems were compared to the Kutztown wells for the same time period from year 2000 through 2016. While the Kutztown nitrate levels were above 8 mg/l for the first seven years, the Lyons and Maxatawny nitrate levels were less than 4 mg/l. The elevated nitrate concentrations found in the Kutztown wells are not a watershed-wide issue, but an indicator of agriculture pollution. A number of factors can influence water quality, but the crystalline geology and land use play a major role. The upgradient area for both Lyons and Maxatawny wells are primarily forested (69%), with less agriculture (22%), resulting in lower nitrate levels. The historical nitrate analytical results for Lyons, Maxatawny and Kutztown wells are contained in **Appendix D.**

The aquifer providing the Kutztown water is located in the heart of "Farm Country". Agriculture accounts for 66% of the land use in the mid-basin. Most of the farms are small family owned and operated. Prior to the watershed restoration efforts, many farms spread manure on the fields, often regardless of the weather, season or soil conditions. These farms did not have adequate manure storage and management options. As a result of the lack of manure management, nitrates leached into the groundwater causing elevated levels in the Kutztown source water.

The Saucony Creek Watershed restoration efforts kicked off in 2002, with over 9,000 feet of streambank fencing installed over four farms to keep the livestock out of the Saucony Creek. Through 2002 to the end of 2007, additional BMPs were installed, including riparian buffers and barnyard controls such as rain gutters and stormwater controls. Although not technically a BMP, but just as important, numerous Conservations Plans and Nutrient Management Plans were developed for farms located upgradient of the Kutztown Borough Farm. The Saucony Marsh was also preserved during this time period. As displayed in **Figure 10**, the nitrate levels stayed very consistent from 2000 until the last quarter of 2007.

With the groundwater table only 5-8 feet below ground surface at the Borough Farm, the Kutztown wells are very sensitive to land use activities. Based on water quality monitoring, DEP has classified the Kutztown wells as *groundwater under the direct influence of surface water*. As a result, Kutztown filters, denitrifies and disinfects their raw water before serving it to their 14,000 customers. Since Kutztown's source water is directly influenced by land use practices, the BMPs installed on the Borough Farm and surrounding farms had a direct influence on nitrate levels. This is evident in the 2008-2014 nitrate results presented in **Figure** 8. The other significant influence on the downward trend of nitrates was the partnership of NRCS and Berks Nature. By the end of 2014, the manure storage facilities installed on the upgradient farms were managing an estimated 184,700 pounds of nitrogen annually. Previously, these farms had minimum controls to manage the nutrient/sediment runoff. During this time period only 29% of the nitrate samples collected from the Kutztown wells were above 8 mg/l. With the nitrate levels fluctuating between less than 5 mg/l to over 9 mg/l, elevated levels of nitrates remained in the aquifer as pockets of higher concentrations. Over time with additional farm BMPs installed, accounting for nearly

270,000 pounds of nitrogen, nitrate loading was greatly reduced in the aquifer. The end result is declining nitrate levels in the Kutztown wells. **Figure 10** ties together the watershed restoration milestones, pounds of nitrogen captured and trend lines of the nitrate analytical results.

An important feature of the Saucony Creek Watershed is the headwater area. Based on factors including the underlying geology, forest cover, relatively steep slopes and land use; the headwaters produce high quality water. When an impaired watershed starts with high quality headwaters, there is a chance of improving the water quality downstream in the non-forested areas. To ensure that the water quality of the headwaters stays pristine, several agriculture and land preservation programs were utilized. Woodland properties with stream footage were targeted for protection. Also, working with the NRCS, several farms are enrolled in the Conservation Reserve Enhancement Program (CREP) grassland and wetland reserves programs. Maintaining the pristine water quality of the headwaters is an important component of the future of the Saucony Creek Watershed.

As farmers better manage their nutrients, soil, and water resources by following their approved Conservation and Nutrient Management Plans, the natural ecosystem can function properly and enhance the watershed restoration results. The ecosystems role is hard to quantify, but the process is continuous.

Clean drinking water and high quality waterways are possible in heavy agricultural producing areas. To effectively manage agriculture and clean water, it takes a paradigm shift, from "*This is the way it's always done*" to "*Clean Drinking Water is Everyone's Responsibility*". This is a major change in thinking that takes active partners, planning and community buy-in. Cleaning up the Saucony Creek Watershed is not only important to the Borough of Kutztown, but to all of the down-stream water purveyors. The water discharging from the Saucony Creek flows to Lake Ontelaunee, the drinking water source for the City of Reading. Once the water enters the Schuylkill River, there are many downstream water systems, including Philadelphia Water Department, that benefits from the watershed restoration activities of the Saucony. Although in the big picture, it may appear insignificant at first, but watershed restorations like Saucony Creek are having a positive impact on the Delaware River Basin.

7.0 Future Watershed Restorations

Updating obsolete agriculture infrastructure has an immediate payback for the privately owned farms. Having the ability to store manure for up to six months, allow the farms to optimize the use of manure for crop uptake during the prime growing seasons. Farms become more sustainable and the need to purchase manufactured fertilizer is reduced. So why do drinking water systems invest in SWP measures, like the Saucony Creek Watershed restoration? Investing in SWP measures help to reduce treatment costs of the finished water. To remove nitrates from drinking water, a higher level of treatment is required, such as Reverse Osmosis or Ion Exchange. These water treatment methods are expensive and energy intensive to operate. When water systems annually invest a portion of their budget for SWP projects, the payoff is cleaner source water and less treatment cost to deliver safe and reliable drinking water. Since its inception, Kutztown and RAWA has been investing in the Saucony Creek Watershed restoration project. Where does the Saucony Creek Watershed restoration go starting in 2017?

The larger Maiden Creek Watershed, which includes the Saucony Creek Watershed, has similar physical characteristics. The majority of the land use is agriculture (58%), with the prime agriculture soils located in the carbonate valley. The next logical progression is to expand the Saucony Creek Watershed restoration model to the Maiden Creek Watershed.

The critical funding partners are in place to expand the success of the Saucony Watershed restoration to the larger Maiden Creek Watershed. The NRCS has recognized the Maiden Creek as a priority watershed with the designation of the NWQI status. There are numerous community drinking water sources located in the watershed, including the largest water system in Berks County, RAWA. A majority of these community water systems are already working together to protect their drinking water quality by participation in the Berks County Source Water Protection Plan, which is one of the first of its kind.

A study of the Maiden Creek Watershed could include water quality data from numerous monitoring stations already established throughout the watershed, both surface water and groundwater. Additionally, some of the organizations conducting surface water monitoring have the flexibility to establish new monitoring stations at critical stream points to best analyze water quality improvements due to agricultural BMPs. The groundwater and drinking water monitoring can be achieved by working with additional community water systems in the Maiden Creek Watershed.

Through the efforts of the Schuylkill Action Network (SAN) and the William Penn Foundation's DRWI, it has been long recognized that nutrients, pathogens and sediments from agricultural sources are the main water quality issues of the Maiden Creek Watershed and other watersheds located in Berks County. A focus on watershed restoration practices in the Maiden Creek Watershed can have a positive impact on the quality of life of the region. The Saucony Creek Watershed restoration has demonstrated that intensive agriculture production areas and clean water can coexist in a mutually beneficial way.

Figures

Figure 1

Project Location Map

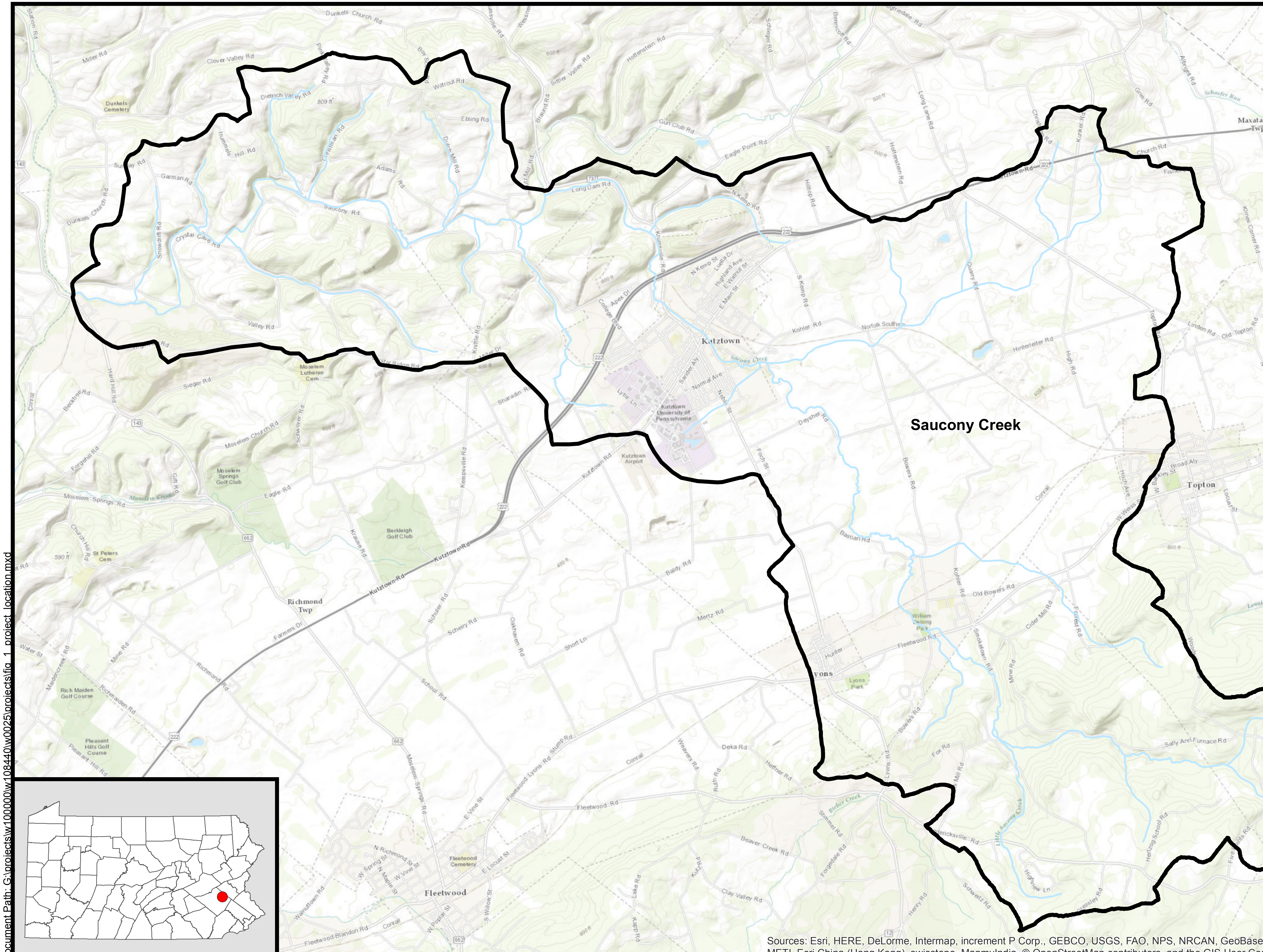

Figure 1
Saucony Creek Watershed
Project Location Map
Berks County, PA

Stream

Watershed Boundary

N

0 3,700 7,400 Feet

1:48,000

Data Source:
Watershed, ERRI, 2007
Stream, PA DEP, 2014

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Document Path: G:\projects\w100000\w108440\w0025\projects\fig_1_project_location.mxd

