Long Term 2 Enhanced Surface Water Treatment Rule
Watershed Control Program Plan
Queen Lane Drinking Water Treatment Plant
Schuylkill River, Philadelphia, PA

This report was produced for the Pennsylvania Department of Environmental Protection in accordance with the Environmental Protection Agency National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule.

Prepared by The Philadelphia Water Department
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Office of Watersheds

Philadelphia PWD Water Department

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Executive Summary

Introduction and Objective

The Philadelphia Water Department's Source Water Protection Program is a multi-faceted program that is primarily responsible for ensuring the safety and quality of Philadelphia's drinking water. A critical component of the program's mission is to fulfill all source water protection regulatory requirements. On January 5th, 2006, the EPA promulgated the first drinking water regulation based on source water quality under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2). The LT2 serves as a series of amendments to the Safe Drinking Water Act, and aims to protect public health from illness due to *Cryptosporidium* and other microbial pathogens in drinking water.

A bin classification system forms the basis of the EPA's risk-targeted approach to reducing *Cryptosporidium* in drinking water sources. Filtered public water systems (PWSs) are classified in one of four bins based on results from a two-year-long source water monitoring program. PWD's three drinking water treatment plants have been monitoring for *Cryptosporidium* in conjunction with the LT2 since 2001. Based on monitoring results, the Baxter and Belmont intakes are in Bin 1, which requires no additional treatment. Results from the Queen Lane intake, however, indicate a slightly higher average oocyst concentration that resulted in Bin 2 classification. Conventional treatment plants, such as Queen Lane, that are placed in Bin 2 require an additional 1-log treatment credit. To achieve this credit, PWD plans to implement a Watershed Control Plan (WCP) and two treatment performance options, which in combination will achieve 1-log removal.

Scope of Work

To fulfill the EPA's requirements for a WCP, PWD must designate an area of influence, which is defined as the area outside of which the likelihood of *Cryptosporidium* contamination affecting the treatment plant intake is not significant. PWD has designated the entire Schuylkill River watershed as the area of influence due to several factors, including the extended survival of *Cryptosporidium* oocysts, the pathogen's potential to travel long distances downstream before significant die-off, the high degree of removal required by drinking water treatment, and *Cryptosporidium's* extremely low infectious doses. Designating the entire Schuylkill River watershed as the area of influence presents many challenges in regard to *Cryptosporidium* source prioritization and the implementation of watershed control plan measures. The WCP is composed of the following elements, which aim to address these watershed-wide challenges and identify feasible action items for reducing *Cryptosporidium* contamination:

- identification of potential and actual sources of *Cryptosporidium* within the area of influence;
- an analysis of control measure to mitigate sources of *Cryptosporidium*;
- an in-city and watershed-wide vulnerability assessment for high priority sources of *Cryptosporidium*;

- a statement of goals and specific actions that PWD will undertake to reduce source water vulnerability to *Cryptosporidium* contamination and a description of how actions are expected to contribute to specific goals;
- identification of partners and their roles, PWD's resource requirements and commitments, and a schedule for plan implementation; and,
- a means by which to maintain the 0.5 log removal credit that will include submittal of an annual status report to the PADEP.

PWD's extensive Source Water Protection Program forms the basis for the LT2 Watershed Control Plan Program. The plan's scope encompasses a series of ongoing and proposed, or future, initiatives to address priority sources of *Cryptosporidium* in the watershed. Initiatives to be included in the plan implementation process fall into one of four categories: wastewater dischargers and compliance, agricultural land use and runoff, animal vectors, and education and outreach.

PWD's ongoing initiatives include the following: *Cryptosporidium* source tracking studies in collaboration with Lehigh University; partnership work, particularly involving the Schuylkill Action Network (SAN); action items outlined in the City's Combined Sewer and Stormwater Management Plans; the Delaware Valley Early Warning System (EWS); and, the City's extensive education and outreach efforts that encompass both in-city and watershed-wide projects and partnerships.

