Treatment and Disposal of Wastewater in the Spring Creek Watershed

Spring Creek Watershed Community
Water Resources Monitoring Project

2008 State of the Water Resources Report

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From the Chair

In this annual report, we have continued to use a two-part format that includes a section describing results of our monitoring efforts and a section that highlights a particular theme. This year's thematic emphasis is on wastewater treatment plants in the Spring Creek watershed. While wastewater treatment plants may not seem like an interesting topic to some folks, these facilities are vitally important to the health of Spring Creek.

In my view, the water quality in Spring Creek is better today than it has been over the past 100 years. Part of the reason for improved water quality is the reduction in the number of wastewater treatment plants discharging into the stream. At one time we had five plants producing treated effluent, and now, only two plants discharge into Spring Creek and the Penn State plant disposes of all of its treated effluent in a spray irrigation system. But more importantly, all three wastewater treatment plants are using the latest technologies to achieve the high degree of treatment necessary to meet their permit requirements. It is likely that no other watershed in the state has the varied and sophisticated wastewater treatment systems that we have here in the Spring Creek watershed.

I want to thank all of the contributors to this year's report, especially John Gaudlip, Cory Miller, Tom Smith, and their staffs who wrote the informative sections on wastewater treatment plants.

2008 marks the tenth full year that our surface water monitoring network has been in operation. Our mission has remained unchanged, and through time we have been able to develop a network that comprehensively monitors the quantity and quality of surface waters and ground water. We have been able to sustain this effort because of the generous support from local governmental and nongovernmental organizations. Their support is vital, and we sincerely thank them on behalf of the entire Spring Creek community.

Introduction

Spring Creek near Fisherman's Paradise (credit: B. Hutchison)

Welcome to the Spring Creek Watershed Community's Water Resources Monitoring Project (WRMP) 2008 Annual Report. This year's report, entitled *Treatment and Disposal of Wastewater in the Spring Creek Watershed*, focuses on an issue that most people seldom consider - where does our wastewater go and how is it treated? In this year's report, we provide a brief overview of the municipal wastewater treatment process, discuss the history of wastewater treatment in the Spring Creek Watershed, and describe the unique ways that our local wastewater treatment plants are protecting our water quality.

The monitoring data collected each year by the WRMP will be important in measuring the effects of new treatment practices such as the University Area Joint Authority's Beneficial Reuse Project in the Slab Cabin Run subwatershed. The type and quantity of information collected by the WRMP is unique for a watershed of this size. Measurement of the conditions within the Spring Creek Watershed will be useful in the management of this resource for years to come.

In addition to addressing the treatment and disposal of human wastewater, we will also review water quality and quantity for 2008 throughout the Spring Creek Watershed. This will cover both surface and ground water levels and surface water quality for the calendar year 2008. Water quality and quantity data are available upon request by contacting the Water Resources Monitoring Project Manager, Brianna Hutchison, at (814) 237-0400.

Contributed by WRMP committee member John Sengle (PA Department of Environmental Protection)

This section provides a broad overview of the scientific principles, facilities, and operating practices common to municipal wastewater treatment plants across Pennsylvania. More specific details about how our local treatment plants are constructed and how they operate are presented in subsequent sections.

Municipal wastewater treatment facilities, often referred to as POTWs (Publicly Owned Treatment Works), are found across Pennsylvania and range in size from plants serving large cities with millions of customers and discharging hundreds of millions of gallons of wastewater per day, to small plants serving communities of less than 100 people and discharging a few thousand gallons per day. Wastewater treatment plants are typically rated and sized by their wastewater treatment capacity expressed in million gallons per day (MGD).

The wastewater treatment process begins with a collection system of buried pipes, including main interceptors, tributary interceptors, and service laterals to individual homes and businesses, to convey sewage wastes from individual connections to the treatment plant. Individual home laterals are usually 4-inch PVC pipe and interceptors may range in size from 8 to 60 inches or larger. Buried collection piping is connected through a network of manholes located at changes in sewer grade and sewer alignment, that allow for access, inspection and maintenance of the collection system. Collection systems are designed to the greatest extent possible to convey sewage from source to POTW simply by gravity. Depending upon local topography, collection systems often include pump stations that convey sewage over terrain where it will not flow via gravity by use of buried pressure force-mains.

In many parts of the northeastern United States, sanitary collection systems may be more than 100 years old and constructed of a range of materials, including terra-cotta clay, asbestos-cement brick, etc. that do not provide an effectively sealed sanitary sewage collection system. New sewers are now constructed almost exclusively of sealed joint PVC pipe in a range of sizes and pre-cast concrete manholes that are pressure and vacuum tested for leakage during installation. As a result of the extensive areas of old, dilapidated, and unsealed piping in some municipal collection systems, significant volumes of clean groundwater and surface water are able to enter the sanitary collection system, especially in response to extended rainfall events, snowmelt, and elevated groundwater levels. Collectively this leakage <u>into</u> the sanitary collection systems is referred to as inflow and infiltration (I&I), and can greatly increase the volume of sewage reaching a treatment plant. Excessive I&I is a common problem across the northeastern U.S. and often may result in direct discharges of untreated sewage from overflow pipes due to collection systems being unable to carry the flow that is entering them.

The collection system delivers the sewage to the POTW, which employs an integrated combination of physical and engineering controls, biological processes, and chemical processes that remove both particulate and dissolved contaminants from the wastewater, provide effective disinfection for potential pathogens, and discharges that treated wastewater back into a receiving stream under the auspices of a PA DEP issued NPDES (National Pollution Discharge Elimination System) discharge permit.

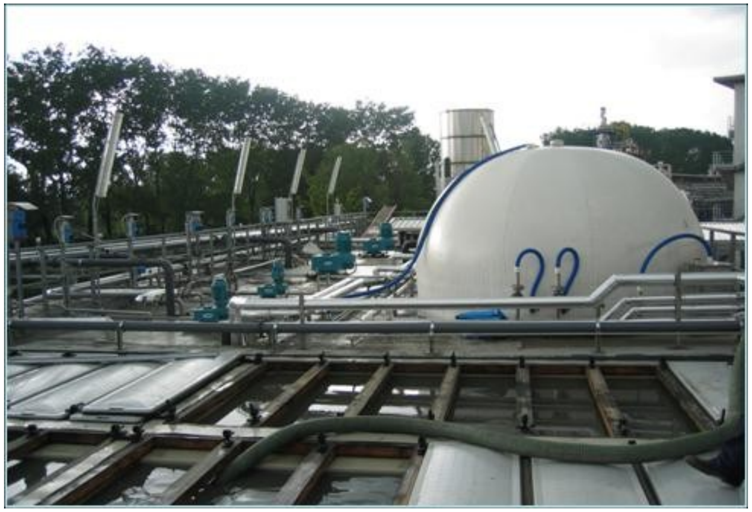
Efficient functioning of POTWs is dependent upon the continuous growth and reproduction of a wide variety of microorganisms that use the contaminants in sewage as FOOD! While filtration and chemical addition have important functions in meeting NPDES effluent criteria, it is hard to overemphasize the extent to which POTWs succeed or fail largely by how well they create and maintain conditions that support the healthy growth of wastewater microorganisms in their processes.

Wastewater treatment plants come in a variety of shapes and sizes, and some specific treatment processes are determined largely by facility-specific effluent criteria in the NPDES discharge permit, while other processes are almost universal in their application. What follows are major unit processes in the sequential order in which they might be found in municipal wastewater treatment plants, and a brief description of their functions.

(1) Headworks/Pretreatment: Raw sewage entering the POTW frequently passes through a flow meter, is sampled for influent testing, and then may proceed to a range of largely physical processes to grind up into smaller sizes, or screen out and completely remove inert trash and debris, and settle out and remove grit (anti-skid, cinders, etc). This step is important to remove materials that might foul pumps and piping further into the process, and also to remove contaminants that are largely not susceptible to microbial breakdown.

(2) Primary Clarification: Not all POTWs are equipped with primary clarifiers (typically large concrete tanks), but where they are employed, they settle out a significant portion of the solid or settleable contaminants in the wastewater. These settled solids, known as primary sludge, are pumped to digesters for further treatment and mixing with other sludges and ultimately processed into biosolids for composting, land application, or landfill disposal. Primary clarification is largely a physical settling process, with only limited microbial treatment.

(3) Activated Sludge/Extended Aeration: Biological treatment units are generally large steel or concrete tanks that receive raw sewage or primary clarifier effluent. The tanks contain what is known as “mixed liquor,” which is normally the color and consistency of chocolate milk, and contains a rich, diverse mix of microorganisms capable of using the particulate and soluble wastes in the sewage (carbohydrates, sugars, proteins, and starches) as food for growth and reproduction. The “mixed liquor” is provided with air from a blower and tributary system of diffusers that essentially create small air bubbles at the bottom of the tank. These air bubbles pass through the mixed liquor as they rise and in the process provide essential oxygen exchange for aerobic (with oxygen) microbial respiration and breakdown of sewage contaminants. These same tanks are also frequently capable of mixing the liquor without supplemental air. This creates an anoxic (without oxygen) environment, which favors a different assemblage of microorganisms that are capable of removing contaminants (primarily nitrate-nitrogen) through a process known as denitrification The use of anoxic zones in biological treatment units is an important component of the ongoing effort to reduce total nitrogen



Anaerobic biological treatment tank (credit: Austep SRL)

loads to the Chesapeake Bay, and a number of local POTWs have implemented plant upgrades specifically to provide denitrification capabilities.

(4) Secondary Clarification: Mixed liquor leaving the aeration tanks settles in secondary clarifiers. The largest portion of the sludge that settles to the bottom of the clarifier is returned as an "innoculant" or essentially a source of hungry microorganisms to the aeration tank (return sludge), while a portion is pumped out of the system (waste sludge) and processed with primary sludge into biosolids. Where discharge criteria are more stringent (such as discharges to Spring Creek), chemical coagulants such as alum are frequently added at the secondary clarifiers to enhance settling and provide for phosphorus removal.

(5) Tertiary Treatment: Where discharge criteria are stringent, the secondary clarifier effluent is directed to either sand filters, microscreens, or synthetic fabric filters, which provide an additional degree of particulate removal to meet stringent total suspended solids and nutrient NPDES criteria.

(6) Disinfection: All NPDES permits require the effective disinfection of treated sewage. While for many years that was provided almost exclusively by applying liquid or gas chlorine mixes to the effluent, many POTWs now use ultraviolet (UV) light for disinfection. Use of UV disinfection has dramatically reduced the chlorine discharged into streams and rivers, and has also dramatically reduced the threats to public safety associated with storage, transportation, and usage of liquid and gas chlorine.

(7) Biosolids: All successful biological treatment processes generate solid wastes. The treatment process by its very nature removes contaminants from wastewater by converting them into the biomass of microorganisms. Sludges and solids removed at various points in the treatment process are collectively stabilized aerobically or anaerobically, thickened by a variety of mechanical and chemical processes to remove excess water, and then processed for landfill disposal, land application, or composting.

(8) Advanced Treatment: Some POTWs have installed additional treatment processes to provide a further degree of treatment with the intent of changing our approach to wastewater treatment from a "disposal problem" to a "resource opportunity". Typical treatment processes might include micro or ultra filtration and reverse osmosis, producing a very high quality effluent. As potable water supplies are placed under increased demand from urbanization and population growth, the importance of wastewater reuse and recycling will increase. Those efforts have specific relevance to providing wastewater treatment for the rapidly increasing sewage flows generated by growth and development in the Spring Creek basin.

At the influent and effluent ends of the POTW process, representative samples are collected to ensure compliance with NPDES limits. POTWs routinely perform internal process control testing to cope with the very dynamic nature of biological processes, including changing flows coming into the plant, changing quality of wastewater entering the plant, temperature changes, and mechanical equipment variability.

Advances in wastewater treatment technology, increasingly stringent discharge criteria, capable professional design and operations personnel, and the expenditure of billions of dollars of private, public and municipal dollars has produced dramatic improvements in water quality across Pennsylvania. Large reaches of rivers and streams across Pennsylvania are now fishable and swimmable thanks to those efforts, and water quality from municipal wastewater treatment plants in Pennsylvania continues to show notable improvement.

Contributed by WRMP committee chair Robert Carline (Retired, PA Cooperative Fish and Wildlife Research Unit)

It is likely that humans and their livestock had a substantial impact on the water quality of Spring Creek from the time the watershed was first settled until the early 1900s. Wastes from people living along Spring Creek and its tributaries and wastes from the many mills and forges were probably dumped directly into streams. Hugh Manchester, a long-time columnist for the *Centre Daily Times*, noted that human wastes flowed down the streets of Bellefonte and into Spring Creek up until the first wastewater treatment plant was built in Bellefonte in 1939. We suspect that the situation was similar across all the other villages in the watershed.

The Pennsylvania State University built the first wastewater treatment plant in the watershed in 1913 at its present location on the headwaters of Thompson Run. This plant provided sewer service to the campus and the borough of State College. Its treated wastewater was discharged into Thompson Run.

The second treatment plant was constructed at the Rockview State Correctional Institution (SCI) around 1932. Before construction of this plant, untreated sewage from the prison was discharged directly into Spring Creek in the Canyon reach. Bellefonte constructed its first treatment plant in 1939 and it discharged into Spring Creek. The next plant was constructed in 1966 in Ferguson Township, Pine Grove Mills; it discharged into Slab Cabin Run. And finally, the University Area Joint Authority constructed a plant on Spring Creek in 1969. This plant provided sewer service to much of the Centre Region.