Figure 2

Stream Classification Map

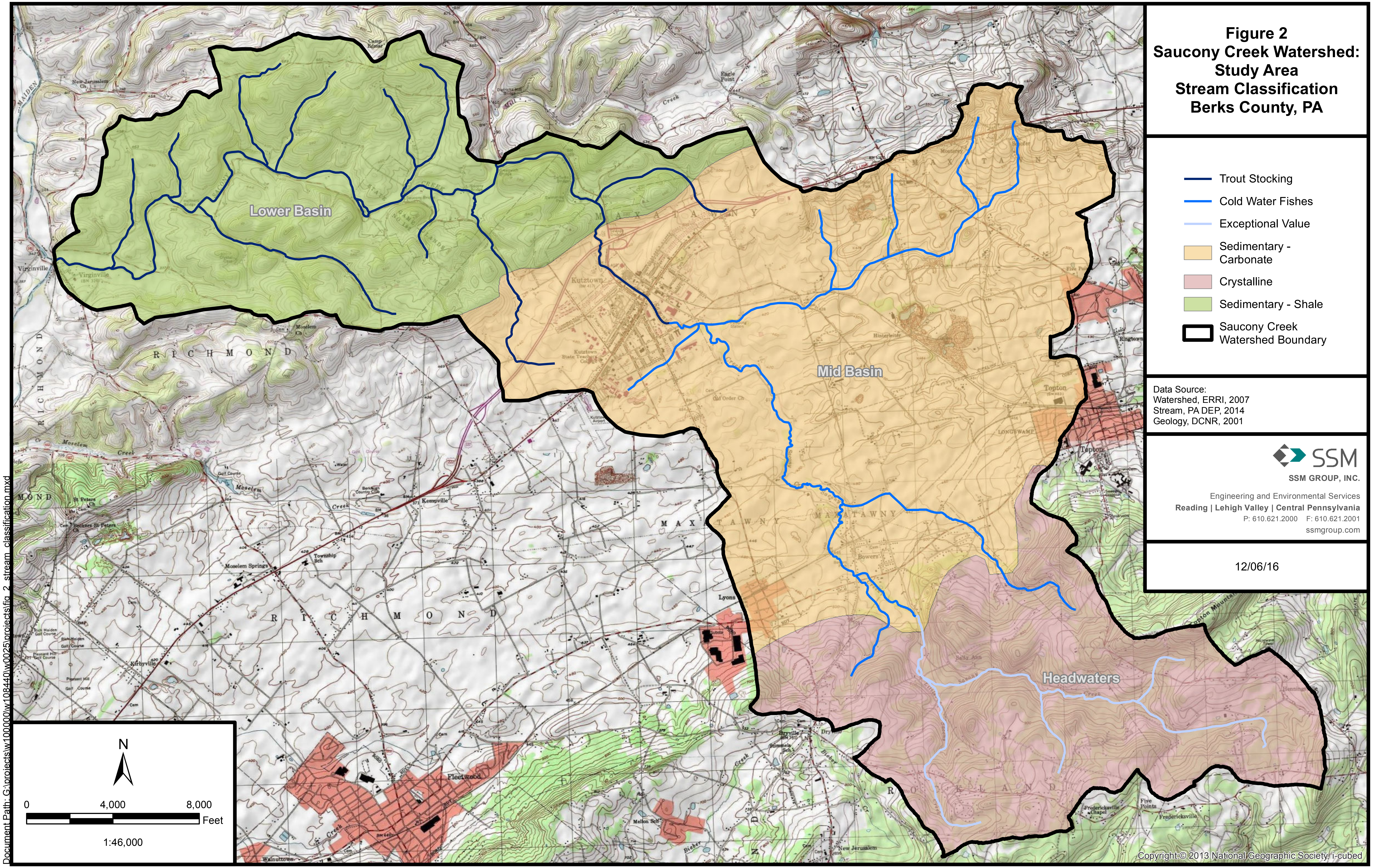

Figure 2
Saucony Creek Watershed: Study Area
Stream Classification
Berks County, PA

Document Path: G:\projects\w100000\w108440\w0025\projects\fig_2_stream_classification.mxd

Figure 3

Geology Map

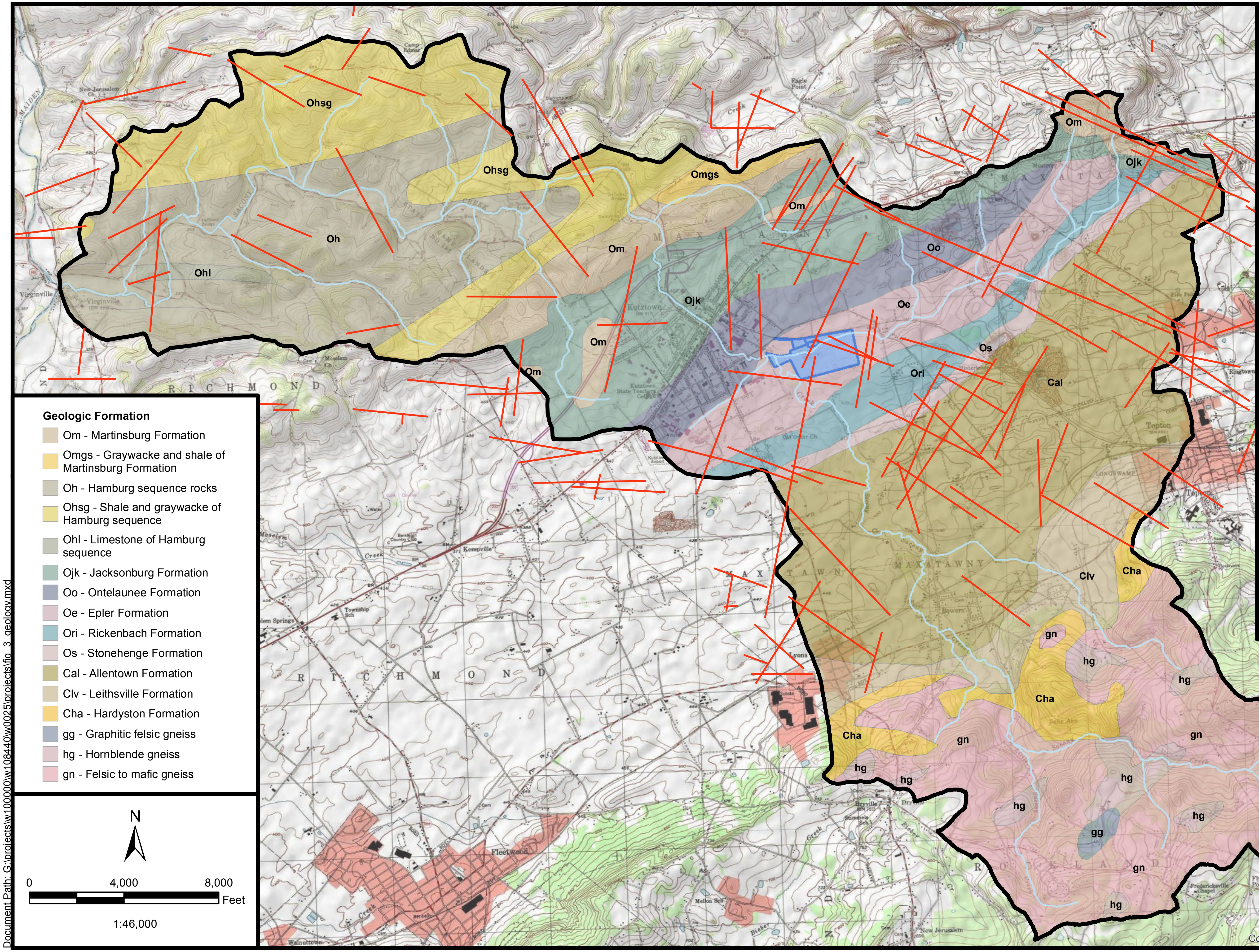

Figure 3
Geology
Saucony Creek Watershed
Berks County, PA

Data Source:
Watershed, ERRI, 2007
Stream, PA DEP, 2014
Geology, DCNR, 2001
Fracture Trace, DEP, 1978