Future initiatives that have been identified to further reduce the risk of *Cryptosporidium* contamination throughout the watershed and at the Queen Lane intake are summarized below for each implementation category.

<u>WWTP Dischargers/Compliance:</u>

- Develop a Source Water Assessment update for the Schuylkill River.
- Develop an effluent monitoring plan for *Cryptosporidium* at major WWTPs in the Schuylkill River watershed.
- Through participation in the SAN Pathogens/Compliance Workgroup, ensure that high-priority areas requiring regulatory enforcement action are identified and addressed.
- Coordinate with SAN to provide wet weather and high flow management education to WWTP operators.
- Support future research initiatives surrounding the impact of WWTP effluent on *Cryptosporidium* surface water concentrations.

<u>Agricultural Land Use & Runoff:</u>

- Develop maintenance plans for agriculture Best Management Practices (BMPs) installed both within Philadelphia and throughout the watershed.
- Coordinate with the National Lands Trust to install additional agriculture BMPs at Erdenheim Farm in the Wissahickon watershed.
- Re-assess land use in the Schuylkill River watershed.
- Identify and assess CAFOs located in the Schuylkill River watershed.

- Explore opportunities to partner with academic institutions on research related to the impact of agricultural sources on *Cryptosporidium* surface water concentrations.

Animal Vectors:

- Complete implementation of waterfowl management programs at Fairmount Park properties, including Peter's Island, and at the Queen Lane, Belmont, and Baxter WTPs, as well as PWD's three WWTPs.
- Raise awareness throughout the watershed as to the threat animal vectors pose to source water quality.

Education & Outreach:

- Maintain and expand in-city and watershed-wide partnership work and education and outreach initiatives.
- Complete implementation of in-city source water programs in the East Falls and Manayunk neighborhoods of Philadelphia.

The above initiatives are included in the Queen Lane Watershed Control Plan because they address priority sources of *Cryptosporidium* in the Schuylkill River watershed, or area of influence. In addition to qualitatively assessing the impact of priority sources, and identifying appropriate control measures, PWD also attempted a quantitative assessment of *Cryptosporidium* in the Schuylkill River watershed. The quantitative assessment involves a series of calculations that aim to: 1) provide an estimate of the total watershed load attributable to priority sources and 2) provide estimates of the reduction in watershed load achieved through the implementation of source water protection initiatives. A first attempt was also made to define a benchmark or target reduction for the estimated total load of oocysts in the Schuylkill River watershed**.**

Observations

According to the Source Water Assessment's *Cryptosporidium* source prioritization, National Pollutant Discharge Elimination System (NPDES) dischargers—particularly WWTPs and runoff from sub-watersheds associated with agricultural land use—are the primary point and non-point sources, respectively, of *Cryptosporidium* contamination.

In addition to the Source Water Assessment's source prioritization results, PWD classifies raw sewage discharges resulting from upstream combined sewer overflows (CSOs), defective laterals, wildcat sewers, separate sewer overflows (SSOs), and inadequate or failing sewer infrastructure as priority sources of *Cryptosporidium*.

Source tracking studies in collaboration with Lehigh University reveal that certain animals, particularly geese, can serve as vectors, transferring viable and human-infectious oocysts from original hosts to Philadelphia's source waters.

In-city and watershed-wide vulnerability assessments reveal that all high priority sources, which include WWTP effluent, agricultural runoff, raw sewage discharges, and

animal vectors, are still potential threats to *Cryptosporidium* contamination at Queen Lane.

PWD has identified in-city and watershed-wide ongoing and proposed initiatives to address high priority sources of *Cryptosporidium*. In-city initiatives address raw sewage discharges, animal vectors, and agricultural runoff. WWTP effluent cannot be managed or mitigated directly by PWD since no City-owned plants are located upstream of the Queen Lane intake.

Quantitatively estimating the impact of different sources of *Cryptosporidium* is only possible using a presumptive approach that relies heavily on values found in literature. Moving forward, expanding data collection and research opportunities will be necessary to develop a better understanding of the sources of *Cryptosporidium* and the effectiveness of source water protection initiatives.