During the period of 1969 to 1983, treated human wastewater was being discharged at three locations on Spring Creek and two tributaries. In 1983 the Pennsylvania State University plant diverted its entire treated waste stream to a spray irrigation system near Toftrees, thus eliminating one of the five discharges to streams. The next significant reduction in discharge occurred in 1992 when Rockview SCI closed its treatment plant and diverted its entire waste stream to the Bellefonte plant for treatment. Finally, in 2000 the Ferguson Township treatment plant was closed, and its wastewater was rerouted to the University Area Joint Authority plant for treatment. This reduction from five to two treated wastewater discharges was one of the most important developments that contributed to improved water quality in the watershed.

Bellefonte's Big Spring in 1931 (credit: S. Llewellyn)

University Area Joint Authority

Submitted by Cory Miller, Executive Director, University Area Joint Authority

The University Area Joint Authority (UAJA) operates the largest wastewater treatment plant in the Spring Creek and Bald Eagle Creek watersheds. UAJA's 241 miles of collection system pipes serve approximately 47 square miles of College, Harris, Patton, and Ferguson townships. UAJA directly serves approximately 16,400 households and businesses in that area. In addition, the Borough of State College is a wholesale customer. UAJA treats the wastewater coming from the Easterly Parkway drainage basin of the Borough, as well as a portion of the Borough wastewater diverted around the Penn State treatment plant. UAJA also collects and treats wastewater from 17 industrial customers and 992 commercial customers

Sign at the entrance of the University Area Joint Authority wastewater treatment facility in College Township (credit: B. Hutchison)

UAJA's monthly average daily flow ranges from about 3.2 Million Gallons per Day (MGD) to 5.5 MGD, with an annual average of 4.9 MGD. The flow to the plant is expected to gradually increase over time with the growth of the Centre Region. UAJA is currently permitted to discharge up to 6 MGD to Spring Creek as a monthly average, although it can treat an additional 3 MGD by diverting that flow through its unique beneficial reuse project.

The primary and secondary treatment facilities are designed to handle a 12 MGD sustained flow.

During the 1990s an extensive thermal impact study determined that without cooling the treated wastewater discharge, UAJA could discharge only 6 MGD without negatively impacting the aquatic life in Spring Creek. To overcome this limitation and allow the Centre Region to continue to grow, UAJA and the Centre Region municipalities developed the Beneficial Reuse Project. The project provides high purity, low hardness water to local businesses and municipalities for irrigation, industrial purposes, and groundwater recharge. It is the first project of this type in the Northeastern United States.

A portion of the secondary effluent produced at UAJA's plant is diverted to an Advanced Water Treatment (AWT) facility, which uses a combination of membrane microfiltration, reverse osmosis, ultraviolet light (UV), and chorine disinfection to produce water that meets all drinking water standards. The water is then distributed through a pipeline that winds its way through the Dale Summit industrial area, under Spring Creek below Lemont, along the bike path adjacent to Rt. 322, to the Centre Hills

University Area Joint Authority's Advanced Water Treatment (AWT) facility (credit: J. Brown)

Country Club, which is the endpoint of the pipeline. Currently, the beneficial reuse project generates 1 MGD of high purity, non-potable water, but this will be expanded to 3 MGD capacity as demand increases. UAJA has worked closely with State agencies, local utilities, and experienced reuse operators and engineers from other states to develop standards for water reuse in Pennsylvania that will encourage other communities to adopt beneficial reuse technology, and thus reduce the impact of water extraction on local watersheds.

The sensitive nature of the Spring Creek watershed and its location in the greater Chesapeake Bay Watershed places severe limits on total nitrogen (N) and dissolved phosphorous (P) in UAJA's plant effluent. UAJA's dissolved P limit of 0.13 mg/l is among the lowest in Pennsylvania. The desire to enhance biological P removal and the challenge of controlling total N output to below the targets set by the Chesapeake Bay Tributary Strategy has resulted in UAJA adopting an advanced activated sludge treatment process known as A_2O, in which effluent from primary settling tanks is detained in a series of tanks maintained at a low oxygen reducing condition. This process results in the biological removal of nitrate and phosphate under anaerobic and anoxic conditions, respectively. After passing through a sequence of four anaerobic and two anoxic tanks, treated effluent passes into three large aeration tanks where nitrogen gas is expelled, ammonia is converted to nitrate, and aerobic decomposition removes the more resistant biochemical impurities in the waste. The key to the system is the rapid recycling of the wastewater and sludge combination (mixed liquor) from the oxidation tanks back to the an-

UAJA aeration basins (credit: J. Brown)

oxic tanks, so that nitrate formed under aerobic conditions can be converted to environmentally benign nitrogen gas. The part of the treatment stream that exits the oxidation tanks to the secondary clarifier has dramatically lower total N than the plant influent. In the future, this removal process will be further enhanced by adding an additional high carbon food source such as food processing waste prior to secondary treatment.

Secondary clarification and chemical (alum) addition removes most of the solids and almost all of the dissolved P from the secondary effluent. The portion that is not diverted for beneficial reuse passes through tertiary coal-media and membrane filtration and UV disinfection prior to discharge into Spring Creek. Most of the solids removed in the secondary clarifiers are returned to the A_2O tanks where they provide the microorganisms necessary to process the incoming wastewater stream. The remainder of the biosolids is sent to UAJA's unique dewatering and composting facility.

UAJA was an early adopter of composting as a solution to the disinfection and disposal of municipal biosolids. Sludge from primary and secondary clarifiers is mixed with septage received from local on-site wastewater services and raw biosolids received from rural treatment plants in the surrounding area where it is dewatered and sent to the compost facility. Composting is achieved by mixing the dewatered sludge with sawdust from local mills and then turning it in an aerated windrow over a period of 20-30 days, after which it is cured in a static pile and made available to consumers. The result is an exceptional quality compost product that is safe for handling by all consumers and is in great demand by nurseries, construction companies, and the general public. The compost is approved for use on vegetable gardens.

Since its founding in 1967, UAJA has been committed to meeting the treatment needs of the rapidly growing Centre Region through innovative solutions that enhance not only the economy of the Centre region, but also the quality of its environment, including the status of Spring Creek as a high quality trout stream. Since the construction of the first phase of UAJA's Spring Creek Pollution Control Facility, the population of the Centre Region has tripled and yet the stream segment below UAJA's outfall remains the home of two of the State's eight cold water fish hatcheries, and of "Fisherman's Paradise," a revered recreational area for fly fisherman. Further downstream, Bald Eagle Lake, and eventually the Chesapeake Bay are also protected by UAJA's commitment to the environment .

UAJA's secondary clarifiers (credit: J. Brown)

Submitted by Tom Smith, Plant Superintendent, Bellefonte Wastewater Treatment Plant

The Bellefonte Wastewater Treatment Plant (credit: G. Smith)

In 1939 Bellefonte constructed its first wastewater treatment plant at 615 Pleasant View Boulevard in Spring Township between Bellefonte and Milesburg. That original plant provided wastewater treatment service for most of the Borough of Bellefonte. It was in operation until the mid 1960s when it was upgraded and expanded to accommodate the increasing development taking place on the east side of town. The newly renovated plant operated until 1989 when it was again upgraded and expanded to accommodate growth and development in the service area. By that time the service area had grown to include not only the Borough but also parts of Spring, Benner, and Walker Townships where wastewater collection and conveyance is provided by the Spring Benner Walker Joint Authority. Wastewater collected by the Authority is piped to the Bellefonte plant for treatment. Last year, to accommodate continued growth in the service area, Bellefonte and the Authority completed a piping project that increased capacity of the main interceptor sewer feeding the plant.

The geographic area serviced by Bellefonte Wastewater Treatment Plant is fairly extensive. In addition to Bellefonte Borough, the service area extends as far as University Park Airport and Continental Courts in Benner Township, to Pleasant Gap and Greens Valley Road in Spring Township and the top of Centre Hall Mountain in Potter Township, to Zion and Mingoville in Walker Township. The number of equivalent dwelling units served is approximately 8,870.

The single largest contributor of wastewater to the system is the State Correctional Institution at Rockview with an average daily discharge of approximately 265,480 gallons per day. That contribution will increase significantly when the State completes a recently announced 2000-bed expansion of the Rockview facility. Official flow projections for the new 2000-bed facility have not been finalized; however, a reasonable assumption is that the new facility will generate an additional 230,000 gallons of wastewater per day. The impact of this additional wastewater flow has been mitigated somewhat by Rockview's aggressive water conservation programs coupled with their efforts to remove storm water and groundwater from the sanitary sewer. Over the past year Rockview's wastewater discharge has decreased by 190,000 gallons per day.

Under the Pennsylvania Department of Environmental Protection regulations, Bellefonte Wastewater Treatment Plant is permitted to treat an average daily wastewater flow of 3,220,000 gallons. During 2008, the average daily flow to the plant was 2,078,000 gallons. For planning purposes, the average flow for the three highest consecutive months during the year is used. In 2008 that flow was 2,352,000 gallons per day. Looking ahead five years to the end of 2013, average daily flows are projected to be 2,298,000 gallons per day. The average flow for three highest consecutive months is projected to be 2,482,000 gallons per day. These projections indicate that at the end of 2013 the permitted capacity remaining at Bellefonte Wastewater Treatment Plant will be approximately 700,000 gallons per day.

Last year in July another plant upgrade was initiated. The main purpose of this latest upgrade, in addition to replacing or improving aging components of the plant, is to enable the plant to meet more stringent treatment standards adopted by the PA Department of Environmental Protection as part of the Department's Chesapeake Bay Tributary Strategy. The new Chesapeake Bay standard for total nitrogen will be achieved by installation of special filters designed to remove nitrate from the wastewater by means of biological activity that occurs in the filter bed. Other features of the plant upgrade include replacement of the aging influent pumps, influent screen, and grit removal systems. The process control computer system is being replaced due to obsolescence. Additionally, the chlorine disinfection system is being replaced

Bellefonte Wastewater Treatment Plant's final clarifier system (credit: T. Smith)

with an ultraviolet system, eliminating chlorine from the plant's discharge to Spring Creek and the potential hazards of handling and storing large quantities of chlorine on site. Improvements to the digestion system for wastewater solids (biosolids) will enhance the quality of the biosolids, which is important to the plant's biosolids recycling program. September 2009 is the planned completion date for these upgrades.

No upgrade was necessary to meet the new Chesapeake Bay standard for total phosphorous. The plant's current treatment process of chemical precipitation using aluminum sulfate to remove phosphorous is very effective. Other treatment processes currently in place at the plant are influent flow equalization to smooth out flow peaks and valleys, complete mix activated sludge and secondary clarification processes to provide biological removal of pollutants that contribute to biochemical oxygen demand and total suspended solids, and rotating biological contactors to provide biological conversion of ammonia nitrogen to nitrate. Lastly, final clarification provides additional removal of total suspended solids and is the process unit where phosphorous is chemically precipitated from the wastewater.

Solids handling is a significant part of the plant's operation. The biosolids removed from the wastewater during the treatment processes are stabilized in aerated digestion tanks, conditioned with polymer, and mechanically thickened and dewatered on a gravity belt thickener and a belt filter press. The resulting biosolids cake is recycled on area farmland. Implemented in 1990, Bellefonte's biosolids recycling program has been operating for the past 19 years under permit from the PA Department of Environmental Protection. The program's success has resulted in the recycling of approximately 9,000 dry tons of natural fertilizer/soil conditioner and has provided area farmers with valuable plant nutrients including approximately 450 tons of nitrogen, 270 tons of phosphorous, and 45 tons of potassium.

Dewatering tank at Bellefonte Wastewater Treatment Plant
(credit: T. Smith)

One important aspect of maintaining the quality of the biosoilds, as well as the quality of the plant's effluent outfall to Spring Creek, is to monitor and control the pollutants being discharged to the plant. This is accomplished through regulations set forth under the Industrial Pretreatment Program adopted by Bellefonte Borough and Spring Benner Walker Joint Authority. Under the program, industries in the service area are surveyed and inspected to determine what pollutants can reasonably be expected present in their wastewater. Those industries that have the potential to discharge one or more pollutants of concern are issued a Wastewater Contribution Permit. The permit sets limits on pollutant levels allowed in their discharge and requires that those levels be verified by periodic sampling and analysis. Industrial dischargers that cannot meet the pollutant limits in their permits must install wastewater pretreatment systems that are designed to treat or remove the pollutants of concern from their wastewater before it is discharged to the sewer.

There is also a permitting program in effect for septage pumpers who deliver septic tank, holding tank, and portable toilet waste to the plant for treatment. Pumpers must hold a valid Waste Hauler Permit, issued by the plant, that places limits on the waste being delivered and sets forth the terms and conditions that must be met for the waste to be accepted for treatment. A manifest documenting the type and source of each load of waste is completed by plant personnel and signed by the hauler. Plant personnel then enter information about the load into a log book, oversee the actual discharge of the waste, and periodically collect samples of the waste for analysis.