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Figure 4

Quarry Discharge Map

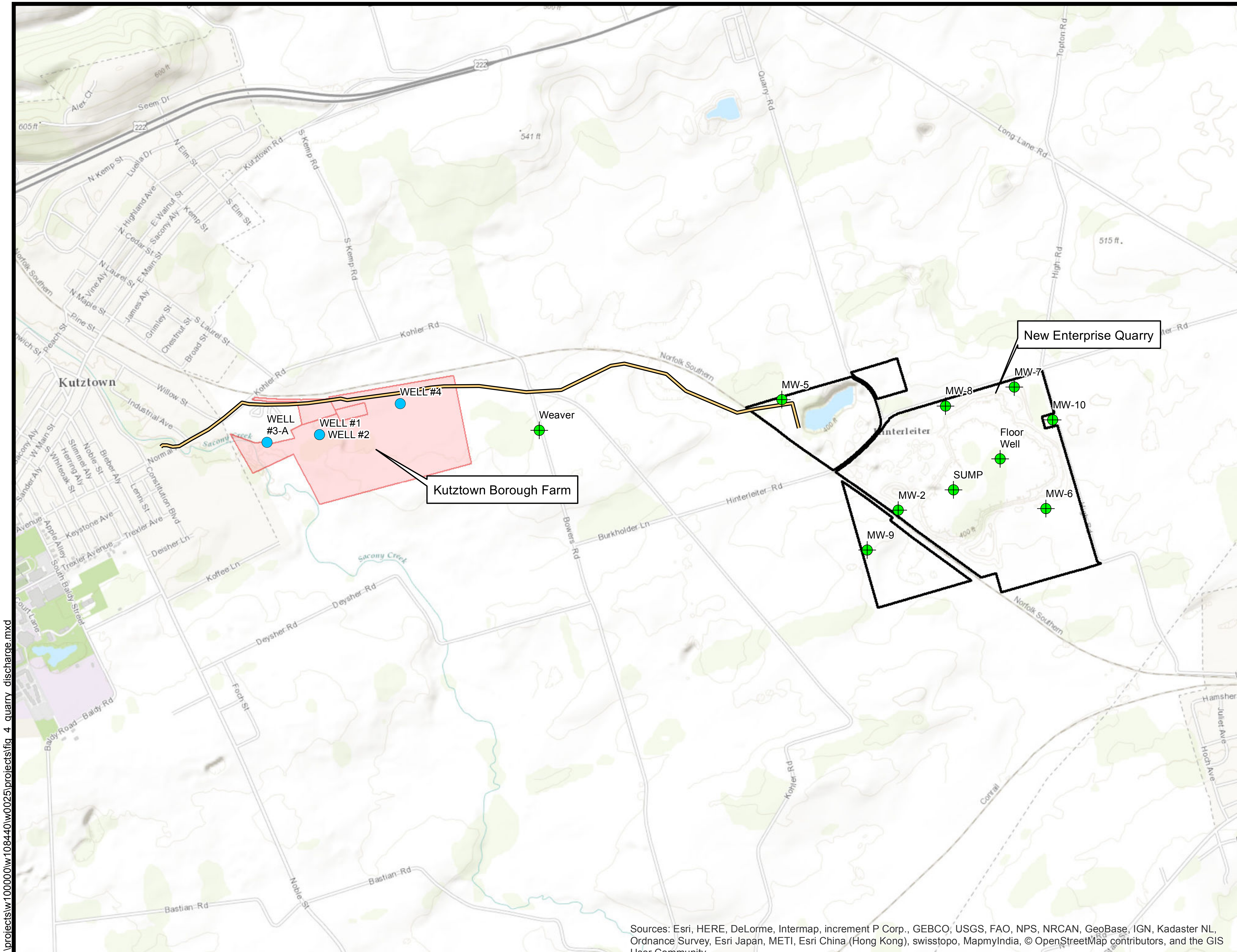

Figure 4
Quarry Discharge Line
Kutztown Borough Farm
Berks County, PA
PWSID# 3060041

- Kutztown Borough Water
- Monitoring Well
- Discharge Pipeline
- Kutztown Borough Farm
- Quarry Property

N

0 1,500 3,000 Feet

1:18,000

Data Source:
Public Well, SSM, 2007
Monitoring Well, NESL, 2015
Property, Berks Co., 2014
Pipeline, NESL, 2015

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Figure 5

Kutztown Borough Farm

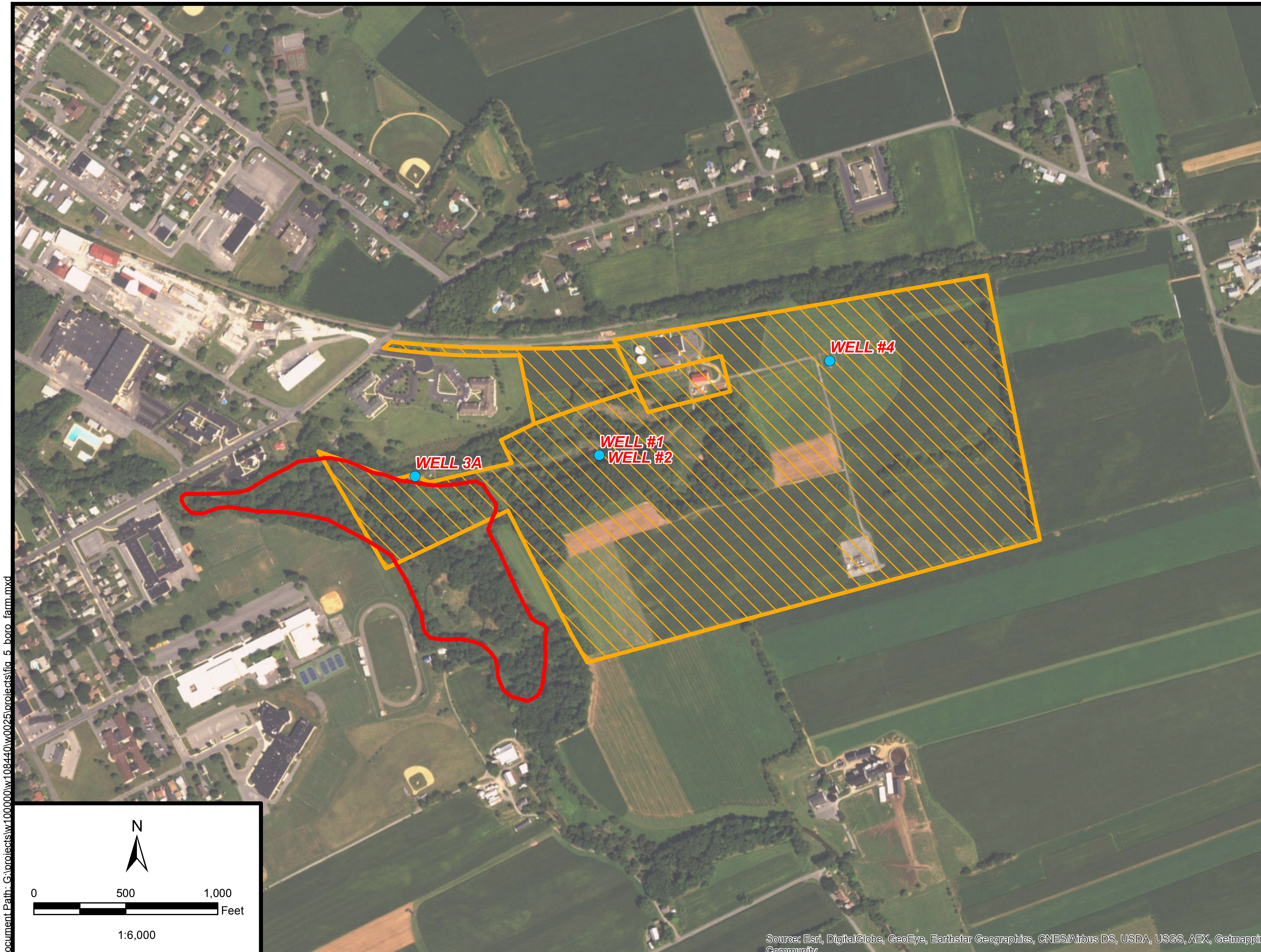

Figure 5
Kutztown Borough Farm
Saucony Creek Watershed
Berks County, PA

Kutztown Borough Water Well
Kutztown Borough Farm
Saucony Marsh & Associated Wetlands

Data Source:
Boro Farm, SSM, 2016

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Figure 6

Farm Restoration Projects

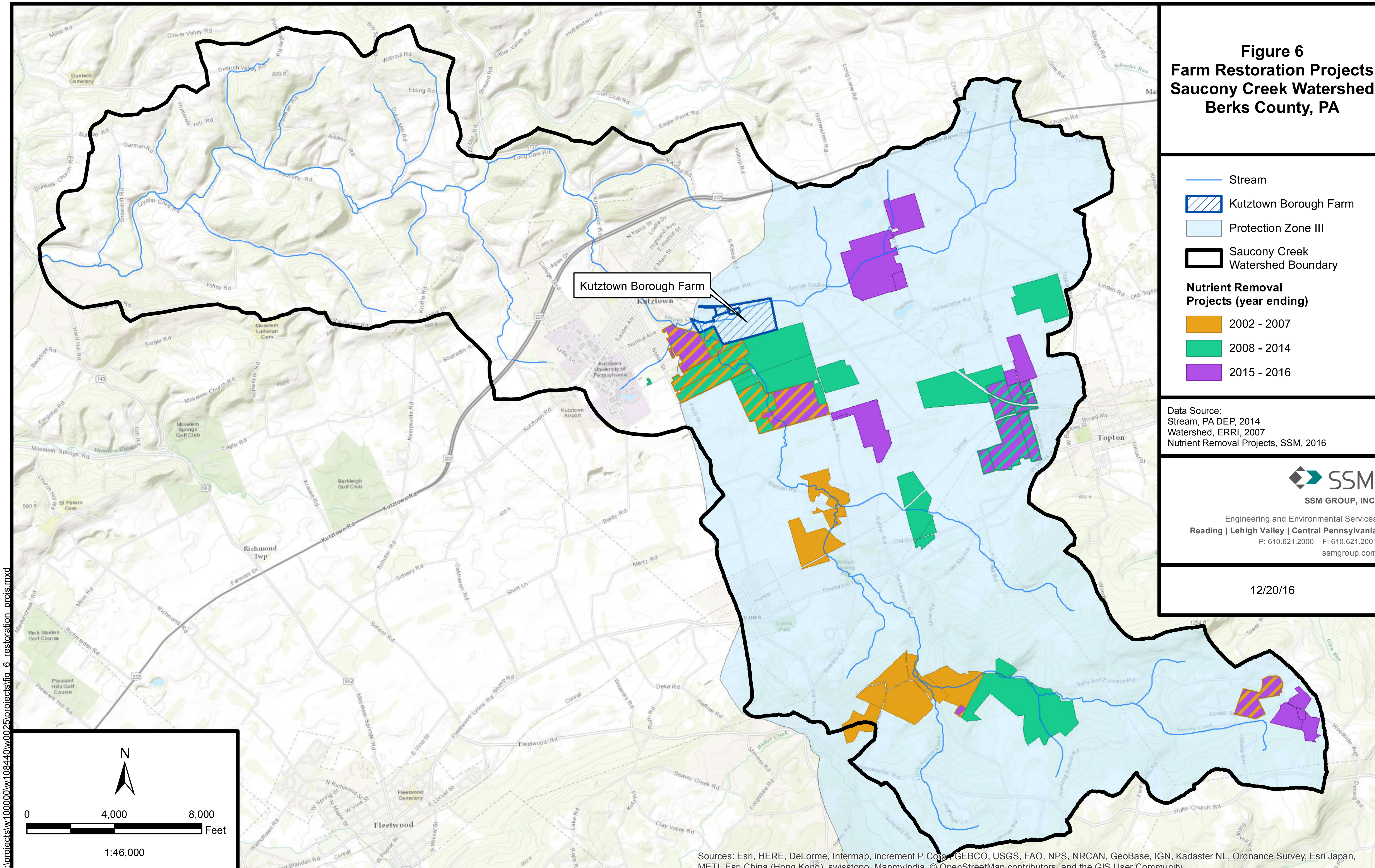

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Figure 7

Land Use Patterns

Figure 7
Land Use Patterns
Saucony Creek Watershed
Berks County, PA

- Kutztown Borough Farm
- Headwaters
- Mid Basin
- Saucony Creek Watershed Boundary