Watershed control plan initiatives that address priority sources of *Cryptosporidium* on a watershed-wide scale will require collaboration and cooperation between PWD and its upstream partners. Certain initiatives will also require support from state and federal regulatory authorities. One of PWD's most influential partners in the Schuylkill River Watershed, and one which will be a critical component of WCP implementation, is the Schuylkill Action Network (SAN). SAN strives to improve the water resources of the Schuylkill River watershed by transcending regulatory and jurisdictional boundaries in the strategic implementation of partnership-based protection measures.

During the second round of LT2 monitoring, improvements in the analytical methods used to detect *Cryptosporidium* may affect the observed surface water concentrations at the intake. Therefore, the oocyst concentration at the intake during the second round of monitoring may reflect the improved recovery rates of the analytical method, and not the impact or success of source water protection initiatives.

Conclusions

PWD believes it is necessary to examine the potential sources of *Cryptosporidium*, its vectors throughout the watershed, and its movement through the City's source waters in order to reduce the levels of *Cryptosporidium* that require treatment upon reaching Philadelphia's drinking water intakes. Through this approach, PWD's ultimate goal is to lower *Cryptosporidium* concentrations at Queen Lane during the second round of LT2 monitoring, which is due for submittal in April 2015. However, the success of the watershed control plan program should not focus on sampling and water quality analyses. At this point in time, *Cryptosporidium* monitoring is not an adequate means of assessing changes in the oocyst watershed load, or the number of oocysts that ultimately reach the intake. State approval of the watershed control plan is due in April 2012, which allows for one year between plan approval and commencement of the 2nd round of monitoring. Due to the large area of influence and the extensive list of short and long-term initiatives outlined in this plan, one year is not likely to produce measurable reductions in the *Cryptosporidium* concentration at the Queen Lane intake. In addition to the brief monitoring timeline, results from the 1st and 2nd rounds of monitoring are not

suitable for comparison due to recovery rate improvements under the current analytical method. Despite the challenges associated with quantitatively assessing the watershed control plan's impact, PWD recognizes that no single action item will guarantee lower *Cryptosporidium* concentrations at the intake, highlighting the importance of a comprehensive implementation approach that addresses all priority sources and emphasizes cooperation and collaboration with watershed partnerships and regulatory agencies.

Although coordinating source water protection efforts over such a large area of influence is a challenge, PWD's Source Water Protection Program has already successfully developed a holistic watershed approach to drinking water protection that will form the basis of the WCP implementation process. The program's approach recognizes the interconnectedness between source water protection concerns, upstream land and water use, partnership development, and the need to maintain a healthy aquatic ecosystem. Following implementation of this watershed control plan, pathogen contamination risks will not only be reduced from a drinking water perspective, but also in regard to human infection risks associated with river-based recreational activities. In order to lower *Cryptosporidium* concentrations and reduce the risk of pathogen contamination from both a drinking water and a recreational perspective, PWD will continue to work with upstream partners, such as the Schuylkill Action Network, to communicate and consult on regulatory issues, funding opportunities, and watershed-wide initiatives.

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Table of Contents

List of Tables

List of Figures

List of Acronyms

AFO	animal feeding operation
AMD	abandoned mine drainage
APHIS	Animal and Plan Health Inspection Services
ARRA	American Recovery and Reinvestment Act
AST	aboveground storage tank
BCC	Berks County Conservancy
BCCD	Berks County Conservation District
BMP	best management practices
CAC	Citizens Advisory Council
CAFO	concentrated animal feeding operation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Act Information System
COA	consent order & agreement
CRP	Conservation Reserve Program
CSO	combined sewer overflow
CWA	Clean Water Act
DMR	discharge monitoring report
DRBC	Delaware River Basin Commission
DWTP	Drinking Water Treatment Plant
ECHO	Enforcement and Compliance History Online
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
EWS	Early Warning System
FISH	fluorescent in-situ hybridization
FPC	Fairmount Park Commission
FWWIC	Fairmount Waterworks Interpretive Center
IESWTR	Interim Enhanced Surface Water Treatment Rule
IWMP	Integrated Watershed Management Plan
IWU	Industrial Waste Unit
MGD	million gallons per day
MS4	Municipal Separate Storm Sewer System
LT2ESWTR	Long Term 2 Enhance Surface Water Treatment Rule
LTCP	Long Term Control Plan
NLCD	National Land Cover Dataset
NLT	National Lands Trust
NMP	Nutrient Management Plan
NPDES	National Pollutant Discharge Elimination System