Municipal wastewater treatment is vital to the water quality of our region. The plants that provide this treatment are continuous operations where dedicated employees work tirelessly, around the clock, everyday to ensure that their plants achieve optimum results. Bellefonte Wastewater Treatment Plant has been helping to protect and improve the water quality of Spring Creek since 1939. Last year's completion of the interceptor sewer expansion project, combined with the completion later this year of new treatment plant upgrades, positions the plant to continue providing the sewer users in Bellefonte Borough, and Spring, Benner, and Walker Townships with quality wastewater treatment services for many years into the future.

Submitted by John Gaudlip, Penn State University Office of Physical Plant

Penn State University Wastewater Treatment Facility (credit: R. Carline)

The University's first wastewater treatment plant (WWTP) was constructed in 1913 on the present site. Over the years the University's management goals have included maximizing the useful life of all treatment plant components and optimizing energy efficiency while producing the highest quality effluent possible. The present plant includes some treatment components that remain in service after 50+ years. Over time these components have been supplemented with the latest treatment technology such as biological nutrient removal to control total nitrogen. The plant is designed and permitted to treat 4.0 million gallons per day and continues to meet all regulatory requirements for discharge to the land treatment area also known as the "Living Filter". This is where all of the University's treated effluent is beneficially recharged (see page 16, 2007 State of the Water Resources in the Spring Creek Watershed report). The 12-month average daily flow to the plant in 2008 was 2.32 million gallons per day. The 2008 fall degree enrollment at the University Park Campus was 44,406. No septic waste is treated at the plant.

The University WWTP is unique in several ways including: zero surface discharge through effluent disposal by the "Living Filter", ownership and operation by a major university, and two different biological secondary treatment processes (trains) in parallel within the same plant. Treatment is accomplished by creating a "happy home" for bacteria and microorganisms ("bugs") that exist in the wastewater. These "bugs" consume organic and other matter coming to the plant resulting in clean water.

Collection System

The University's sanitary sewer collection system includes over 26 miles of pipes ranging in size from 6 to 18 inches in diameter and six pumping stations and associated force mains. Most wastewater within the University is conveyed by gravity sewers to the WWTP except for a few areas that require pumping facilities.

Headworks/Primary Treatment

Wastewater is received from the collection system at the headworks where the flow is measured by Parshall flumes. Automatic flow-paced composite samplers are located upstream of the flumes to characterize influent wastewater constituents and strength. Discharge from the Parshall flumes enters a 10-foot diameter vortex grit chamber that removes settleable grit, which are disposed of in a landfill. Following the grit chamber, the flow splits between two mechanical screens that remove primarily large solids (rags, plastics, etc.), which are washed and disposed of at a landfill.

Following the headworks, the influent wastewater flows into three rectangular primary aeration/settling tanks constructed around 1956. Flow from these tanks is split between two biological treatment trains, the trickling filter train and the activated sludge train. A flow-paced automatic composite sampler collects primary settling tank effluent. Typically, 30% of organic matter and 50% of the solids are removed at this stage.

Trickling Filter Biological Treatment Train

Approximately 50% of the primary treatment effluent is diverted to the trickling filter biological treatment train that was constructed around 1956. The other 50% is directed to the activated sludge treatment train. Typically, 96% of the organic matter in wastewater is removed by a trickling filter train. This train was modified around 1997 to include a biological nutrient removal process. A modified single-stage nitrification-denitrification system consisting of the aeration tanks (existing) and the anoxic tank (new) was provided. Nitrification-denitrification is a biological process (using special "bugs") that reduces the effluent total nitrogen in two stages. Stage 1, nitrification, is the oxidation of ammonia to nitrite and nitrate. Stage 2, denitrification, is the conversion of nitrate to nitrogen gas.

Trickling Filters

Primary effluent is distributed to the trickling filter media through four rotary distribution arms per filter. The trickling filters are 76-foot diameter rock media filters. The media depth is 6 feet and is supported by clay tile filter beds. The effluent from the trickling filters enters the recycle pumping station where a portion is recycled to the trickling filter and the remaining flow is sent to the two plug flow aeration tanks operated in parallel.

Aeration Tanks

The plug flow aeration tanks were originally constructed in 1956 and 1962. These tanks provide sufficient retention time for carbonaceous biochemical oxygen demand (BOD_5) (organic load) oxidation and partial nitrification to occur under normal operating conditions. Mixed liquor (concentrated "bugs") from the aeration tanks flows to final clarifiers for gravity solids separation.

Two blowers controlled by variable frequency drives provide air to the "bugs" in the aeration tanks. The automated aeration control system consists of a dissolved oxygen (DO) probe in the tanks that provides feedback to a programmable logic controller to control the combined airflow to all aeration tanks. The programmable logic controller maintains the blower speed (energy) necessary to provide the airflow required to meet the DO set-point in tank.

Anoxic Tank

The anoxic tank is composed of three serpentine runs divided by baffle walls. Submerged mixers are mounted at the end of each run facing against the current to keep mixed liquor in suspension. No aeration is provided for this tank.

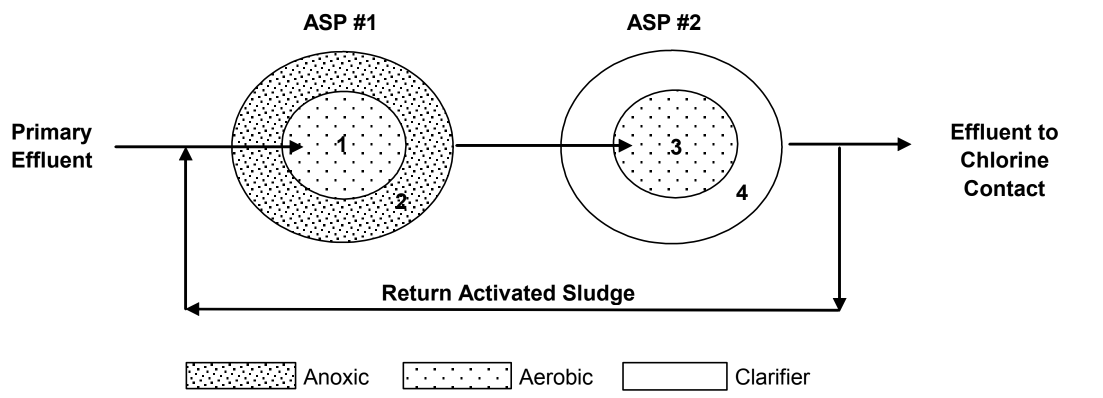


Figure 1. Diagram of the activated sludge biological treatment train. Ninety-six percent of organic matter in wastewater is removed by the two activated sludge plants (ASP), which operate in series to provide an alternating aerobic-anoxic-aerobic denitrification cycle ending in a final clarification process.

Final Clarifiers

Mixed liquor from the aeration tanks is discharged to two final clarifiers operated in parallel. Final clarifier effluent is discharged to the chlorine contact tanks for disinfection to kill pathogenic microorganisms. A flow-paced automatic composite sampler collects final clarifier effluent to characterize removal efficiencies of the trickling filter biological treatment process.

Activated Sludge Biological Treatment Train

The activated sludge treatment train consists of two factory manufactured package activated sludge units installed around 1963. Typically, 96% of the organic matter in wastewater is removed at this train. This process train has been modified to a single-sludge nitrification-denitrification with little or no infrastructure cost. This is achieved by operating the two units in series to provide a three-stage alternating aerobic-anoxic-aerobic cycle followed by final clarification as shown in Figure 1.

Aeration System

The air requirements of the “bugs” in the aeration tanks are met by two positive displacement blowers each rated at 100 horse power equipped with a variable frequency drive. A dissolved oxygen (DO) control system similar to the one described earlier for the trickling filter aeration tanks is provided. A flow-paced automatic composite sampler collects final clarifier effluent to characterize removal efficiencies of the activated sludge treatment process.

Disinfection

The effluent flow from the trickling filter treatment train and activated sludge treatment train combine and enter the two chlorine contact tanks for disinfection to kill pathogenic microorganisms.

Effluent Pump Station

All effluent from the plant flows by gravity to the effluent pump station located near the "Duck Pond". This station contains three 350 horsepower pumps that pump effluent approximately 2.5 miles to the living filter. These pumps are also equipped with a variable frequency drive to conserve energy.

Residuals Management

Sludge from both the trickling filter treatment train and the activated sludge treatment train is pumped for conditioning and thickening in a dissolved air flotation thickener constructed around 1965. This sludge is further conditioned through a two-stage high-rate anaerobic digestion process utilizing a special "bug". First it is fed to one of two complete-mixed, heated primary anaerobic digesters. Methane gas generated by the digesters is used in a hot water boiler that heats sludge in the digesters to keep the sludge at an optimum temperature of about 98ºF year-round. The secondary digester has a floating cover for gas collection. Gas collected is used as fuel for the primary digester heat exchange boiler.

Sludge from the secondary digester is periodically pumped to the belt filter press (BFP) for dewatering. The dewatered sludge is stored on a covered air drying storage pad and periodically transported to a landfill for disposal.

Conclusion

Penn State University, in addition to providing education, research and service to Pennsylvania, is a large landowner with extensive facilities and responsibilities. The University employs a holistic approach to wastewater and stormwater management, as well as potable source water protection. The University's wastewater treatment plant in conjunction with the "Living Filter" system create a cost-effective beneficial reuse of water that for over a quarter century has promoted sustainability while protecting both ground and surface water resources in the Spring Creek watershed.

The Spring Creek Watershed Community, a grassroots stakeholder group composed of concerned citizens and professionals, initiated the Water Resources Monitoring Project (WRMP) in 1997 as part of its strategic plan for the watershed. Their goal was to gather baseline information about the quantity and quality of the water resources in the Spring Creek Watershed that could be used for the long-term protection of these resources as demands on them increase over time. A group of local environmental professionals formed the Water Resources Monitoring Committee in 1998 to develop and oversee the WRMP. The first surface water monitoring stations were established in late 1998/early 1999. Groundwater, stormwater, and spring monitoring stations were added as the project gained momentum (see Figure 2 for a timeline of events). Over the past 10 years, the WRMP has strived to:

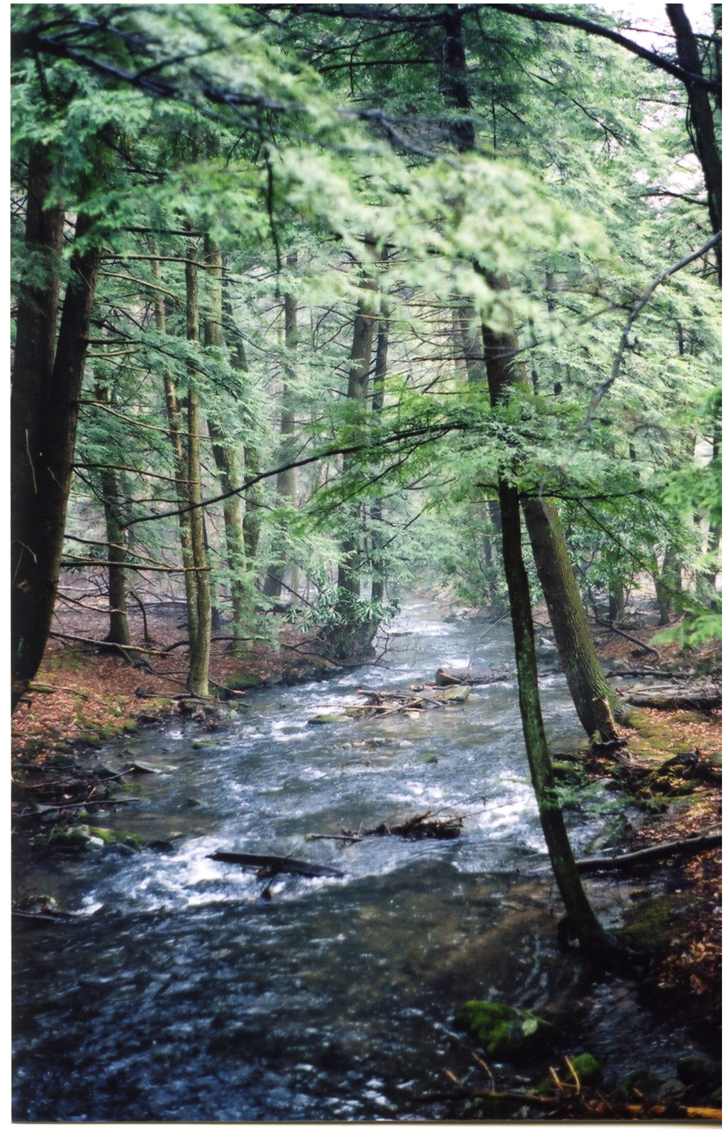
A. Provide a description of the quantity and quality of the surface waters of Spring Creek and its tributaries, including springs;
B. Provide a description of the quality of stormwater runoff throughout the watershed;
C. Monitor groundwater levels in critical areas;
D. Provide the means to detect changes in quantity and quality of surface waters under baseflow and stormwater runoff conditions, as well as groundwater reserves;
E. Provide sufficient measurement sensitivity through long-term monitoring to permit the assessment of the previously mentioned parameters.

The WRMP field stations and database are maintained primarily by the Water Resources Coordinator, a full-time staff position housed at ClearWater Conservancy, with the assistance of volunteers and ClearWater interns. A number of local partners provide funding to carry out WRMP data collection activities, contributing over $67,000 to support this one-of-a-kind project in 2008. Donors in support of the 2008 effort included:

- Bellefonte Borough
- Benner Township
- College Township
- College Township Water Authority
- Ferguson Township
- Halfmoon Township
- Harris Township
- Patton Township
- Potter Township
- Pennsylvania State University Office of Physical Plant
- Spring Township
- Spring Township Water Authority
- Spring-Benner-Walker Joint Authority
- State College Borough
- Spring Creek Chapter of Trout Unlimited
- University Area Joint Authority.