Data Source:
Watershed, ERRI, 2007
Kutztown Borough Farm, SSM, 2016
Nutrient Removal Projects, SSM, 2016

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Figure 8

Kutztown Borough Wells: Nitrate Concentrations

Figure 8
Nitrate Concentration
Saucony Creek Watershed
Berks County, PA

Data Source:
Graph, SSM, 2016

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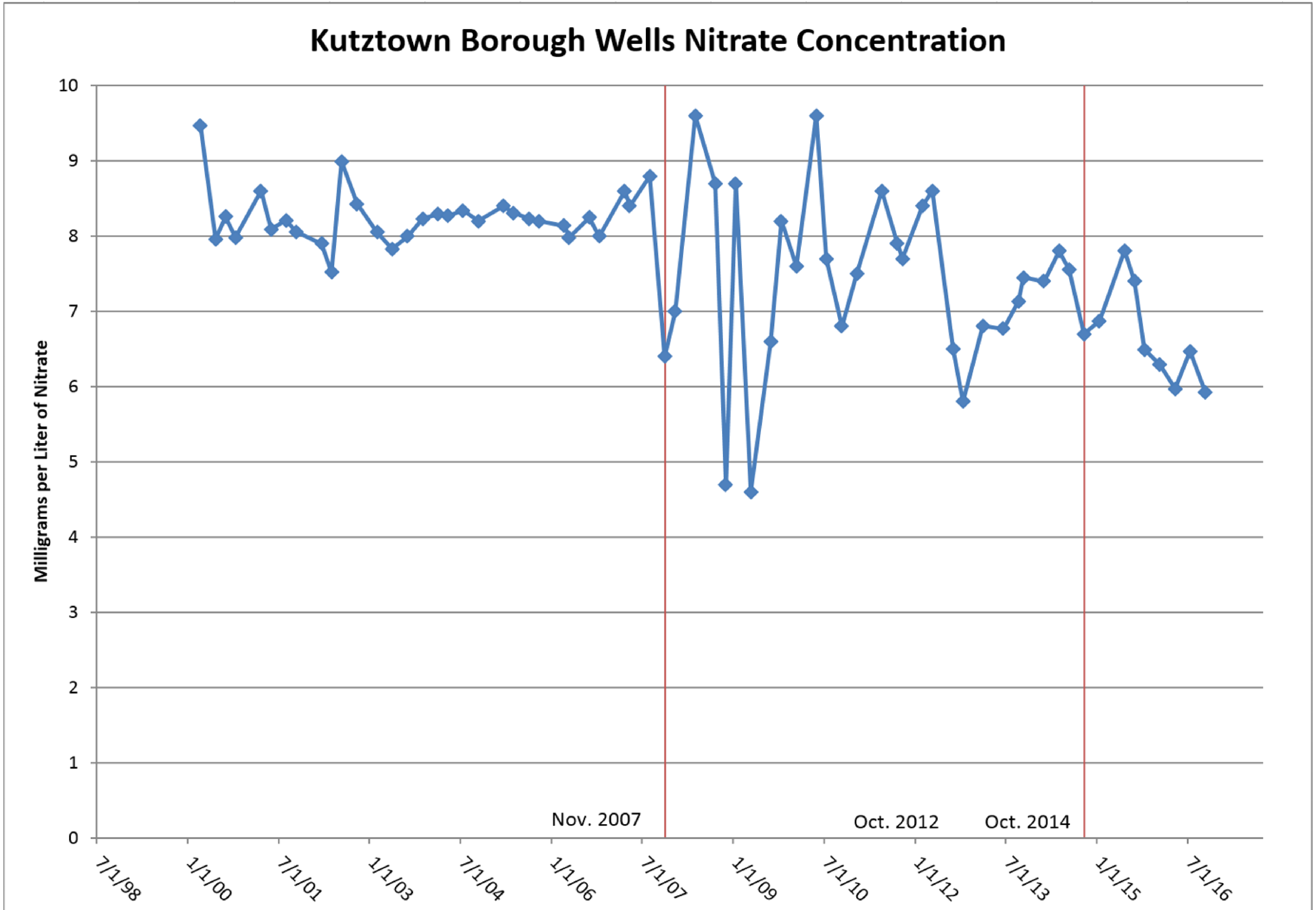

Document Path: G:\projects\w100000\w108440\w0025\projects\fig_8_nitrate_concentration.mxd

Figure 9

Kutztown Borough Wells: High & Low Nitrate Concentrations

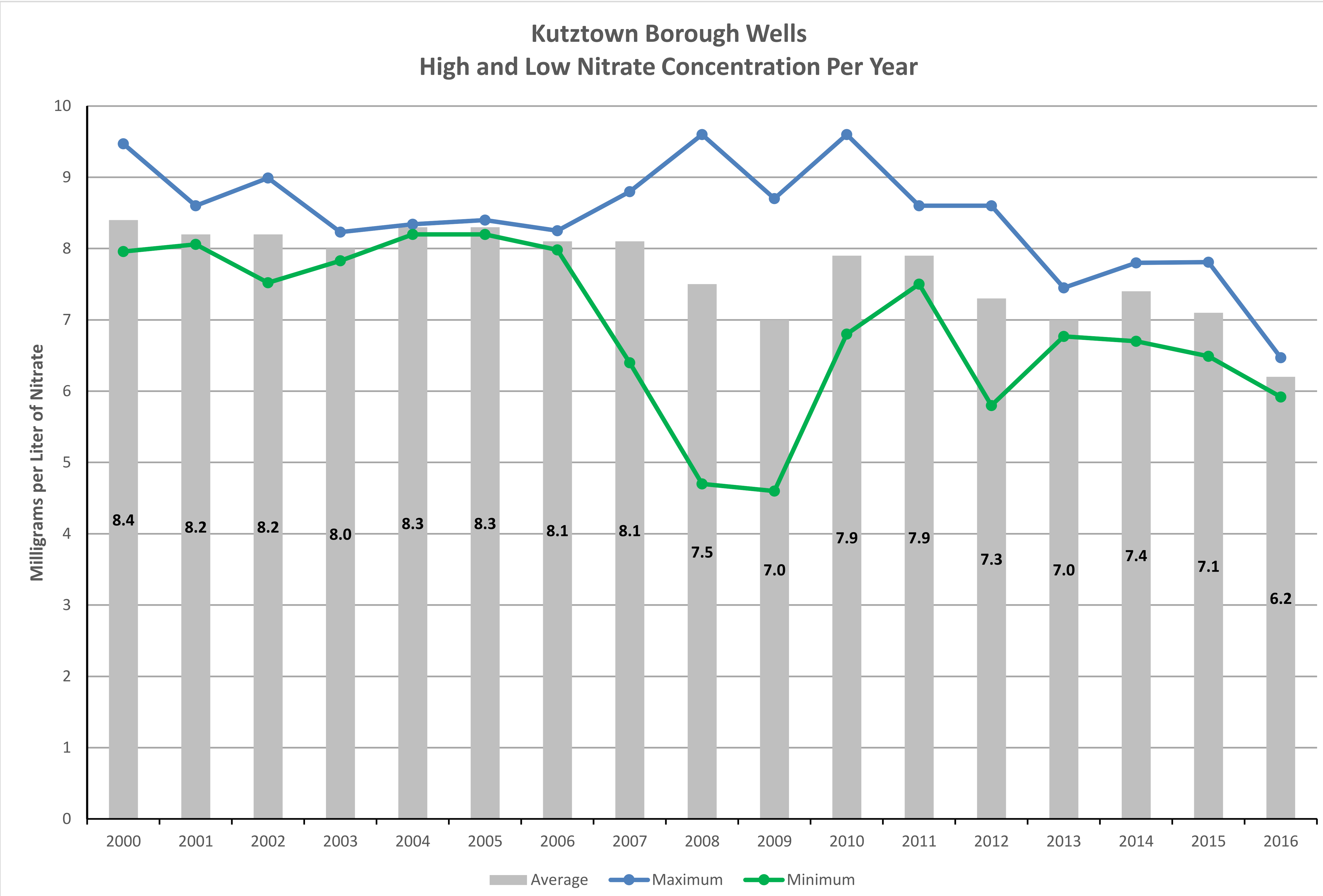

Figure 9
High and Low
Nitrate Concentration
Saucony Creek Watershed
Berks County, PA