NRCS	National Resources Conservation Service
OLDS	on-lot sewage disposal systems
PADEP	Pennsylvania Department of Environmental Protection
PCR	polymerase chain reaction
PCS	Permit Compliance System
PDE	Partnership for the Delaware Estuary
PEACCE	Pennsylvania Environmental Agricultural Conservation Certification of Excellence
PEC	Pennsylvania Environmental Council
POTW	publicly owned treatment works
PWD	Philadelphia Water Department
RAWA	Reading Area Water Authority
RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Act Information System
SAN	Schuylkill Action Network
SAP	Sewer Assessment Program
SDWA	Safe Drinking Water Act
SPILL	Sewage Pollution Incident and Location Log
SRLM	Schuylkill River Loading Model
SSO	separate sewer overflow
SWA	Source Water Assessment
SWIG	Schuylkill Watershed Initiative Grant
SWMM	Storm Water Management Model
SWPP	Source Water Protection Plan
TMDL	Total Maximum Daily Load
TRI	Toxic Release Inventory
TSS	total suspended solids
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WCP	Watershed Control Plan
WQC	Water Quality Council
WRT	Waterways Restoration Team
WS	Wildlife Services
WTP	water treatment plant
WWTP	wastewater treatment plant

Section 1 Introduction

On January 5th, 2006, the EPA promulgated the Long Term 2 Enhanced Surface Water Treatment Rule (LT2). The LT2 serves as a series of amendments to the Safe Drinking Water Act and is the first drinking water regulation based on source water quality. The LT2 serves to protect public health from illness due to *Cryptosporidium* and other microbial pathogens in drinking water and to address risk trade-offs with the control of disinfection byproducts. Key provisions of the regulation that pertain to the Philadelphia Water Department (PWD) include the following: source water monitoring for *Cryptosporidium*; risk-targeted *Cryptosporidium* treatment by filtered systems; and criteria for the use of *Cryptosporidium* treatment and control processes. The following Watershed Control Plan (WCP) presents a comprehensive source water protection approach to reducing levels of infectious *Cryptosporidium* in finished drinking water (US EPA 2006). The elements within this plan will be achieved through previously established and ongoing efforts of PWD's Source Water Protection Program. Primary elements of the plan concern the identification of *Cryptosporidium* sources in the Schuylkill River watershed, prioritization of the identified sources, development of control measures to address the prioritized sources, and a plan for the continuation of these efforts in the future. By implementing the following WCP, an effective approach to reducing *Cryptosporidium* in Philadelphia's source water, and thereby finished drinking water, can be achieved and dependency on treatment removal processes can be reduced.