In addition to financial support, the WRMP received in-kind donations of professional services, laboratory analyses and supplies, technical assistance, and transportation from the following in 2008:

- Groundwater well owners
    - Corning Asahi
    - Howard Dashem
    - Pennsylvania Department of Conservation and Natural Resources (DCNR)
    - Todd Giddings
    - Penn State University—Office of Physical Plant
    - United States Geological Survey (USGS)
- Pennsylvania Department of Environmental Protection
- Pennsylvania Cooperative Fish and Wildlife Research Unit, USGS
- United States Geological Survey
- University Area Joint Authority
- Volunteer field assistants
- Water Resources Monitoring Committee (Table 1).



Galbraith Gap Run, Rothrock State Forest (credit: K. Ombalski)

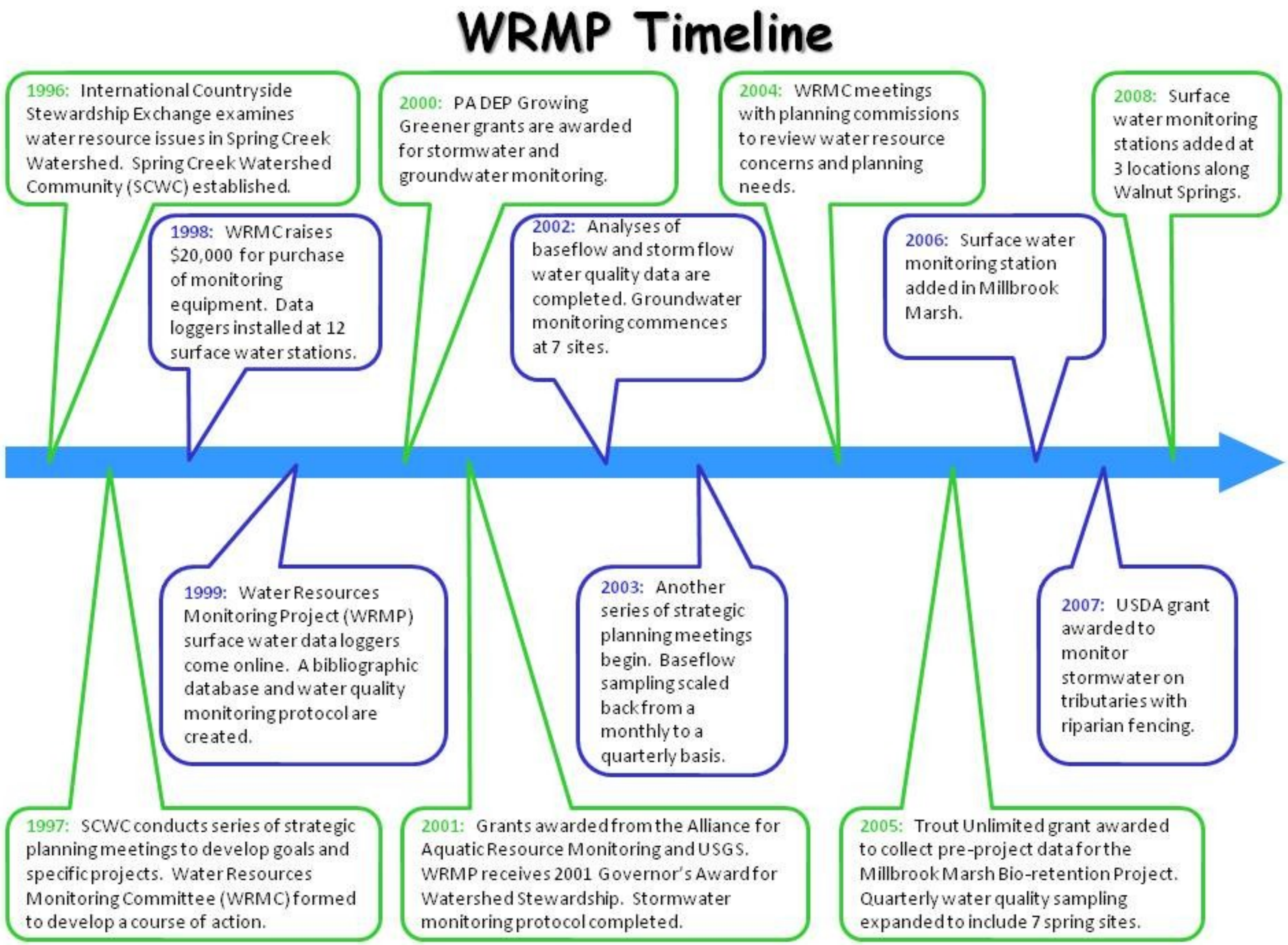


Figure 2. Timeline of activities associated with the Water Resources Monitoring Project

Table 1. Water Resource Monitoring Project Committee Members for 2008

WRMP Committee Member	Affiliation	WRMP Committee Member	Affiliation
Robert Carline, Ph.D. ***Committee Chair***	Pennsylvania Cooperative Fish and Wildlife Research Unit, USGS—retired	**James Hamlett, Ph.D.** Associate Professor of Agricultural Engineering	Department of Agriculture and Biological Engineering, The Pennsylvania State University
Bert Lavan ***Committee Vice-chair*** *West Nile Virus Program Coordinator*	Centre County Planning Office	**Brianna Hutchison** Water Resources Coordinator	ClearWater Conservancy
Jason Brown Project Manager	University Area Joint Authority	**Mark Ralston, P.G.** Hydrogeologist	Converse Consultants
Susan Buda Aquatic Ecologist	Susquehanna River Basin Commission	**Kristen Saacke-Blunk** Director	Agriculture and Environmental Policy Center College of Agricultural Sciences, The Pennsylvania State University
Hunter Carrick, Ph.D. Assistant Professor of Aquatic Ecology	School of Forest Resources The Pennsylvania State University	**John Sengle** Water Quality Specialist	Pennsylvania Department of Environmental Protection
Ann Donovan Watershed Specialist	Centre County Conservation District	**David Smith** Assistant Executive Director	University Area Joint Authority
Rebecca Dunlap Project Manager	Trout Unlimited	**Rick Wardrop, P.G.** Hydrogeologist and Industrial Contamination Specialist	Shaw Environmental & Infrastructure
Larry Fennessey, Ph.D., P.E. Utility Systems Engineer - Stormwater	Office of Physical Plant , The Pennsylvania State University	**Doug Weikel, P.E., C.S.I.** Service Group Manager	Herbert, Rowland, and Grubic, Inc.
Todd Giddings, Ph.D., P.G. Hydrogeologist	Todd Giddings and Associates, Inc.	**Dave Yoxtheimer, P.G.** Senior Hydrogeologist	ARM Group, Inc.

The WRMP tracks quality and quantity of surface water and ground-water reserves at a number of sites throughout the Spring Creek Watershed.

Stream Monitoring Stations

In 2008, the WRMP measured conditions at four sites along the mainstem of Spring Creek and 10 tributary sites located throughout the stream's five major sub-basins (Figure 3). Twelve of the 14 sites currently included in the WRMP have been monitored since 1998. The Water Resources Monitoring Committee (WRMC) chose the 12 original sites to be representative of land use practices across the watershed. Three of the original sites were chosen to coincide with existing United States Geological Survey Gaging Stations. In 2004, the WRMC added a thirteenth site on an unnamed tributary to Buffalo Run in order to track impacts associated with acid drainage from pyritic rock uncovered during construction of interstate 99 northwest of State College. The fourteenth WRMP stream site, located on Slab Cabin Run downstream of Millbrook Marsh, was added in 2005 to assess the marsh's ability to control storm-water impacts from downtown State College and University Park.

Groundwater Monitoring Stations

The WRMP monitored water levels at seven wells in 2008 (Figure 4). These wells were selected by the WRMC because they are not subject to frequent fluctuations caused by external factors such as high-yield pumping, stormwater, artificial groundwater recharge, or surface water discharges. When considered together, the seven wells provide a picture of representative groundwater conditions across the Spring Creek Watershed.

Spring Monitoring Stations

Spring monitoring became part of the WRMP in 2005 with the addition of seven spring sites (Figure 4). Like the stream and ground-water sites, these springs were chosen to be representative of various land use, geologic, and hydrologic conditions encountered in the Spring Creek Watershed. For a detailed discussion of the watershed's springs and their importance to the region, please see the 2006 State of the Water Resources Report.

Stream monitoring station on Spring Creek near Oak Hall (credit: B. Hutchison)

Monitoring stations

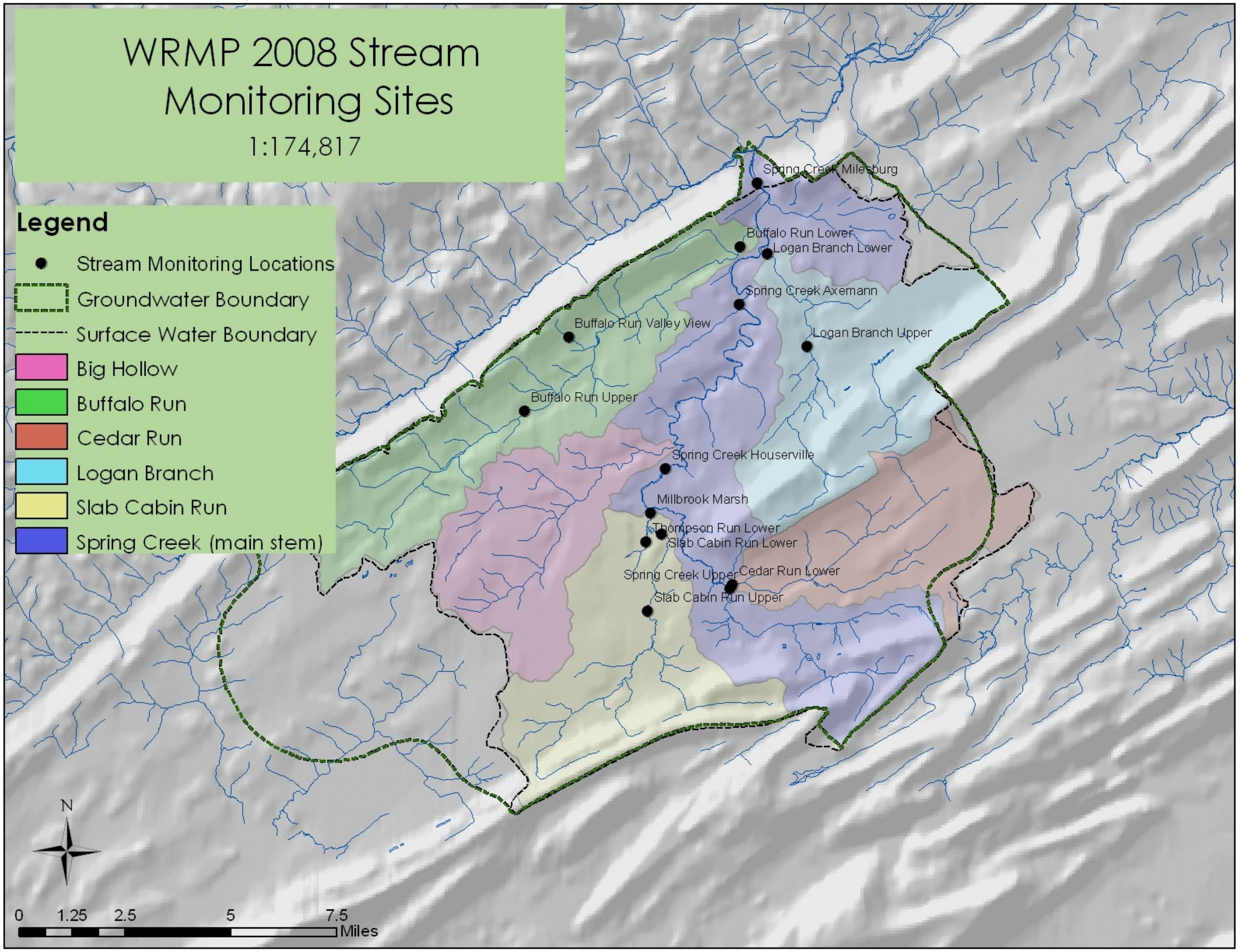


Figure 3: Stream sampling sites surveyed in 2008 as part of the Water Resources Monitoring Project.