Data Source:
Graph, SSM, 2016

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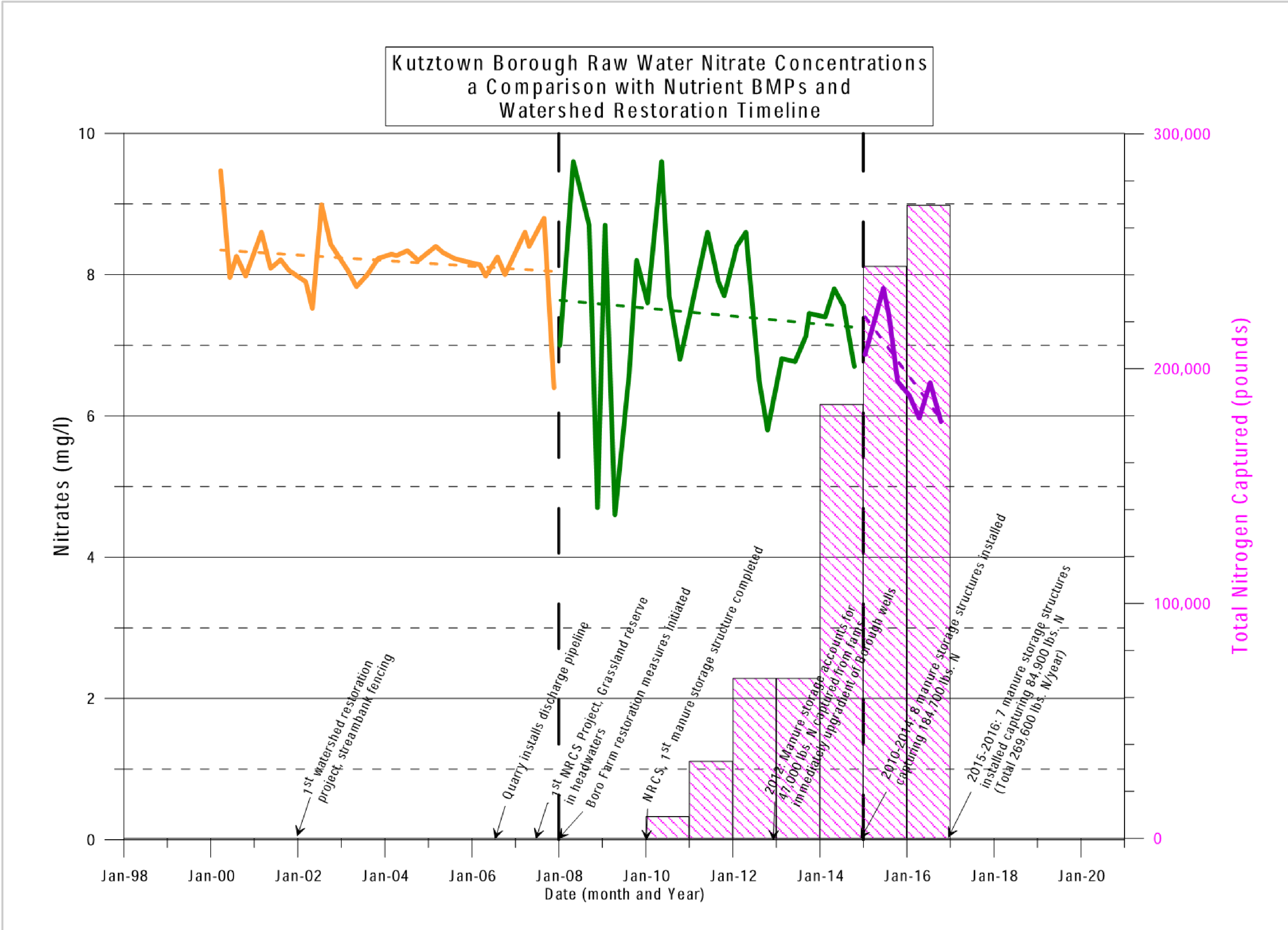
Figure 10

Nitrate Trends and Watershed Restoration Timeline

Figure 10
Nitrate Concentrations and Watershed Restoration
Saucony Creek Watershed
Berks County, PA



Nitrogen Capture

2000 - 2007 NO_3-N (mg/l)

2008 - 2014 NO_3-N (mg/l)

2015 - 2016 NO_3-N (mg/l)

Data Source:
Graph, SSM, 2016

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Document Path: G:\projects\w100000\w108440\w0025\projects\fig_10_nitrate_conc_restoration_comp.mxd

Appendix A

NRCS Soil Resource Report

United States Department of Agriculture

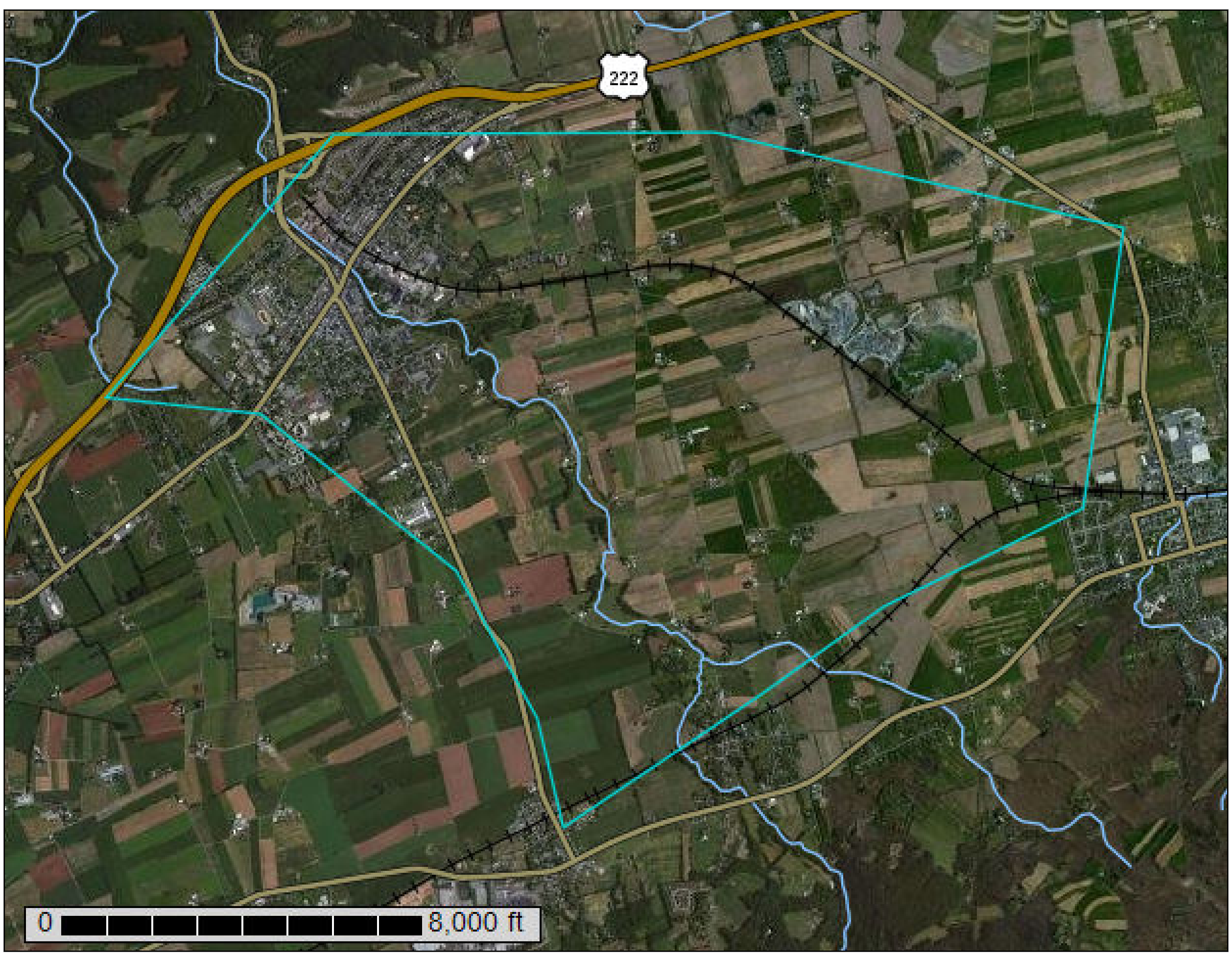
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Berks County, Pennsylvania



January 16, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

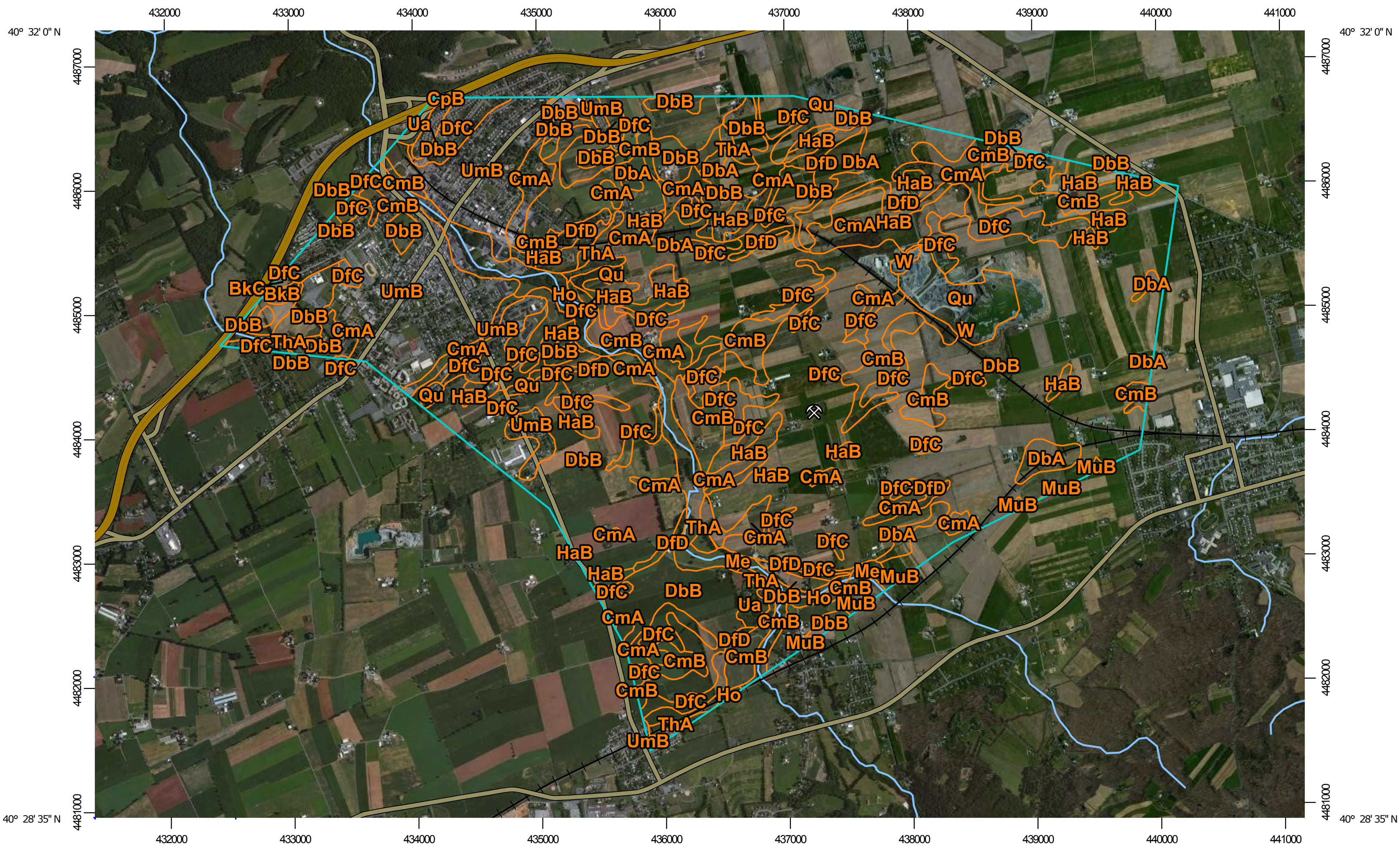
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map (Saucony Mid-basin Soils)