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Section 2 Background

The amendments found in the LT2 supplement existing microbial treatment regulations and target public water systems (PWSs) with a higher potential risk from *Cryptosporidium* (US EPA 2006, 40 CFR Parts 9, 141, 142). The LT2 focuses on *Cryptosporidium* because it has been identified as the cause of several waterborne disease outbreaks in the United States by means of an infectious and potentially severe gastrointestinal illness termed cryptosporidiosis. The LT2's proposed amendments apply to all PWSs supplied by a surface water source and PWSs supplied by a ground water source under the direct influence of surface water. A bin classification system forms the basis of the EPA's risk-targeted approach to reducing *Cryptosporidium* in these drinking source waters. Filtered PWSs are classified in one of four bins based on results from a two-year-long source water monitoring program. PWSs classified in the lowest bin, Bin 1, are subject to no additional treatment requirements, whereas PWSs assigned to higher bins must reduce *Cryptosporidium* levels beyond IESWTR and LT1ESWTR requirements. The total *Cryptosporidium* treatment required for plants in Bins 2, 3, and 4 is 4.0-log, 5.0-log, and 5.5-log, respectively. The majority of plants, including PWD's three drinking water treatment plants, treat surface water using conventional treatment, which is defined in 40 CFR 141.2 as coagulation, flocculation, sedimentation, and filtration. The EPA has estimated that conventional treatment plants in compliance with the IESWTR or LT1ESWTR typically achieve a *Cryptosporidium* removal efficiency of approximately 3-log, implying that an additional 1-log, 1.5-log, or 2-log treatment credit(s) is required depending upon bin classification. In order to achieve these credits, today's rule outlines a variety of treatment and control options collectively termed the "microbial toolbox." Options for credit include source protection and management programs, pre-filtration processes, treatment performance programs, additional filtration components, and inactivation technologies.

PWD's three drinking water treatment plants (DWTPs) have been monitoring for *Cryptosporidium* in conjunction with the LT2 since 2001. PWD maintains two EPA-approved *Giardia*/*Cryptosporidium* analysts at their Bureau of Laboratory Services (BLS), who maintain in-house expertise and are actively involved in methods improvement. This team provided the data for PWD's first round of *Cryptosporidium* LT2 compliance, and it will provide data for the second round of monitoring due in 2015.

Two of Philadelphia's DWTPs, Queen Lane and Belmont, rely on surface water from the Schuylkill River to provide an average of 110 million gallons per day (MGD) of potable drinking water to nearly 400,000 customers in Philadelphia and surrounding communities. Both plants are located within 10-12 miles upstream of the Schuylkill River's confluence with the Delaware River. The Queen Lane DWTP is located immediately downstream of the confluence of the Wissahickon Creek and Schuylkill River in the East Falls neighborhood of Philadelphia. The intake of the Belmont DWTP is located two miles downstream of Queen Lane. PWD's third DWTP, Baxter, is located on the Delaware River in the Torresdale neighborhood and provides approximately 60% of the drinking water to Philadelphia (PWD 2009c). The average production rate for Baxter in FY2010 was 159 MGD.

In compliance with LT2 regulations, PWD analyzed its monitoring results and categorized each treatment plant in one of four bins. It was determined that Baxter and Belmont have average *Cryptosporidium* levels below 0.075 oocysts/L, classifying the plants in Bin 1, with no additional treatment necessary. Results from Queen Lane, however, indicated a slightly higher average oocyst concentration of 0.076 oocysts/L that resulted in a Bin 2 classification. Bin 2 is characterized by plants whose average oocyst concentration is 0.075 oocysts/L or higher, but less than 1.0 oocysts/L. As mentioned above, all of PWD's drinking water treatment plants use conventional treatment methods and are therefore automatically awarded 3-log treatment credit toward *Cryptosporidium* removal. Therefore, Queen Lane requires an additional 1-log removal credit to achieve the 4-log removal required of plants in Bin 2. PWD plans to utilize the combined filter effluent credit of 0.5 log, the individual filter credit of 0.5 log, and the watershed control program back-up credit of 0.5 log to achieve the goal of an additional 1 log removal. PWD's WCP is comprised of the following elements:

- designation of an area of influence;
- identification of both potential and actual sources of *Cryptosporidium;*
- an analysis of control measures to mitigate the sources of *Cryptosporidium;*
- a statement of goals and specific actions PWD will undertake to reduce source water *Cryptosporidium* levels and a description of how actions are expected to contribute to specific goals;
- identification of partners and their roles, PWD's resource requirements and commitments, and a schedule for plan implementation; and,
- a means by which to maintain the credit that will include an annual status report.

Although the WCP is a secondary treatment credit option in Pennsylvania, PWD's Source Water Protection Program recognizes that the successful control of *Cryptosporidium* is not only dependent on physical removal processes such as filtration, but on an understanding of the sources and vectors that enable the pathogen to reach the City's drinking water intakes.