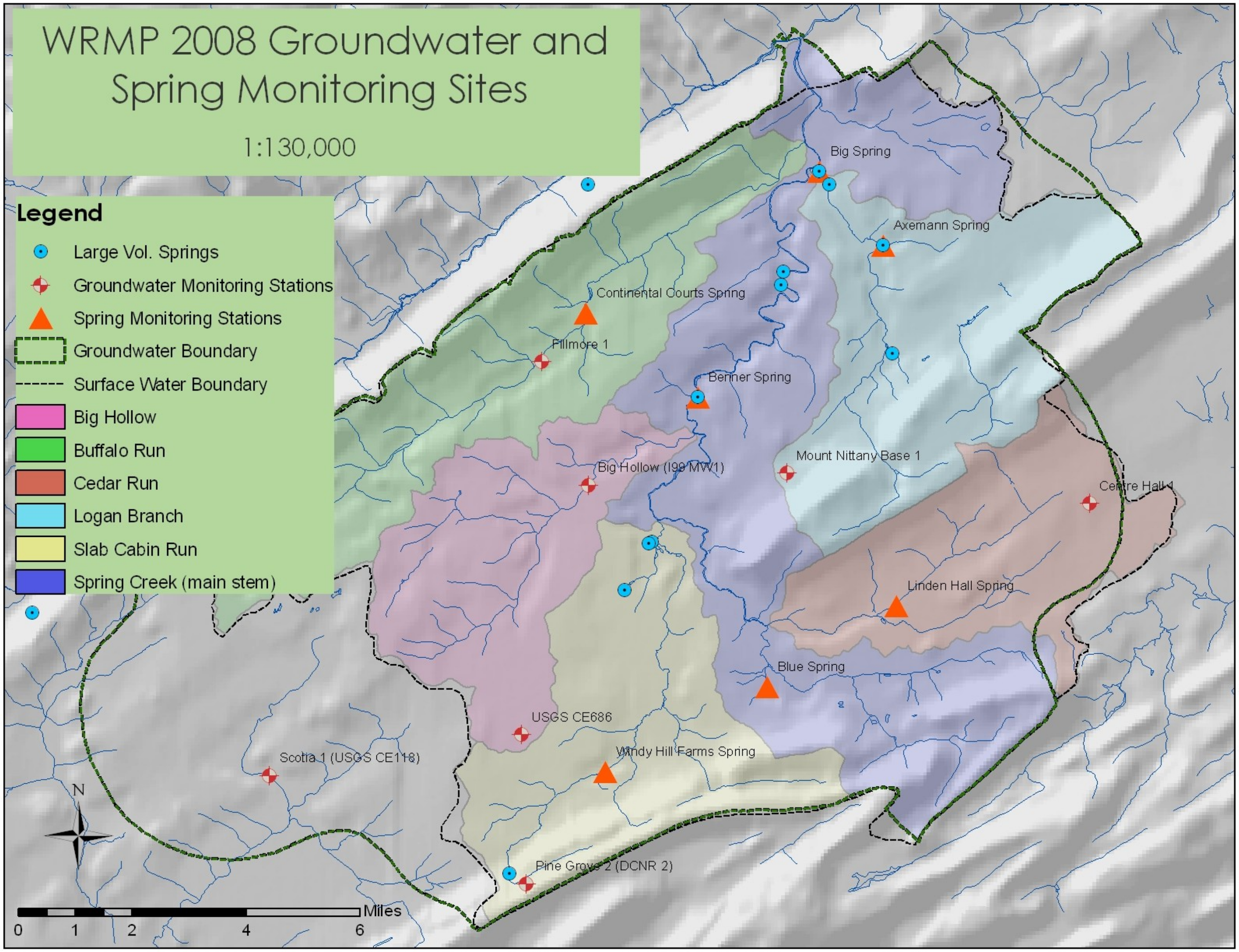


Figure 4: Groundwater and spring stations surveyed in 2008 as part of the Water Resources Monitoring Project.

Monitoring *methodologies*

To assure consistency and quality of data collected as part of the WRMP, the Water Resources Monitoring Committee developed a set of standardized procedures for data collection, sample processing, and database maintenance. A detailed description of these methods can be found in the Spring Creek Watershed Water Resources Monitoring Protocol. To review this document, please contact Brianna Hutchison, ClearWater Conservancy's Water Resources Coordinator, at (814) 237-0400.

Water Resources Coordinator Brianna Hutchison downloading groundwater data from the Pine Grove Mills/DCNR 2 well (credit: D. Silliman)

Water Quality Monitoring

WRMP staff and volunteers collected water samples from 14 stream sites and seven springs in 2008. Sampling took place on a quarterly basis (in March, June, August, and November) during baseflow conditions. The water samples were analyzed for chemical and nutrient content by the Pennsylvania Department of Environmental Protection Analytical Laboratories. Please see Appendix 1 for a list of parameters and Appendix 3 for the results of the water quality analyses.

Volunteer Bryce Boyer filters water samples collected from Upper Buffalo Run (credit: G. Smith)

Continuous Measurements

Thirteen stream stations were equipped with instruments to continuously monitor stream stage. Ten of these were maintained by the WRMP and outfitted with Design Analysis Associates, Inc. DH-21 pressure loggers, which measured stream stage every 30 minutes. The equipment at the other three stream stations was maintained by the U.S. Geological Survey (USGS). Stream stage measurements were taken every 15 minutes at these stations.

Water temperature was measured hourly at 11 stream stations using Onset Computer Corporation Optic Stowaway TidBit data loggers. At the Thompson Run station, the temperature data logger was set to record temperature every 5 minutes instead of every hour. Readings were taken more frequently at this site because past data have shown that temperatures in Thompson Run often fluctuate wildly in a short period of time during storm events.

Water surface elevation was recorded every 3 hours at the seven wells comprising the ground-water monitoring network. WRMP staff and volunteers maintained the monitoring instruments at five of the seven wells, which were equipped with InSitu miniTROLL pressure loggers. The other two wells, CE118 and CE686, were maintained by the USGS.

Discharge Measurements

In order to develop and calibrate the rating curves used to calculate stream flow from the DH-21 stage measurements, WRMP staff and volunteers took periodic instantaneous discharge measurements at each stream site using a Marsh-McBirney flow meter. These measurements were also used to detect any changes in stream channel dimensions due to sediment erosion or deposition.

Water Resources Technician Nicole Rhodes takes a discharge measurement at the Buffalo Run Upper site (credit: G. Smith)

Water Quality

Water quality at 14 stream and seven spring sites across the Spring Creek Watershed was assessed quarterly during baseflow conditions. WRMP water samples were evaluated for a number of organic and inorganic pollutants that are listed in Appendix 1. A summary of water resource management issues for each municipality in the Spring Creek Watershed is found in Appendix 2.

Trends in concentrations of the various parameters were similar to those observed for previous years' samples. Appendices 3 and 4 show median concentrations of all parameters analyzed at each of the stream and spring sites, respectively. Here are some generalizations:

- The concentration of nitrate nitrogen, a common pollutant found in treated wastewater and agricultural runoff, was detected at relatively high levels across all sites in 2008; however, concentrations were similar to those in previous years. Nitrate levels were high at the springs, indicating that groundwater may be an important source of nitrates under baseflow conditions.
- Orthophosphorus, another pollutant commonly associated with agriculture, hovered around concentrations near the lower detectable limit and remained relatively unchanged compared to previous years. Orthophosphorus concentrations were largely below detectable levels in the spring samples, indicating that groundwater inputs are not a primary source of this contaminant during baseflow conditions.
- Chloride concentrations, which when elevated point to impacts from urbanization and water treatment processes, were similar to those observed over the history of the WRMP.
- Sulfate concentrations were high in the Buffalo Run sub-watershed in 2007 due to leaking pipes associated with the treatment of pyritic waste material produced by the Interstate 99 construction project. In 2008, sulfate concentrations at the three Buffalo Run sites were lower than in 2007 and more similar to historical WRMP values.
- Total aluminum concentrations were slightly lower at stream sites in the upper part of the watershed in 2008 compared to data from 2007. In the lower part of the watershed, total aluminum concentrations were slightly higher in 2008 than in 2007 at the stream sites. Total aluminum concentrations were higher at Benner Spring and Blue Spring in 2008 compared to data from 2006 and 2007.
- Total iron concentrations were lower at stream sites in the upper part of the watershed in 2008 compared to 2007. With the exception of the Buffalo Run sub-watershed and Upper Logan Branch, total iron concentrations were higher at stream sites in the lower part of the watershed in 2008 compared to 2007. Benner Spring and Blue Spring had much higher concentrations of total iron in 2008 than in 2006 and 2007, while the total iron concentrations at Windy Hill Spring were much lower. Blue Spring and Windy Hill Spring often become stagnant or dry in times of drought, which can create conditions uncharacteristic of baseflow conditions.
- Total manganese concentrations at all sites were similar to historical WRMP values.
- Zinc was not detected in 2008 except at the Logan Branch sites, Spring Creek Axemann, and Benner Spring. The presence of zinc in the Logan Branch sub-

watershed is likely a legacy of factory production in that area because the record of permitted discharges shows that current contributions are not from present operations.

- Fecal coliform bacteria were detected at Benner Spring, Big Spring, Blue Spring, Continental Courts Spring, and Windy Hill Farm Spring; however, contamination did not exceed the PA DEP bathing standard of 200 colonies/100mL.

Stream Discharge

Stream discharge is defined as the volume of water in a stream passing a given point at a given moment in time. Larger streams have higher discharge rates than smaller ones; therefore, Spring Creek has a higher discharge than any of its tributaries. A stream's ability to move sediment and to dilute chemical pollutants is governed by discharge. Generally, the higher the discharge, the more effective a stream will be at moving sediment downstream and diluting pollutants. A stream's discharge determines the biological communities that will be found in its waters. Species that prefer to live in lakes or slow-moving rivers obviously would not be found in a fast-flowing stream like Spring Creek. Stream discharge also fluctuates with the seasons and with storm events, making it a measurement of interest when studying the effects of runoff and flooding.

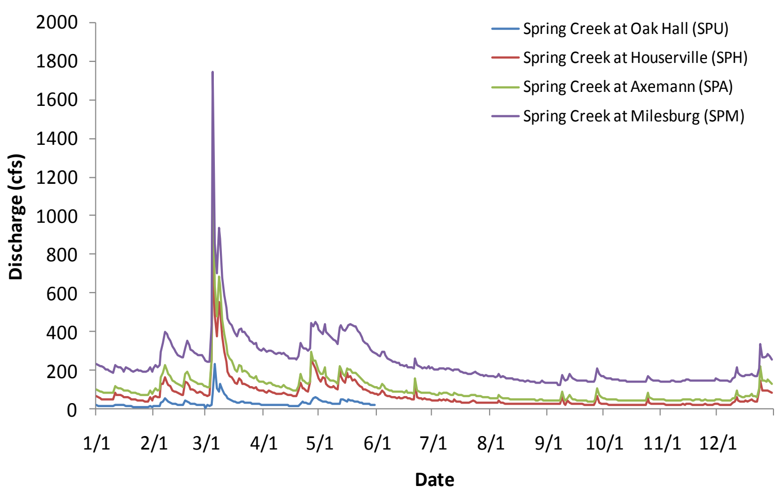


Figure 5. Average daily stream discharge at four locations on Spring Creek in 2008.

Figure 5 depicts average daily stream discharge at four sites along the mainstem of Spring Creek during calendar year 2008. Average daily discharge in the mainstem of Spring Creek during the first six months of 2008 was somewhat higher than the historical median recorded for the monitoring sites. During the second half of the year, stream discharge closely approximated historical median values. Data recorded for the second half of the year at the Spring Creek Oak Hall (SPU) site are not presented because of suspect values in the dataset.

Figures 6 and 7 (page 32) depict average daily stream discharges at eight tributary sites during 2008. Average daily discharges in 2008 were above or very close to the historical medians at several sites along tributary streams, including Cedar Run (CEL), Slab Cabin Run at South Atherton Street (SLU), Thompson Run (THL), and Buffalo Run above Fillmore (BUU). At the same time, average daily discharges were below historical median values at Slab Cabin Run at East College Avenue (SLL), both Logan Branch sites (LOU & LOL), and Buffalo Run near Coleville (BUL). In most streams, as drainage area increases in an upstream to downstream direction, stream discharge also increases. Although East College Avenue

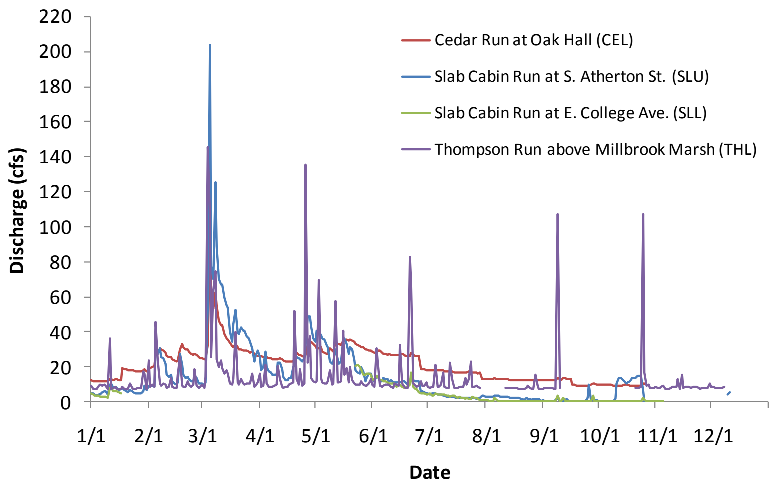


Figure 6. Average daily stream discharge at four tributary sites in the upper Spring Creek Watershed in 2008.