Map Scale: 1:44,700 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 500 1000 2000 3000

Feet: 0 2000 4000 8000 12000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Berks County, Pennsylvania
Survey Area Data: Version 13, Sep 19, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 19, 2011—Jul 1, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Saucony Mid-basin Soils)

Berks County, Pennsylvania (PA011)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BkB	Berks-Weikert complex, 3 to 8 percent slopes	12.0	0.2%
BkC	Berks-Weikert complex, 8 to 15 percent slopes	16.8	0.3%
CmA	Clarksburg silt loam, 0 to 3 percent slopes	257.5	4.5%
CmB	Clarksburg silt loam, 3 to 8 percent slopes	443.2	7.7%
CpB	Comly silt loam, 3 to 8 percent slopes	0.2	0.0%
DbA	Duffield silt loam, 0 to 3 percent slopes	111.1	1.9%
DbB	Duffield silt loam, 3 to 8 percent slopes	2,964.9	51.5%
DfC	Duffield-Ryder silt loams, 8 to 15 percent slopes	558.8	9.7%
DfD	Duffield-Ryder silt loams, 15 to 25 percent slopes	89.5	1.6%
HaB	Hagerstown-Duffield silt loams, 3 to 8 percent slopes	258.5	4.5%
Ho	Holly silt loam	170.8	3.0%
Me	Middlebury silt loam	59.7	1.0%
MuB	Murrill gravelly loam, 3 to 8 percent slopes	13.2	0.2%
Qu	Quarries	111.3	1.9%
ThA	Thorndale-Penlaw silt loams, 0 to 3 percent slopes	59.6	1.0%
Ua	Udorthents	17.9	0.3%
UmB	Urban land-Duffield complex, 0 to 8 percent slopes	606.8	10.5%
W	Water	7.2	0.1%
Totals for Area of Interest		**5,759.2**	**100.0%**

Map Unit Descriptions (Saucony Mid-basin Soils)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Berks County, Pennsylvania

BkB—Berks-Weikert complex, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2sgbh
Elevation: 250 to 1,740 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 47 to 56 degrees F
Frost-free period: 148 to 192 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Berks and similar soils: 65 percent
Weikert and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berks

Setting

Landform: Ridges
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 7 inches: channery loam
Bw1 - 7 to 14 inches: channery silt loam
Bw2 - 14 to 21 inches: very channery silt loam
C - 21 to 30 inches: extremely channery loam
R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 1 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Very low (about 2.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e

Hydrologic Soil Group: B
Other vegetative classification: Very Rocky, Acid Soils (RA2), Very Rocky, Acid Soils (RA3)
Hydric soil rating: No

Description of Weikert

Setting

Landform: Ridges
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gray and brown acid residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 8 inches: channery silt loam
Bw - 8 to 15 inches: very channery silt loam
C - 15 to 18 inches: extremely channery silt loam
R - 18 to 28 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very low to very high (0.00 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Available water storage in profile: Very low (about 1.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: D
Other vegetative classification: Droughty Shales (SD2)
Hydric soil rating: No

Minor Components

Comly

Percent of map unit: 6 percent
Landform: Ridges
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Brinkerton

Percent of map unit: 4 percent
Landform: Ridges
Landform position (two-dimensional): Backslope, footslope

Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: Yes

BkC—Berks-Weikert complex, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2sgbj
Elevation: 210 to 3,270 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 47 to 56 degrees F
Frost-free period: 148 to 192 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Berks and similar soils: 65 percent
Weikert and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berks

Setting

Landform: Ridges
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 7 inches: channery loam
Bw1 - 7 to 14 inches: channery loam
Bw2 - 14 to 21 inches: very channery silt loam
C - 21 to 30 inches: extremely channery loam
R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Calcium carbonate, maximum in profile: 1 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Very low (about 2.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Other vegetative classification: Very Rocky, Acid Soils (RA2), Very Rocky, Acid Soils (RA3)
Hydric soil rating: No

Description of Weikert

Setting

Landform: Ridges
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Gray and brown acid residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 8 inches: channery silt loam
Bw - 8 to 15 inches: very channery silt loam
C - 15 to 18 inches: extremely channery silt loam
R - 18 to 28 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (0.28 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Available water storage in profile: Very low (about 1.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Other vegetative classification: Droughty Shales (SD2)
Hydric soil rating: No

Minor Components

Comly

Percent of map unit: 6 percent
Landform: Ridges
Landform position (two-dimensional): Footslope, backslope

Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Brinkerton

Percent of map unit: 4 percent
Landform: Ridges
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

CmA—Clarksburg silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: l711
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 48 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Clarksburg and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Clarksburg

Setting

Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Residuum weathered from limestone

Typical profile

Ap - 0 to 8 inches: silt loam
Bt - 8 to 27 inches: silt loam
Btx - 27 to 51 inches: silt loam
C - 51 to 84 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 36 inches to fragipan; 60 to 99 inches to
Natural drainage class: Moderately well drained
Runoff class: Low

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Thorndale

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

CmB—Clarksburg silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l712
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 48 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Clarksburg and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Clarksburg

Setting

Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Residuum weathered from limestone

Typical profile

Ap - 0 to 8 inches: silt loam

Bt - 8 to 27 inches: silt loam
Btx - 27 to 51 inches: silt loam
C - 51 to 84 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 36 inches to fragipan; 60 to 99 inches to
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Thorndale

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

CpB—Comly silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l714
Elevation: 300 to 1,400 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 120 to 214 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Comly and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Comly

Setting

Landform: Valleys
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Acid fine-loamy colluvium derived from shale and siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 25 inches: channery silty clay loam
Btx - 25 to 52 inches: channery loam
C - 52 to 61 inches: very channery silt loam
R - 61 to 80 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 35 inches to fragipan; 60 to 96 inches to lithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Brinkerton

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

DbA—Duffield silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: l718
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Duffield and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Duffield

Setting

Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from limestone and siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Ryder

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Clarksburg

Percent of map unit: 3 percent
Landform: Valley flats
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Penlaw

Percent of map unit: 2 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Thorndale

Percent of map unit: 2 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

DbB—Duffield silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l719
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Duffield and similar soils: 90 percent

Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Duffield

Setting

Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from limestone and siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 5 percent
Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Ryder

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Thorndale

Percent of map unit: 2 percent

Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

DfC—Duffield-Ryder silt loams, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l71b
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Duffield and similar soils: 60 percent
Ryder and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Duffield

Setting

Landform: Hills
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Residuum weathered from limestone and siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Description of Ryder

Setting

Landform: Hills
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Residuum weathered from limestone

Typical profile

Ap - 0 to 8 inches: silt loam
Bt - 8 to 30 inches: silt loam
C - 30 to 38 inches: very channery silt loam
R - 38 to 48 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 24 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 4 percent
Landform: Valley flats
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Penlaw

Percent of map unit: 3 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave

Across-slope shape: Concave
Hydric soil rating: No

Thorndale

Percent of map unit: 3 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

DfD—Duffield-Ryder silt loams, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: l71c
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Duffield and similar soils: 50 percent
Ryder and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Duffield

Setting

Landform: Hills
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Fine-loamy residuum weathered from impure limestone and calcareous siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Hydric soil rating: No

Description of Ryder

Setting

Landform: Hills
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Residuum weathered from shaly limestone

Typical profile

Ap - 0 to 8 inches: silt loam
Bt - 8 to 30 inches: silt loam
BC - 30 to 38 inches: very channery silt loam
R - 38 to 48 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 24 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 4 percent
Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Penlaw

Percent of map unit: 3 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Thorndale

Percent of map unit: 3 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

HaB—Hagerstown-Duffield silt loams, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l71w
Elevation: 200 to 1,500 feet
Mean annual precipitation: 30 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Hagerstown and similar soils: 50 percent
Duffield and similar soils: 40 percent
Minor components: 9 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hagerstown

Setting

Landform: Valleys
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey residuum weathered from limestone

Typical profile

Ap - 0 to 9 inches: silt loam
Bt - 9 to 42 inches: clay
C - 42 to 61 inches: channery silty clay

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 40 to 84 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Description of Duffield

Setting

Landform: Hills, valleys
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy residuum weathered from impure limestone and calcareous siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
B - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Ryder

Percent of map unit: 3 percent
Landform: Hills

Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Clarksburg

Percent of map unit: 2 percent
Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Penlaw

Percent of map unit: 2 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Thorndale

Percent of map unit: 2 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Ho—Holly silt loam

Map Unit Setting

National map unit symbol: l721
Elevation: 100 to 1,300 feet
Mean annual precipitation: 30 to 50 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Holly and similar soils: 94 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Holly

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium derived from sandstone and shale

Typical profile

Ap - 0 to 7 inches: silt loam
Bg - 7 to 26 inches: silty clay loam
Cg - 26 to 44 inches: silty clay loam
2Cg - 44 to 62 inches: gravelly loamy sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: Occasional
Calcium carbonate, maximum in profile: 5 percent
Available water storage in profile: High (about 9.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Linden

Percent of map unit: 2 percent
Landform: Flood plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: No

Gibraltar

Percent of map unit: 2 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Brinkerton

Percent of map unit: 2 percent

Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Me—Middlebury silt loam

Map Unit Setting

National map unit symbol: l72p
Elevation: 800 to 840 feet
Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 45 to 54 degrees F
Frost-free period: 120 to 187 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Middlebury and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Middlebury

Setting

Landform: Flood plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Post glacial alluvium derived from sandstone and shale

Typical profile

Ap - 0 to 8 inches: silt loam
Bw - 8 to 26 inches: silt loam
C - 26 to 63 inches: stratified sand to gravelly sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 60 to 99 inches to lithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Hydric soil rating: No

Minor Components

Holly

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

MuB—Murrill gravelly loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l72v
Elevation: 200 to 1,800 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Murrill and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Murrill

Setting

Landform: Hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Colluvium derived from limestone, sandstone, and shale over residuum weathered from limestone

Typical profile

A - 0 to 9 inches: gravelly loam
Bt - 9 to 31 inches: gravelly clay loam
2Bt - 31 to 64 inches: gravelly silty clay loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 72 to 99 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 4 percent
Landform: Valley flats
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Penlaw

Percent of map unit: 4 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Thorndale

Percent of map unit: 2 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Qu—Quarries

Map Unit Setting

National map unit symbol: l739
Mean annual precipitation: 36 to 46 inches
Mean annual air temperature: 44 to 57 degrees F
Frost-free period: 130 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

Quarries: 90 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quarries

Setting

Landform: Valleys, ridges, hills
Landform position (two-dimensional): Summit
Parent material: Variable