Section 3 PWD's Source Water Protection Program Overview

PWD's decision to employ a Watershed Control Plan to control *Cryptosporidium* reflects the Source Water Protection Program's multi-barrier approach to ensuring the safety and quality of Philadelphia's drinking water. A holistic approach to water quality protection has been used since the program's inception, which occurred in 1998 with the formation of the Office of Watersheds. Over the years, the program has developed a thorough understanding of the City's water supply characteristics, including ambient water quality conditions, major sources of actual and potential contamination, water availability, flow patterns and management practices, and tidal and reservoir impacts. As with other water quality concerns, the Source Water Protection Program deems it appropriate to identify *Cryptosporidium* as a watershed-wide issue requiring a watershed-wide approach. Only through an examination of the potential sources of *Cryptosporidium,* its vectors throughout the watershed, and its movement through the City's water sources, will it be possible to reduce the levels of *Cryptosporidium* that require treatment upon reaching Philadelphia's drinking water intakes.

The success of the Source Water Protection Program's organized and comprehensive approach is evident in the integrity of the Delaware and Schuylkill Rivers as drinking water supplies. In order for the program to meet its high standards, PWD employs a wide range of tools, including research projects, regional partnerships, outreach and education, advanced technologies, and on-the-ground implementation and monitoring to achieve, if not exceed, source water goals. Forming the basis of PWD's various source water protection efforts are the Source Water Assessment (SWA) and Source Water Protection Plan (SWPP), both of which are publicly available. Completed in 2002, the SWA was created in response to the 1996 Safe Drinking Water Act Amendments, which call for the assessment of all source water supplies across the U.S. to identify potential sources of contamination. PWD, along with its project partners, conducted a watershed-based, multi-phase assessment that identified and prioritized potential and existing sources of contamination and evaluated the vulnerability of the water supply to these contaminant sources. The SWPP establishes a set of priority actions to address threats to the water supply identified during the assessment phase. The plan's recommended action items are based on a holistic watershed approach that recognizes the interconnectedness between source water protection concerns, upstream land and water use, and the need to maintain a healthy aquatic ecosystem. Upon completion of the protection plan, PWD became one of the first water suppliers in the state to meet all steps outlined in the Pennsylvania Department of Environmental Protection's (PADEP) minimum criteria for a Source Water Protection Program.

The Source Water Assessment and Protection Plan are fundamental elements of PWD's Source Water Protection Program. However, the program itself encompasses a much wider range of projects related to research, on-the-ground implementation, partnership workgroups, and in-city initiatives. An example of project work relevant to this Watershed Control Plan is PWD's involvement in research to identify and mitigate pathogen levels in the City's source waters. In collaboration with Lehigh University,

PWD participated in source tracking projects to identify the primary sources and vectors of *Cryptosporidium* in the Wissahickon watershed and at the Queen Lane intake. The results of this research are discussed in detail later in this plan. Successful research initiatives within the Source Water Protection Program have also led to on-the-ground project implementation, as is evident with the launching of several projects, including the Delaware Valley Early Warning System (EWS). The EWS, which has been fully operational since 2004, is an integrated monitoring, notification and communication system that provides water suppliers with advanced warning of water quality contamination events. Other implementation efforts include the installation of best management practices (BMPs) throughout the watershed that have reduced water contamination from stormwater runoff, agricultural runoff, and abandoned mine drainage (AMD).

Since the City of Philadelphia owns only a small portion of the Schuylkill River watershed, PWD's partnerships have proved imperative to implementation of many watershed projects. The largest, and perhaps most influential, of these partnerships is the Schuylkill Action Network (SAN). SAN has worked to improve the water resources of the Schuylkill River watershed by transcending regulatory and jurisdictional boundaries in the strategic implementation of partnership-based protection measures (SWIG 2009). SAN has supported projects ranging from the installation of stormwater BMPs to the promotion of education and outreach activities aimed at connecting residents to water quality concerns and solutions.