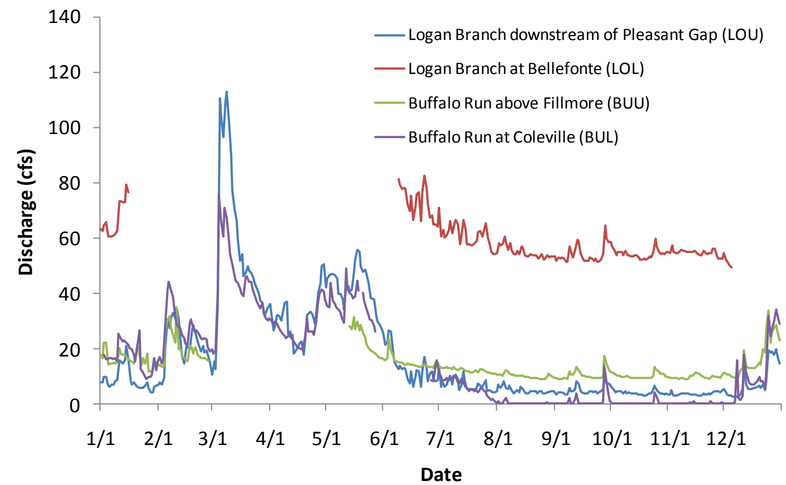


Figure 7. Average daily stream discharge at four tributary sites in the upper Spring Creek Watershed in 2008.

is downstream of South Atherton Street on Slab Cabin Run and Coleville is downstream of Fillmore on Buffalo Run, discharge is higher at the upstream sites. Slab Cabin Run at East College Avenue (SLL) and Buffalo Run near Coleville (BUL) were both dry for periods between August and December 2008. This is because the downstream sections of these streams are perched above the water table and therefore lose water during low-flow conditions. The surface water, in these cases, infiltrates the stream substrate to recharge the groundwater supply. This occurrence is common in karst, or limestone, settings. Figure 8 compares 2008 daily discharge for Buffalo Run above Fillmore (BUU) to historical daily discharge data and 2008 daily discharge data from Buffalo Run near Coleville (BUL).

Stream Temperature

Temperature has a profound influence on aquatic life, governing nearly every process that occurs in streams, from solubility of oxygen and various chemicals to the metabolic functions of fish and other organisms. Despite significant agricultural and urban impacts within the watershed, Spring Creek still manages to support a world-class brown trout fishery famous for its high densities of fish and large numbers of trophy-sized individuals. One of the primary reasons the stream remains so productive is that its waters are relatively cool even on the hottest days of summer. Except in times of extreme heat or drought, inputs from groundwater maintain surface water temperatures in Spring Creek below the brown trout's lethal threshold of 24°C (76°F). When water temperatures rise above 24°C for extended periods, large-scale fish kills like the one that occurred in Slab Cabin Run in June 2005 can result.

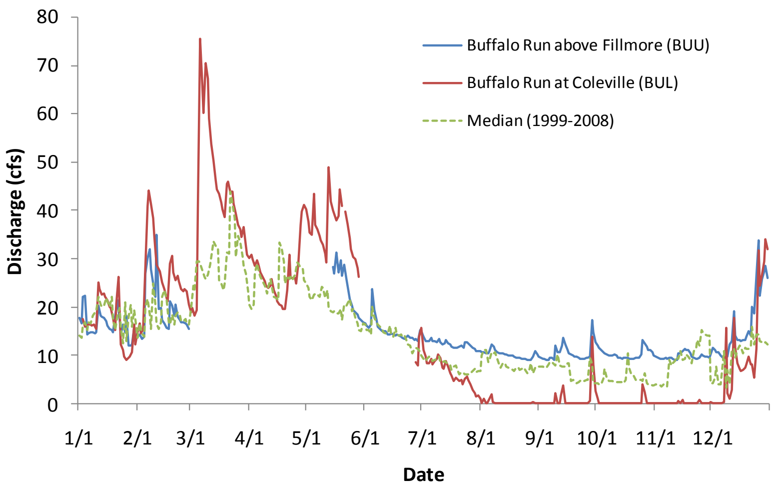


Figure 8. Comparison of 2008 stream discharge at two sites along Buffalo Run and historical data from Lower Buffalo Run.

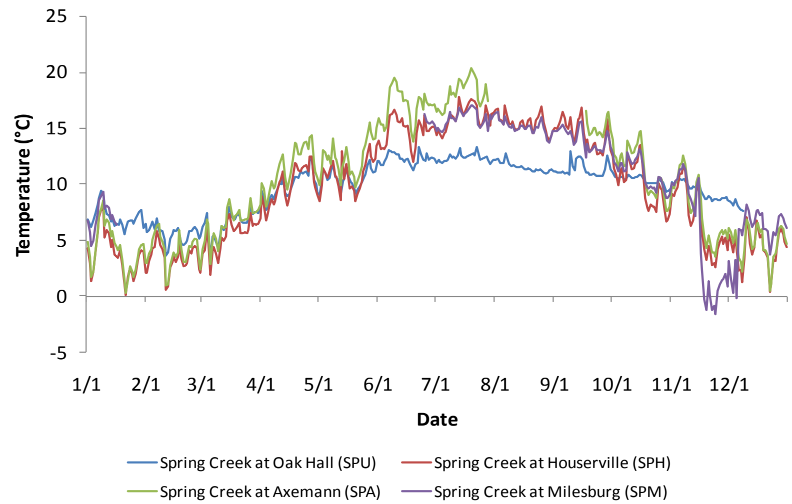


Figure 9. Average daily stream temperature at four locations along Spring Creek in 2008.

Average daily stream temperatures in Spring Creek and its major tributaries remained below the lethal threshold for brown trout in 2008, ranging from about -8°C in the winter to about 20°C in the summer. Figure 9 shows average daily temperatures at the Spring Creek monitoring stations. Figure 10 shows average daily temperatures for tributary sites in the upper part of the watershed and Figure 11 (page 34) shows average daily temperatures for tributary sites in the lower part of the watershed. Although the average daily temperature remained below 24°C at all sites , the maximum daily stream temperature exceeded this value at the lower Slab Cabin site near East College Avenue in State College a number of times during the spring of 2008 (Figure 12, page 34).

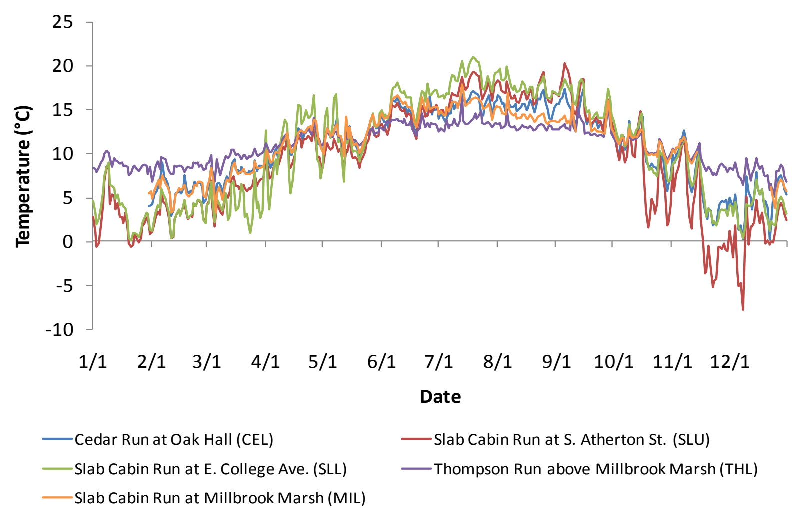


Figure 10. Average daily stream temperature at five tributary sites in the upper Spring Creek Watershed in 2008.

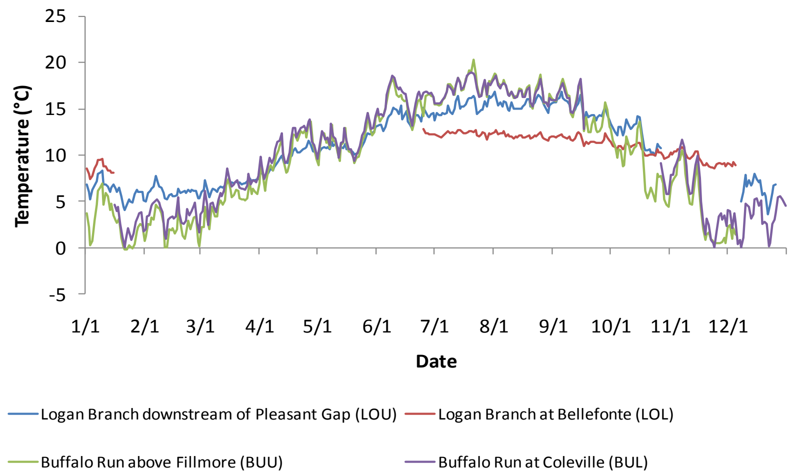


Figure 11. Average daily temperature at four tributary sites in the lower Spring Creek Watershed in 2008.

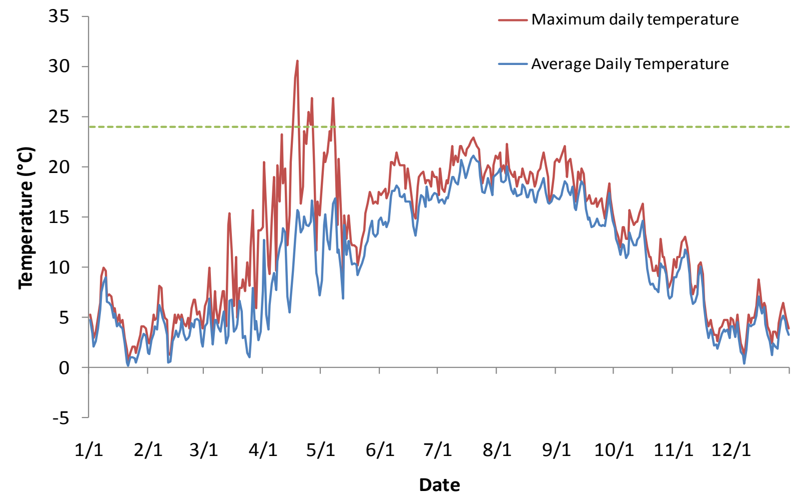


Figure 12. Comparison of average and maximum daily temperature at Slab Cabin Run at E. College Ave (SLL) in 2008. The dashed line represents the upper lethal temperature threshold for brown trout.

Groundwater

In addition to supplying streams with a constant influx of cold water that supports trout and other coldwater aquatic organisms, groundwater is also important to the human inhabitants of the watershed. People living in the Spring Creek Watershed draw over 99% of their potable water from the region's many high volume springs and productive well fields. Without this groundwater resource, the watershed simply could not support such a large population of people; therefore, it is vitally important to closely monitor groundwater elevations throughout the watershed. The WRMP collected groundwater elevation data from five monitoring wells and also assessed data from two additional wells maintained by the U.S. Geological Survey (USGS).

Groundwater elevations in the first half of 2008 exhibited normal fluctuations as a result of wet-dry periods; however, in the second half of the year a steady decline occurred, resulting in groundwater elevations well below the historical medians. A comparison of all wells monitored as part of the WRMP during 2008 is found in Figure 13. USGS monitoring well CE686 began 2008 with groundwater elevations well below historical median levels before rising above median levels in March (Figure 14). Groundwater elevations at CE686 remained close to the historical median until October 2008, when water levels once again dropped. Figure 15 depicts groundwater elevations at USGS monitoring well CE118. This well is located in the Scotia Barrens, which is a vitally important recharge area for Bellefonte's Big Spring. Groundwater elevations at CE118 appeared to be on the rise in 2008 following a long decline that began in 2005.

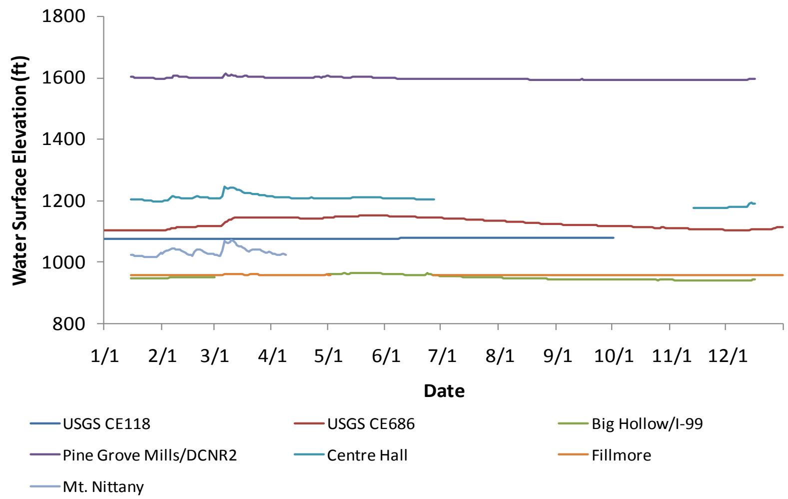


Figure 13. Comparison of water surface elevations at seven wells monitored as part of the WRMP in 2008.

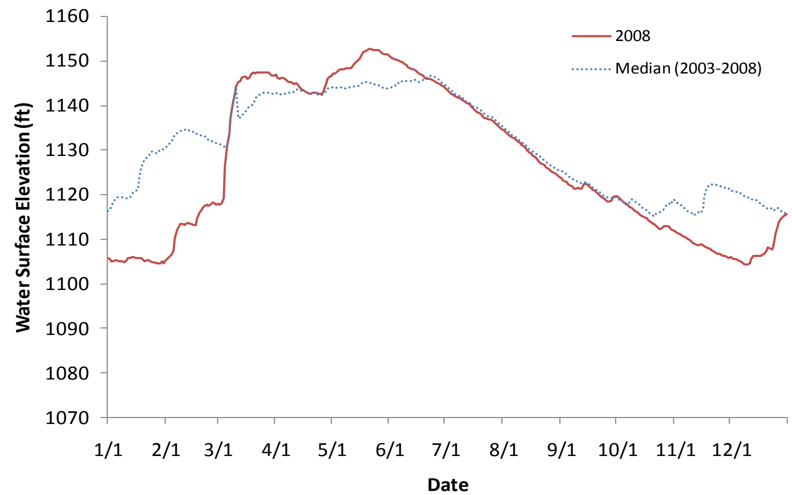


Figure 14. Comparison of 2008 water surface elevation at USGS monitoring well CE686 versus historical median daily water surface elevation.