Properties and qualities

Depth to restrictive feature: 0 to 39 inches to lithic bedrock
Runoff class: Low

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8e
Hydric soil rating: No

ThA—Thorndale-Penlaw silt loams, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: l73k
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Thorndale and similar soils: 55 percent
Penlaw and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Thorndale

Setting

Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Fine-silty colluvium derived from limestone, sandstone, and shale

Typical profile

Ap - 0 to 11 inches: silt loam
Btg - 11 to 22 inches: silty clay loam
Bxg - 22 to 45 inches: silty clay loam
C - 45 to 67 inches: silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 36 inches to fragipan; 60 to 99 inches to lithic bedrock
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Hydric soil rating: Yes

Description of Penlaw

Setting

Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Colluvium derived from limestone, sandstone, and shale

Typical profile

Ap - 0 to 8 inches: silt loam
Bt - 8 to 17 inches: silty clay loam
Bx - 17 to 49 inches: silty clay loam
C - 49 to 72 inches: loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 15 to 30 inches to fragipan; 40 to 72 inches to lithic bedrock
Natural drainage class: Somewhat poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 5 percent
Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Ua—Udorthents

Map Unit Setting

National map unit symbol: l73p
Elevation: 300 to 900 feet
Mean annual precipitation: 42 to 48 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 160 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 95 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Setting

Landform: Hills, valleys, ridges
Landform position (two-dimensional): Toeslope, footslope, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Man made and altered materials from mixed rock types

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 to 100 inches to lithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Very high
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydric soil rating: No

UmB—Urban land-Duffield complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: l73v
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 44 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 65 percent
Duffield and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pavement, buildings and other artifically covered areas

Typical profile

C - 0 to 6 inches: variable

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 to 100 inches to lithic bedrock
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Description of Duffield

Setting

Landform: Valleys
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from limestone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Clarksburg

Percent of map unit: 4 percent
Landform: Valley flats
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Penlaw

Percent of map unit: 4 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Thorndale

Percent of map unit: 2 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

W—Water

Map Unit Setting

National map unit symbol: l745
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Water

Setting

Parent material: Rivers streams ponds

Properties and qualities

Runoff class: Negligible
Frequency of ponding: Frequent

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Appendix B

Saucony Creek Watershed Restoration Timeline

Berks Nature
25 North 11th Street
Reading, PA 19601
Phone: 610.372.4992
Fax: 610.372.2917
BerksNature.org

Nature, essential to our quality of life...

November 2016

SAUCONY CREEK TIMELINE, 1992- 2016

1992 Berks County Natural Areas Inventory (Berks CNAI) which includes Saucony Creek Marsh as a top priority for protection ; one of last remaining fresh water marshes in PA

1992 Berks County Conservancy (BCC) 's Environmental Committee adopts protection of Berks County Natural Areas Inventory (CNAI)'s top priorities, including Saucony Creek Marsh

1993 Friends of the Saucony Marsh is formed as Program of Berks Nature to protect Saucony Creek Marsh

1992- 1993 Kutztown Borough, Lyons Borough, and Maxatawny Township develop the Northeast Berks County Wellhead Protection Plan. Berks County Conservancy and Friends of the Saucony Marsh participate on Steering Committee. This Plan predates DEP guidelines and Sourcewater Protection Plan Program. Friends of Saucony Marsh engage Kutztown Borough on protection of their owned portion of the Saucony Creek Marsh

1998 Friends of Saucony Marsh procure funds and contributions for protection of Saucony Creek Marsh

1999 Maiden Creek Watershed Association (MCWA) with Kutztown University faculty forms and participates in conservation, water testing, and education projects

2002 BCC completes Pa DCNR Maiden Creek Watershed Management Plan which includes Saucony Creek, a primary tributary of Maiden Creek.

2002- 2004 Berks Conservancy and Trout Unlimited, Tulpehocken Chapter installs streambank cattle exclusion fencing on 4 farms along the Saucony Creek - Ethan Burkholder (Clayton Shirk, operator); Roy Martin (with riparian plantings); James Weaver, Meadowview farm (with riparian plantings) ; Lawrence Burkholder (existing riparian plantings) Overall , approximately 9,080 feet

2003 BCC assists farmer/owner (N. and H. Burkholder) of the farm with large portion of the Saucony Marsh with successful application and award for preservation of the entire 120 acre farm in the Berks County Ag Preservation Program . Burkholder is the first Mennonite applicant to the Berks County Ag Preservation Program

2003-2004 BCC utilizes NFWF grant for streambank cattle exclusion fencing and riparian plantings on J. Burkholder (now Edward Burkholder, since 2010) farm and installs roof for dry manure storage . Streambank fence length is ~ 3,600 feet.

2004-2006 BCC utilizes PA DEP grant to install streambank cattle exclusion fencing on H. Burkholder farm and cattle operation and installs rain gutters and barnyard controls. Streambank fence length is ~ 2,600 feet

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2004-2006 BCC and MCWA receive a Berks County grant to develop the Saucony Creek Trail from Main Street in Kutztown Borough through the Kutztown School District campuses to the Saucony Creek Marsh. Project includes riparian plantings, aquatic habitat structures, educational signage, and best management practices along the Saucony Creek (completed 2006) and a Saucony Creek Trail Management Plan (completed 2013)

2004- 2006 Borough of Kutztown develops a DEP Sourcewater Protection Plan as one of the initial applicants to the DEP program for drinking water providers. BCC participates on Steering Committee

2004- 2007 Reading Area Water Authority develops a DEP Sourcewater Protection Plan for Lake Ontelaunee and the contributing Maiden Creek Watershed which includes Saucony Creek Watershed. BCC participates on the Steering Committee and ground-truthing of potential sources of contamination.

2007 NRCS CREP installs grassland reserve in headwaters of Saucony Creek on Ferry farm of 100 + acres

2006-2007 BCC (PA DCNR) and Berks County Ag Land Preservation Program preserve the Dent 288 acre property consisting of farmland and woodlands and EV Saucony Creek and tributary frontage . Ag Conservation Plan developed for farmed acreage

2008-2010 BCC utilizes PA DEP grant to develop a Conservation Plan for the Kutztown Borough Farm/drinking water supply with installation of 300' woody and herbaceous wellhead buffers around drinking water wells eliminating previous tillage and row crops in the 300' buffers. Also installed vegetated swales for stormwater and wildlife habitat tree rows. BCC leases 5.8 acres of farmland and converts to woody buffers and sublets 18.4 acres of grass buffers to H. Burkholder in exchange for Conservation Plan on his farm and designation of Saucony Marsh as wildlife habitat with no farming practices within the 15.4 acre marsh. In addition, BCC brokers 22 year lease of 2.2 acres of wellhead buffer on the adjacent to Kutztown Borough Farm, Saucony Meadows Retirement housing property with woody buffer converted from lawn and installed with Kutztown Area Middle School students . 8.0 acres of woody buffer – Nutrients and sediments are managed

2008-2010 BCC (Berks Watershed Restoration Fund) and NRCS install dry manure storage and rain gutters on the H. Burkholder steer operation. Nutrients captured and managed annually – 9,200 lbs N

2009-2011 BCC (Berks Watershed Restoration Fund) and Berks County Conservation District (PA DEP grant) and NRCS (EQIP contract) install liquid manure storage tank , barnyard controls, rain gutters and surface water controls, with lined outlets , and stream bank cattle exclusion fencing on 450 feet of stream length on P. Martin farm and dairy operation. P. Martin farm is preserved with Berks County Ag Land Preservation Program in 2011. Nutrients captured and managed annually- 23,600 lbs N

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2010 BCC (Pa DCNR grants) preserves the 169 acre Gehman property with primarily woodlands and Saucony Creek frontage

2011-2012 BCC (Berks Watershed Restoration Fund and Schuylkill River Restoration fund) and NRCS install liquid manure storage, barnyard controls, stormwater controls on the E. (formerly J.) Burkholder farm and dairy operation. E Burkholder farm is preserved with Berks County Ag Land Preservation Program in 2015. Nutrients captured and managed annually – 14,200 lbs N

2011-2012 BCC (Berks Watershed Restoration Fund) and NRCS (EQIP contract) installs liquid manure storage tank, barnyard controls, rain gutters and leaders with lined outlet, streambank cattle exclusion fencing, riparian buffer plantings, animal walkway and crossing on the Dan. Weaver Farm. Nutrients captured and managed annually - 21,100 lbs N

2012 NRCS includes carbonate geology in their EQIP scorecard priorities in recognition of Saucony Creek (and other Berks County Great Valley watersheds) which have carbonate geology and limited surface water streams. The entire watershed is elevated as a priority due to importance of carbonate geology.

2013-2014 BCC (Berks Watershed Restoration Fund and Schuylkill River Restoration Fund) and NRCS EQIP contract installs liquid manure storage and dry manure storage, barnyard controls, rain gutters and leaders, pasture paddock/rotational grazing fencing on the V. Weaver organic farm and dairy operation. Nutrients captured and managed annually - 11,400 lbs N

2014-2016 NRCS awards Maiden Creek/Saucony Creek NWQI (National Water Quality Initiative) status for concentrated funds and BMP installation with active partnership.

2013-2014 BCC (Berks Watershed Restoration Fund and Schuylkill River Restoration Fund and NFWF) and NRCS EQIP contract installs liquid manure storage tank, dry manure storage, barnyard controls, stormwater controls, rain gutters and leaders on the E. Martin farm and dairy operation. Nutrients captured and managed annually – 31,500 lbs N

2013-2014 BCC (Berks Watershed Restoration Fund, Schuylkill River Restoration Fund, NFWF) and NRCS EQIP contract installs dry manure storage and stormwater controls on N. Zimmerman farm and chicken operation. Nutrients captured and managed annually – 59,200 lbs N

2013-2015 BCC (Berks Watershed Restoration Fund, Schuylkill River Restoration Fund and NFWF) and NRCS EQIP contract installs liquid manure storage tank, dry manure storage, barnyard controls, stormwater controls, rain gutters and leaders on the A. Leid farm and dairy operation. Nutrients captured and managed annually – 20,100 lbs N

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2013- 2014 BCC (Berks Watershed Restoration Fund and NFWF) , BCCD (Schuylkill River Restoration Fund), and NRCS EQIP contract installs dry manure storage, stormwater controls, rain gutters and leaders on the L. and A. Zimmerman (Phase 1) farm and heifer operation. This farm is preserved with Berks County Ag Land Preservation program and was preserved by the previous owner. Nutrients captured and managed annually – 14,500 lbs N

2013- 2015 BCC (Berks Watershed Restoration Fund) and Kutztown Area Middle School (PA DEP grant) install woody buffers for stormwater control and habitat plantings on KAMS campus and complete Management Plan for same .

2014- 2015 BCC (Berks Watershed Restoration Fund and NFWF), BCCD (Schuylkill River Restoration Fund), and NRCS EQIP contract installs liquid manure storage tank on L. Zimmerman (Phase 2) farm and dairy operation. Nutrients captured and managed annually – 20,400 N

2014- 2015 BCC (Berks Watershed Restoration Fund and NFWF) and NRCS EQIP contract install dry manure storage , stormwater controls, rain gutters and leaders on the A. Hoppes farm and steer operation. Nutrients captured and managed annually – 12,000 lbs N

2014- 2015 BCC (Berks Watershed Restoration Fund and NFWF) and NRCS EQIP contract install dry manure storage, barnyard controls, stormwater controls, and rain gutters and leader on the L. Burkholder farm and vegetable and steer operation (streambank exclusion fencing installed in 2004) . Nutrients captured and managed annually - 6,400 lbs N

2014-2016 BCC (Berks Watershed Restoration Fund and NFWF) and NRCS EQIP contract install dry manure storage, barnyard controls, stormwater controls, rain gutters and leaders on the N.Sauder organic farm and dairy operation. Nutrients captured and managed annually – 11,000 lbs N

2015- 2016 BCC (Berks Watershed Restoration Fund and NFWF), BCCD (Schuylkill River Restoration Fund), and NRCS EQIP installs dry manure storage, barnyard controls, stormwater controls, and rain gutters and leaders on the L. Zimmerman (Phase 3) farm and dairy operation. This farm is preserved with the Berks County Ag Land Preservation Program in 2016. Nutrients captured and managed annually – 6,000 lbs N

2015-2016 BCC (Berks Watershed Restoration Fund, Schuylkill River Restoration Fund, and NFWF) and NRCS contract install dry manure storage, barnyard controls, stormwater controls, grassed waterway, rain gutters and leader on the Dav. Weaver farm and steer operation. Nutrients captured and managed annually – 9,000 lbs N

2016 BCC (in kind consultation) and NRCS WRP(Wetland Reserve program) easement program preserve two properties (Saegner and Ferry) in the headwaters of the Saucony Creek in Longswamp Township . One of the properties was/is previously enrolled in CREP in 2007

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2016-2017 BCC develops updated Conservation Plan for Kutztown Borough Farm and leases (2017) the entire 110 acre farm and converts all cropland to grass and keeps 300 ft buffers around wellheads and Saucony Creek and marsh. BCC sublets farmed acreage to neighboring farmers (H. Burkholder, P. Martin, and L. Weaver) in return for updating and implementing their Conservation Plans on their home farms.

2017 BCC (Berks Watershed Restoration Fund and NFWF), BCCD (Schuylkill River Restoration Fund), and NRCS EQIP contract install barnyard controls, animal walkways and rotation grazing controls on L. Zimmerman (Phase 4) farm and dairy operation. Nutrients captured and managed annually - TBD- N

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Appendix C

Managed Nitrogen Calculations

Managed Nitrogen Calculations

The method utilized for arriving at the significant amount of pounds of nutrients captured, stored, managed, and recycled on any given farm was based on the ***Pennsylvania Act 38 Nutrient Management Program, Technical Manual***. The following are examples of how the nutrient loading reductions were calculated:

a. Lactating cows: 13 gallons per animal unit per day (gal/AU/day) of manure production; 28 pounds (lbs) of nitrogen (N) per 1,000 gallons; 13 lbs phosphorus (P) lbs per 1,000 gal; 25 lbs potassium (K) per 1000 gallons; bedding is not calculated into equation,
b. Heifer: 60 lbs/AU/day of manure production; 10 lbs N per Ton; 3 lbs P per Ton; 7 lbs K per Ton,
c. Finishing Cattle: 65 lbs/AU/day; 14 lbs N per Ton; 5 lbs P per Ton; 8 lbs K per Ton.

For example: an average dairy of 75 milking animals at 1.2 AU generates 1,170 gals of manure per day and 11,956 lbs N and 5,560 lbs. P per year, plus bedding which is captured, stored, managed, and recycled instead of leaching into carbonate geology and groundwater and/or carried by stormwater into surface waters or intermittent stream channels (high water table), wetlands, or sinkholes.

The total nutrients for any given year are the sum totals of all farms through that given year.

Also, not calculated into the nutrient equation are the effects of streambank fencing, riparian buffers, vegetated swales, and tree plantings, which are not easily derived for load reduction calculations.

Appendix D

Historical Nitrate Results

Kutztown Borough Water
Nitrate Analytical Results: 2000-2016

Date	Nitrates (mg/l)	Average Nitrates
3/23/00	9.47	
6/8/00	7.96	
8/3/00	8.26	
10/19/00	7.98	8.4
3/1/01	8.60	
5/17/01	8.09	
8/9/01	8.21	
10/18/01	8.06	8.2
3/7/02	7.90	
5/2/02	7.52	
7/18/02	8.99	
10/3/02	8.43	8.2
2/27/03	8.05	
5/8/03	7.83	
8/7/03	8.00	
11/6/03	8.23	8.0
2/26/04	8.29	
4/8/04	8.27	
7/8/04	8.34	
10/7/04	8.20	8.3
3/3/05	8.40	
5/5/05	8.31	
8/4/05	8.23	
10/6/05	8.20	8.3
3/9/06	8.14	
4/27/06	7.98	
8/3/06	8.25	
10/5/06	8.00	8.1
3/22/07	8.60	
4/26/07	8.40	
8/30/07	8.80	
11/21/07	6.40	8.1
1/10/08	7.00	
5/1/08	9.60	
9/11/08	8.70	
11/20/08	4.70	7.5
1/22/09	8.70	
4/16/09	4.60	
8/13/09	6.60	
10/15/09	8.20	7.0
1/14/10	7.60	
5/13/10	9.60	
7/15/10	7.70	
10/14/10	6.80	7.9
1/13/11	7.50	
6/2/11	8.60	
9/1/11	7.90	
10/20/11	7.70	7.9
2/2/12	8.40	
4/19/12	8.60	
8/9/12	6.50	
10/18/12	5.80	7.3
2/14/13	6.81	
6/6/13	6.77	
9/5/13	7.13	
10/3/13	7.45	7.0
2/14/14	7.40	
5/1/14	7.80	
7/17/14	7.56	
10/16/14	6.70	7.4
1/15/15	6.87	
6/18/15	7.81	
8/6/15	7.40	
10/15/15	6.49	7.1
1/21/2016	6.29	
4/14/2016	5.97	
7/14/2016	6.47	
10/13/2016	5.92	6.2

High N/year
Low N/year

Lyons Borough Water (3060096)
Nitrate Analytical Results: 2000-2016

Date	Nitrates (mg/l)	Average Nitrates
1/19/2000	4.40	4.4
9/12/2001	3.00	3.0
1/2/2002	4.80	
6/5/2002	3.30	
7/3/2002	3.30	
10/9/2002	3.10	3.6
1/10/2003	3.90	
4/9/2003	2.70	
7/9/2003	2.60	
10/1/2003	3.00	3.1
1/7/2004	4.70	
6/16/2004	3.20	
8/4/2004	3.20	
10/13/2004	3.50	3.7
3/2/2005	3.00	3.0
1/4/2006	3.30	3.3
6/6/2007	2.60	2.6
3/28/2008	4.49	
6/27/2008	4.27	
9/23/2008	5.31	
12/12/2008	5.57	4.9
3/24/2009	5.20	
6/12/2009	4.89	
8/31/2009	5.49	
12/9/2009	4.31	5.0
6/8/2010	5.27	
8/10/2010	4.84	
12/1/2010	4.14	4.8
3/14/2011	4.30	
4/11/2011	4.56	
7/25/2011	5.07	
10/17/2011	5.04	4.7
1/9/2012	5.00	
6/20/2012	4.94	
9/10/2012	5.51	
10/11/2012	4.83	
12/18/2012	5.42	5.1
3/19/2013	4.74	
5/29/2013	4.60	
7/18/2013	4.45	
8/20/2013	4.83	
10/4/2013	4.96	4.7
1/2/2014	4.49	
4/29/2014	4.47	
8/8/2014	3.98	4.3
1/28/2015	3.75	
2/18/2015	3.79	
6/23/2015	3.63	
7/8/2015	3.91	
10/27/2015	3.86	3.8
3/16/2016	3.86	
4/6/2016	4.00	3.9

High N/year
Low N/year

Maxatawny Township Municipal Authority (3060013)
Nitrate Analytical Results: 2000-2016

Date	Nitrate (mg/l)	Average Nitrates
1/5/2000	3.88	
5/4/2000	4.60	
9/14/2000	5.04	4.5
2/7/2001	3.65	
4/4/2001	5.34	
7/6/2001	4.99	
10/11/2001	4.25	4.6
1/4/2002	3.93	
4/3/2002	3.81	
7/2/2002	4.89	
10/10/2002	4.72	4.3
2/14/2003	4.31	
4/3/2003	4.14	
7/7/2003	3.61	
10/6/2003	4.60	4.2
3/5/2004	4.56	
4/1/2004	4.44	
7/8/2004	4.30	
10/7/2004	4.56	4.5
1/4/2005	4.45	
4/4/2005	4.44	
7/7/2005	4.16	
10/7/2005	3.77	4.2
1/6/2006	3.57	
4/7/2006	4.40	
7/5/2006	4.54	
10/5/2006	4.33	4.2
1/8/2007	4.24	
4/10/2007	4.38	
8/6/2007	3.47	
10/8/2007	3.35	3.9
4/7/2008	3.12	3.1
4/8/2009	3.39	3.4
3/12/2010	4.58	
5/12/2010	4.31	
7/14/2010	4.12	
11/4/2010	3.78	4.2
2/7/2011	3.52	
5/4/2011	3.26	
9/7/2011	3.44	
11/11/2011	4.27	3.6
2/8/2012	4.32	
6/7/2012	3.75	
9/5/2012	3.25	
12/6/2012	3.25	3.6
2/5/2013	3.47	
6/10/2013	3.70	
8/12/2013	4.05	
11/11/2013	3.28	3.6
3/3/2014	3.66	
4/23/2014	4.47	4.1
12/11/2015	3.50	3.5
7/29/2016	3.72	3.7

High N/year
Low N/year

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