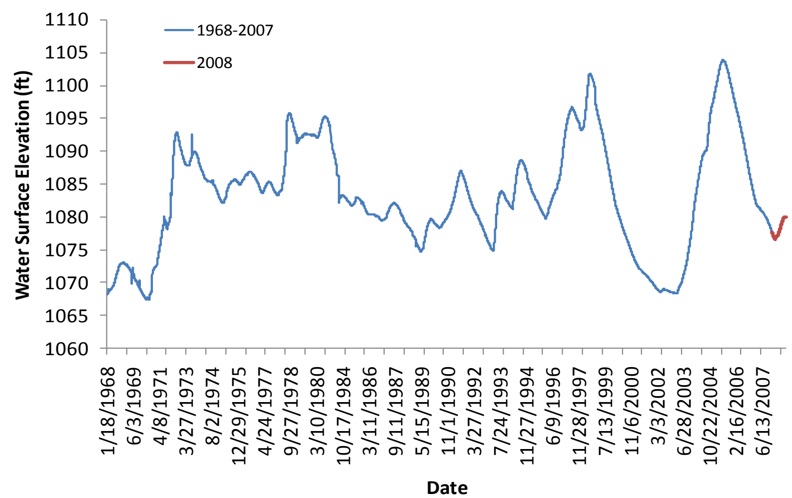
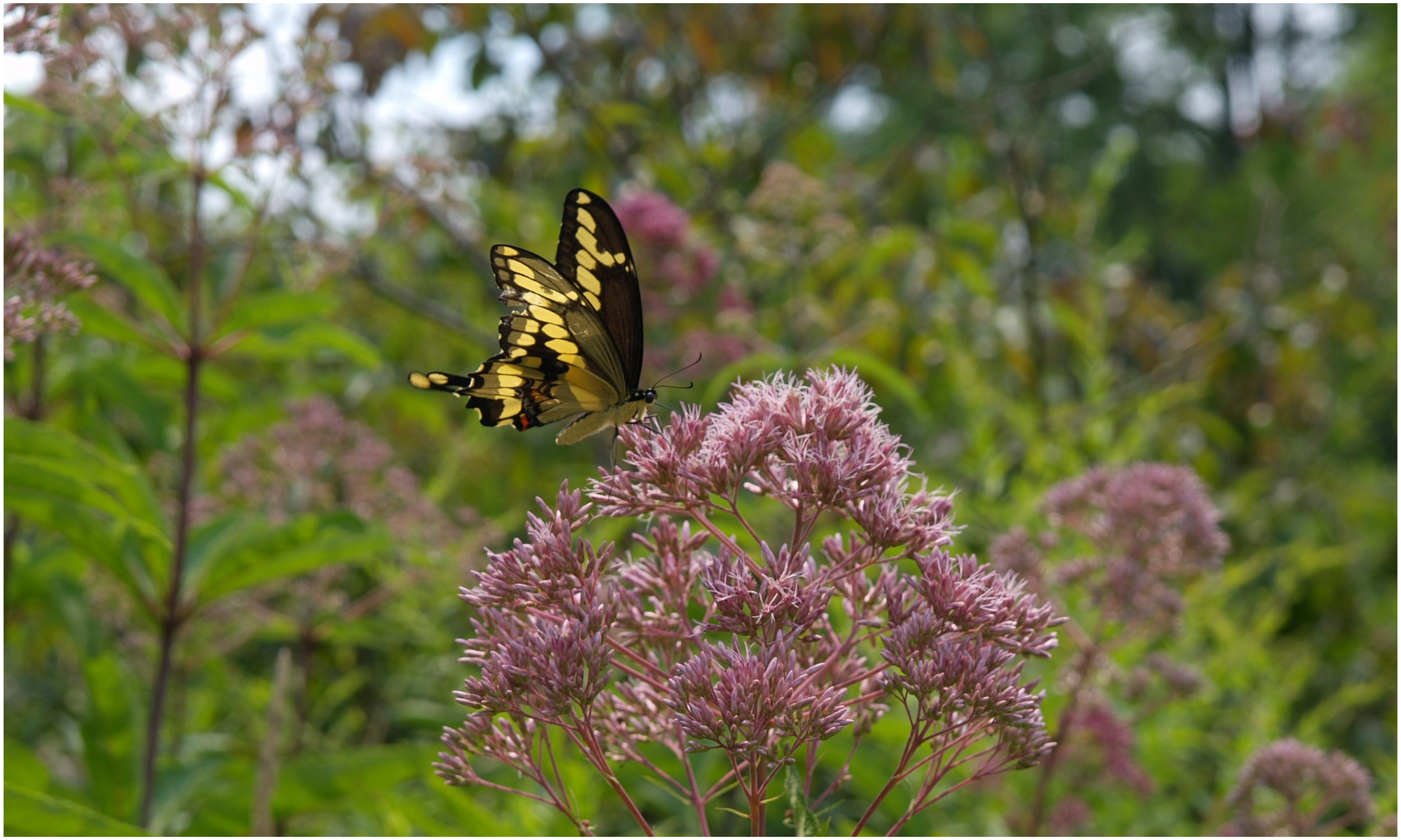


Figure 15. Water surface elevation at USGS monitoring well CE118 throughout the period of record 1968-2008.

Closing

We hope that you found this year's report on the State of the Water Resources both interesting and informative. Residents of Spring Creek Watershed currently enjoy better water quality than the region has seen in nearly 100 years. The commitment of the watershed's three wastewater treatment plants to using only the best, cutting-edge technologies will help ensure good water quality and high quality of life in the region for years to come.

The Water Resources Monitoring Project, which has been in place for over 10 years, will provide vital data to help measure the benefits of new programs such as the Beneficial Reuse Project in the Slab Cabin Run sub-watershed. Your continued support will help this project maintain the ability to respond to new information needs and provide credible data to monitor the future changes within the watershed.



Giant Swallowtail butterfly feeds on JoePye Weed (credit: R. Carline)

Appendices

Appendix 1: Water Quality Parameters

Parameter	Description	Sources	Environmental Effects	Baseflow Monitoring	Spring Monitoring
Aluminum	The most abundant element on Earth	Urban runoff, industrial discharges, and natural sources	May adversely affect the nervous system in humans and animals	X	X
Cadmium	Natural element found in the Earth's crust	Industrial sources and urban sources including fertilizer, non-ferrous metals production, and the iron and steel industry	Toxic to humans and aquatic life	X	X
Chloride	The concentration of chloride salt ions dissolved in the water	Washes off roads where used as a deicing agent	Very high chloride concentrations can be toxic to macroinvertebrates and limit osmoregulatory capacity of fishes	X	X
Chromium	A trace element essential for animals in small quantities	Found in natural deposits of ores containing other elements	Toxic to humans and aquatic life if present in excess	X	X
Conductivity	Measure of the water's ability to conduct electricity. Proportional to the amount of charged ions in the water	Sources of ions are both naturally occurring and anthropogenic in origin. Include soil, bedrock, human and animal waste, fertilizers, pesticides, herbicides, and road salt	Suspended solids clog fish gills and alter stream-bed habitat upon settling. Dissolved materials limit the osmoregulatory ability of aquatic animals	X	X
Copper	A heavy metal less common than lead and zinc in nature	Used in wiring, plumbing, and electronics. Also used to control algae, bacteria, and fungi	Toxic to humans and aquatic life. Solubility is effected by water hardness	X	X
Dissolved Oxygen	The amount of oxygen gas dissolved in the water, saturation inversely related to temperature	Dissolved oxygen is depleted by respiration and microbial breakdown of wastes. It is restored by photosynthesis and physical aeration	Low levels of dissolved oxygen are harmful to aquatic animals. This is usually the result of organic pollution or elevated temperature	X	X
Coliform Bacteria	Common intestial bacteria of warm and cold-blooded animals	Animal wastes and sewage contamination	Pathogenic to humans		X
Iron	Common element found in the Earth's crust	Urban runoff, industrial discharges, and natural sources	Toxic to humans and aquatic life	X	X
Lead	A heavy metal that occurs naturally as lead sulfide but may exist in other forms	Urban and industrial uses include gasoline, batteries, solder, pigments, and paint	Toxic to humans and aquatic life. Solubility is effected by water hardness.	X	X
Manganese	Common element found in the Earth's crust	Urban runoff, industrial discharges, and natural sources	Toxic to humans and aquatic life	X	X
Nickel	A trace element essential for animals in small quantities	Industrial wastewaters	Toxic to humans and aquatic life if present in excess	X	X
Nitrate (NO_3)	One of three forms of nitrogen found in water bodies, this form is used by plants. Organic nitrogen is converted to nitrate by bacteria	Any nitrogen-containing organic waste, including sewage from treatment plants and septic systems and runoff from fertilized lawns, farms, and livestock areas	High nitrate levels promote excessive plant growth and eutrophication. Excess nitrate in drinking water can cause illness or death in infants	X	X
Orthophosphate	The form of inorganic phosphorus required by plants. Often the limiting factor in plant growth	Rocks and minerals provide low natural levels. Human sources include commercial cleaning products, water treatment plants, and fertilized lawns and farmland	A small increase in orthophosphorus can cause eutrophication, the loss of dissolved oxygen through the stimulation and decay of excessive plant growth	X	X
pH	A measure of the the acidity of water on a logarithmic scale of 1 to 14 with 7 being neutral, below 7 acidic, and above 7 alkaline	Alkaline conditions can be a result of carbonate bedrock geology. Acidic conditions could be caused by acid deposition and pyritic reactions associated with acid mine drainage	Extreme acidity or alkalinity can inhibit growth and reproduction in aquatic organisms. Acidic waters also increase the solubility of metals from the sediment	X	X
Sodium	Soft metal commonly found in nature	Various salts of sodium occur in considerable concentrations in the Earth's crust	There is some evidence to suggest that these high levels of sodicity are toxic to some plants	X	X
Total Suspended Solids	Any particles carried by the water including silt, plankton,organic stream matter, industrial waste, and sewage	Include urban runoff, wastewater treatment plants, soil erosion, and decaying plant and animal material	Suspended solids clog fish gills and alter stream-bed habitat when settled. Particles may carry bound toxic compounds or metals	X	X
Turbidity	A measure of water clarity expressed as the amount of light penetrating the water. It is relative to the amount of suspended material in the water	While in some cases high turbidity is natural, it is usually the result of earth-moving activities, urban runoff, and erosion	High turbidity blocks light from the water column, inhibiting productivity of aquatic plants and periphyton. These particles also absorb sunlight and increase temperature. Also, particles will eventually come out of suspension and cause sedimentation	X	X
Zinc	A heavy metal commonly found in rock-forming minerals	Urban runoff, industrial discharges, and natural sources	Somewhat toxic to humans and aquatic life. Solubility is affected by water hardness	X	x

Appendix 2: Summary of monitoring sites and management issues in their vicinity by municipality

Municipality	Monitoring sites with the municipality	Other sites influenced by activities within the municipality	Water resources management issues
Benner Township	Unnamed tributary to Buffalo Run (BVV) Continental Courts Spring (COS) Fillmore Well Benner Spring (BES) Spring Creek at Axemann (AXS)	Buffalo Run near Coleville (BUL) Spring Creek at Milesburg (SPM) Logan Branch near Pleasant Gap (LOU)	Agricultural practices (ground and surface water) Urbanization/ Suburbanization (storm-water and water supply)
Boggs Township	Spring Creek at Milesburg (SPM)		
College Township	Spring Creek at Houserville (SPH) Slab Cabin Run at Millbrook Marsh (MIL) Slab Cabin Run at East College Avenue (SLL) Thompson Run (THL) Spring Creek at Oak Hall (SPU) Cedar Run at Oak Hall (SPU) Big Hollow/ I-99 Well Mount Nittany Well		Urbanization/ Suburbanization (storm-water and water supply) Agricultural practices (upstream areas)
Ferguson Township	Windy Hill Farm Spring (WIS) DCNR/ Pine Grove Mills Well USGS CE686 Monitoring Well USGS CE118 Monitoring Well	Thompson Run (THL)	Urbanization/ Suburbanization (storm-water and water supply) Agricultural practices
Halfmoon Township		Buffalo Run near Fillmore (BUU) Big Spring (BIS)	Agricultural practices Suburban development
Harris Township	Blue Spring (BLS) Linden Hall Spring (LIS) Galbraith Gap Run (GGU)	Slab Cabin Run at South Atherton Street (SLU) Spring Creek at Oak Hall (SPU) Cedar Run at Oak Hall (CEL)	Agricultural practices (surface and ground water) Suburban development
Patton Township	Buffalo Run near Fillmore (BUU)		Agricultural practices/ suburbanization
Potter Township	Dashem/ Centre Hall Well		Agricultrual practices
Spring Township	Logan Branch near Pleasant Gap (LOU) Axemann Spring (AXS) Buffalo Run near Coleville (BUL)	Logan Branch at Bellefonte (LOL) Spring Creek Milesburg (SPM)	Agricultural practices (surface and ground water) Suburban development Industrial water usage
Walker Township			Agricultural practices/ suburbanization
Bellefonte Borough	Logan Branch in Bellefonte (LOL) Big Spring (BIS)	Spring Creek at Milesburg (SPM)	Urbanization/ Suburbanization (storm-water)
Centre Hall Borough			Agricultural practices in surrounding areas
Milesburg Borough		Spring Creek at Milesburg (SPM)	Urbanization (storm-water)
State College Borough	Slab Cabin Run at South Atherton Street (SLU)	Thompson Run (THL) Slab Cabin Run at East College Avenue (SLL) Slab Cabin Run at Millbrook Marsh (MIL)	Urbanization/ Suburbanization (storm-water)

Appendix 3: Median Stream Water Quality Results (Metals) for 2008

Site Name	Abbrev	Aluminum (µg/L)		Cadmium (µg/L)		Chromium (µg/L)		Copper (µg/L)		Iron (µg/L)	
		Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Galbraith Gap Run	GGU	ND	23.3*	ND	ND	ND	ND	ND	ND	ND	22.5*
Cedar Run - Lower	CEL	ND	40.6	ND	ND	ND	ND	ND	ND	ND	61.0
Slab Cabin Run - Upper	SLU	5.0*	29.9	ND	ND	ND	ND	ND	ND	ND	64.0
Slab Cabin Run - Lower	SLL	ND	32.5	ND	ND	ND	ND	ND	ND	10.0*	54.5
Slab Cabin Run - Millbrook	MIL	5.0*	36.3	ND	ND	ND	ND	ND	ND	ND	57.5
Thompson Run - Lower	THL	5.0*	30.4	ND	ND	ND	ND	ND	ND	10.0*	61.0
Buffalo Run - Upper	BUU	ND	60.9	ND	ND	ND	ND	ND	ND	ND	105.5
Buffalo Run - Valley View	BVV	5.0*	74.5	ND	ND	ND	ND	ND	ND	35.0*	141.5
Buffalo Run - Lower	BUL	ND	111.5	ND	ND	ND	ND	ND	ND	ND	145.5
Logan Branch - Upper	LOU	7.6*	54.1	ND	ND	ND	ND	ND	ND	ND	82.5
Logan Branch - Lower	LOL	ND	27.5	ND	ND	ND	ND	ND	ND	ND	33.0*
Spring Creek - Upper	SPU	ND	18.6	ND	ND	ND	ND	ND	ND	ND	30.0*
Spring Creek - Houserville	SPH	ND	47.2	ND	ND	ND	ND	ND	ND	ND	71.5
Spring Creek - Axemann	SPA	5.0*	48.2	ND	ND	ND	ND	ND	ND	ND	67.5
Spring Creek - Milesburg	SPM	ND	80.0	ND	ND	ND	ND	ND	ND	ND	61.5

Site Name	Abbrev	Lead (µg/L)		Manganese (µg/L)		Nickel (µg/L)		Sodium (mg/L)		Zinc (µg/L)	
		Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Galbraith Gap Run	GGU	ND	ND	ND	3.9*	ND	ND	0.6	0.6	ND	ND
Cedar Run - Lower	CEL	ND	ND	1.6*	4.0*	ND	ND	5.6	6.2	ND	ND
Slab Cabin Run - Upper	SLU	ND	ND	4.6	7.2	ND	ND	12.2	12.3	ND	ND
Slab Cabin Run - Lower	SLL	ND	ND	3.5	6.8	ND	ND	25.5	26.7	ND	ND
Slab Cabin Run - Millbrook	MIL	ND	ND	4.5	6.4	ND	ND	27.0	28.0	ND	ND
Thompson Run - Lower	THL	ND	ND	3.8*	6.6	ND	ND	22.4	23.1	ND	ND
Buffalo Run - Upper	BUU	ND	ND	8.3	13.0	ND	ND	17.5	16.7	ND	ND
Buffalo Run - Valley View	BVV	ND	ND	24.2	36.3	ND	ND	10.0	10.2	ND	ND
Buffalo Run - Lower	BUL	ND	ND	5.8	13.0	ND	ND	9.2	9.6	ND	ND
Logan Branch - Upper	LOU	ND	ND	3.9	6.9	ND	ND	12.1	12.2	ND	5.0*
Logan Branch - Lower	LOL	ND	ND	ND	2.7	ND	ND	10.7	11.1	ND	10.0*
Spring Creek - Upper	SPU	ND	ND	1.6*	2.3	ND	ND	8.9	9.5	ND	ND
Spring Creek - Houserville	SPH	ND	ND	3.8	5.7	ND	ND	17.6	17.8	ND	ND
Spring Creek - Axemann	SPA	ND	ND	2.3	5.2	ND	ND	27.5	27.4	5.0*	5.0*
Spring Creek - Milesburg	SPM	ND	ND	3.4	10.0	ND	ND	18.1	18.6	ND	ND

* At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations

ND All concentrations for all sites were below detection limits so no value was assigned for concentrations

Appendix 3: Median Stream Water Quality Results (Nutrients & Physicochemical) for 2008

Site Name	Abbrev	Calcium (mg/L) Total	Magnesium (mg/L) Total	Hardness (mg/L) Total	Chloride (mg/L) Total	Sulfate (mg/L) Total	Suspended Solids (mg/L) Total	Turbidity (NTU)
Galbraith Gap Run	GGU	3.0	1.5	13.5	1.3*	ND	1.0*	ND
Cedar Run - Lower	CEL	76.7	24.6	292.5	14.8	20.9	1.0*	1.5*
Slab Cabin Run - Upper	SLU	53.5	21.9	224.0	26.5	20.6	1.0*	0.5*
Slab Cabin Run - Lower	SLL	64.6	28.4	278.5	56.5	27.5	5.0*	0.5*
Slab Cabin Run - Millbrook	MIL	65.3	28.4	280.0	62.5	24.2	3.5*	0.9*
Thompson Run - Lower	THL	69.1	30.6	298.5	57.5	22.6*	8.0*	1.3*
Buffalo Run - Upper	BUU	73.4	29.5	304.5	32.3	41.8	6.0*	1.8*
Buffalo Run - Valley View	BVV	42.5	5.0	127.5	14.0	19.8	5.0*	2.4*
Buffalo Run - Lower	BUL	67.2	26.9	274.5	19.2	30.7	8.0*	3.4*
Logan Branch - Upper	LOU	62.5	19.1	234.5	27.6	39.7	1.0*	2.5
Logan Branch - Lower	LOL	51.9	21.2	214.0	23.6	22.0*	4.5*	1.3*
Spring Creek - Upper	SPU	62.4	22.0	247.0	20.0	21.1	ND	0.5*
Spring Creek - Houserville	SPH	71.3	26.8	288.5	40.6	29.3	5.0*	1.5*
Spring Creek - Axemann	SPA	61.6	24.3	255.5	54.6	28.9	5.0*	1.5*
Spring Creek - Milesburg	SPM	56.0	22.3	224.5	37.8	24.9	4.5*	2.9*

Site Name	Abbrev	pH	Diss. Oxygen (mg/L)	Temperature (°C)	Conductivity (mS)	Nitrate-N (mg/L)	Orthophosphorus (mg/L) Total
Galbraith Gap Run	GGU	7.8	12.00	7.9	25.3	0.1	0.005*
Cedar Run - Lower	CEL	8.5	11.50	11.2	397.9	4.6	ND
Slab Cabin Run - Upper	SLU	8.3	10.94	13.9	402.8	3.2	0.018*
Slab Cabin Run - Lower	SLL	8.3	12.07	11.9	491.0	2.1	0.011*
Slab Cabin Run - Millbrook	MIL	8.4	11.68	11.2	483.5	3.6	0.014*
Thompson Run - Lower	THL	8.4	11.98	12.5	505.0	3.9	0.014
Buffalo Run - Upper	BUU	8.4	12.07	8.7	466.0	1.3	0.010*
Buffalo Run - Valley View	BVV	8.1	11.29	9.4	168.9	0.2	0.024
Buffalo Run - Lower	BUL	8.3	11.82	10.5	374.2	1.9	0.009*
Logan Branch - Upper	LOU	7.9	10.69	11.3	364.8	2.5	0.047
Logan Branch - Lower	LOL	8.0	11.08	10.2	318.7	3.1	0.015
Spring Creek - Upper	SPU	7.8	9.39	10.1	354.4	2.8	ND
Spring Creek - Houserville	SPH	8.3	11.29	10.6	428.9	3.5	0.001*
Spring Creek - Axemann	SPA	8.3	12.26	11.6	441.1	3.9	0.028*
Spring Creek - Milesburg	SPM	8.2	11.71	9.8	361.9	3.2	0.024

* At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations

ND All concentrations for all sites were below detection limits so no value was assigned for concentrations

Appendix 4: Median Spring Water Quality Results (Metals) for 2007

Site Name	Abbrev	Aluminum (µg/L) Dissolved	Aluminum (µg/L) Total	Cadmium (µg/L) Dissolved	Cadmium (µg/L) Total	Chromium (µg/L) Dissolved	Chromium (µg/L) Total	Copper (µg/L) Dissolved	Copper (µg/L) Total	Iron (µg/L) Dissolved	Iron (µg/L) Total
Axemann Spring	AXS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benner Spring	BES	ND	46.7	ND	ND	ND	ND	ND	ND	ND	87.5*
Big Spring	BIS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Blue Spring	BLS	5.0*	93.6*	ND	ND	ND	ND	ND	ND	19.0*	309.0*
Continental Courts Spring	COS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Linden Hall Park Spring	LIS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Windy Hill Farm Spring	WIS	ND	22.2	ND	ND	ND	ND	ND	ND	ND	26.0

Site Name	Abbrev	Lead (µg/L) Dissolved	Lead (µg/L) Total	Manganese (µg/L) Dissolved	Manganese (µg/L) Total	Nickel (µg/L) Dissolved	Nickel (µg/L) Total	Sodium (mg/L) Dissolved	Sodium (mg/L) Total	Zinc (µg/L) Dissolved	Zinc (µg/L) Total
Axemann Spring	AXS	ND	ND	ND	ND	ND	ND	14.0	14.4	ND	ND
Benner Spring	BES	ND	ND	1.8*	5.6*	ND	ND	23.1	24.2	5.0*	ND
Big Spring	BIS	ND	ND	ND	ND	ND	ND	8.8	9.6	ND	ND
Blue Spring	BLS	ND	0.5*	28.1*	31.4*	ND	ND	2.7	2.8	ND	ND
Continental Courts Spring	COS	ND	ND	ND	ND	ND	ND	8.8	9.5	ND	ND
Linden Hall Park Spring	LIS	ND	ND	ND	ND	ND	ND	2.8	2.9	ND	ND
Windy Hill Farm Spring	WIS	ND	ND	1.0*	2.9*	ND	ND	13.9	14.0	ND	ND

* At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations

ND All concentrations for all sites were below detection limits so no value was assigned for concentrations

Appendix 4: Median Spring Water Quality Results (Nutrients & Physicochemical) for 2007

Site Name	Abbrev	Calcium (mg/L) Total	Magnesium (mg/L) Total	Hardness (mg/L) Total	Chloride (mg/L) Total	Sulfate (mg/L) Total	Suspended Solids (mg/L) Total	Turbidity (NTU)
Axemann Spring	AXS	82.3	35.5	349.5	35.3	31.8	1.0*	ND
Benner Spring	BED	63.5	24.0	259.0	49.2	19.6*	1.0*	1.4*
Big Spring	BIS	33.8	17.3	155.5	18.2	12.7*	ND	ND
Blue Spring	BLS	37.0	17.6	165.0	5.6	ND	10.5*	4.9*
Continental Courts Spring	COS	60.3	27.1	263	19.1	18.4	ND	ND
Linden Hall Park Spring	LIS	80.6	33.7	340.5	7.6	20.8	ND	ND
Windy Hill Farm Spring	WIS	63.8	29.7	282.0	27.3	22.1	1.0*	ND

Site Name	Abbrev	pH	Diss. Oxygen (mg/L)	Temperature (°C)	Conductivity (mS)	Nitrate-N (mg/L)	Orthophosphorus (mg/L) Total	Fecal Coliforms (#col/ 100mL)
Axemann Spring	AXS	7.4	9.67	10.2	495.0	6.3	ND	0.0
Benner Spring	BES	7.5	8.51	10.4	437.1	3.9	0.010*	76.0
Big Spring	BIS	8.0	10.89	10.3	218.2	1.8	ND	4.0
Blue Spring	BLS	8.1	6.86	9.7	227.6	1.4	0.016*	169.3
Continental Courts Spring	COS	7.8	6.76	10.3	359.3	2.3	ND	1.3
Linden Hall Park Spring	LIS	7.4	7.05	9.9	424.7	4.5	ND	0.0
Windy Hill Farm Spring	WIS	7.8	8.17	11.2	340.6	4.3	0.005*	35.7

* At least one sample had an undetectable concentration so a concentration of 1/2 detection limit set as concentration for calculations

ND All concentrations for all sites were below detection limits so no value was assigned for concentrations

$ Values possibly affected by low flow or stagnant conditions due to drought