In addition to collaborating with educational institutions and various other agencies, organizations, and watershed partnerships, PWD has developed several of its own source water protection initiatives. Examples of in-city initiatives are PWD's Stormwater Permit and stormwater ordinance, and the City's Defective Lateral Abatement Program and Goose Control Program. The City's Stormwater Permit is a required NPDES permit under the National Pollutant Discharge Elimination System in compliance with the provisions of the Clean Water Act (CWA), 33 U.S.C. Section 1251 et seq. (the "Act"), 25 Pa. Code Chapter 92, and Pennsylvania's Clean Streams Law, as amended, 35 P.S. Section 691.1 et seq. The City has also enacted a stormwater ordinance in compliance with Pennsylvania's Stormwater Management Act (Act 167). Both permits provide the State with an overview of stormwater pollution control measures and measures to control flooding problems. One such issue addressed in recent annual Stormwater Permit reports is the negative impact of defective laterals on Philadelphia's source water quality. PWD's Defective Lateral Abatement Program focuses on identifying defective laterals within the watershed and correcting the cross connections, thereby reducing bacterial loadings to the river. The City's Goose Control Program is also aimed at reducing bacterial contamination of Philadelphia's source waters through a reduction in the population of geese near drinking water intakes. Geese are an effective vector for the transport of bacteria and protozoa, and a considerable source of these pathogenic microorganisms.

It should also be noted that in conjunction with all of PWD's source water protection efforts, the City of Philadelphia's Department of Public Health has made cryptosporidiosis a reportable disease, meaning that Philadelphia monitors disease rates

and tracks the source of disease outbreaks through enhanced case study forms. Therefore, if Philadelphia were to experience a breakthrough of viable and infectious *Cryptosporidium* from its source water, the Department of Public Health would be able to track the outbreak. So far, after more than 10 years of monitoring, no relationship between cryptosporidiosis outbreaks and drinking water has been found (G. Burlingame, personal communication, August 31, 2010).

PWD's SWPP takes a multi-faceted approach to protecting and improving source water quality throughout the Schuylkill River watershed. The program has a thorough understanding of the threats to Philadelphia's water supply and the level of coordination and collaboration that will be necessary to continue to identify regional protection priorities and implement protection initiatives. Collectively, PWD's source water protection efforts form the basis of a comprehensive and effective Watershed Control Plan.

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Section 4 Delineation of Area of Influence

An accurate assessment of the impact of *Cryptosporidium* at the Queen Lane intake requires the identification of what the EPA terms the "area of influence." The area of influence is defined as the area outside of which there is not a significant likelihood of *Cryptosporidium* or fecal contamination affecting a drinking water intake. Several methods can be used to establish the boundaries of the area of influence. Some of these methods include: characterization of watershed hydrology, modeling *Cryptosporidium* time of travel, or, when sufficient data exists, it can be useful to assess such factors as fate and/or die-off/inactivation times in natural waters. The EPA states that a PWS can use one or more of these methods, or it can use methods that do not include any of the above, as long as the State considers the results sufficient to establish the boundaries of the area of influence. PWD has identified the area of influence using the delineation method set forth in the Source Water Assessment described below. Research involving the fate and transport of *Cryptosporidium,* and the potential effects of future development on pathogen levels in the Schuylkill River, is also referenced to provide additional information regarding the presence and persistence of *Cryptosporidium* throughout the watershed.

PWD's Source Water Assessment delineation methodology specifies three zones of influence: Zones A, B, and C. Together, these zones encompass the entire Schuylkill River watershed, or the entire drainage area with the potential to influence water quality conditions at the Queen Lane intake. The A, B and C time of travel zones are defined in the PADEP's Source Water Assessment Program Plan. The zones used for PWD's assessment were calculated and provided by the USGS and approved for use by the PADEP. They are based on average flow conditions and USGS estimates of flow-velocity relationships.

Zone A includes 73.7 square miles of the Schuylkill River watershed and represents the area within a 5-hour time of travel of the Queen Lane intake. Since proximity to the water supply intake results in reduced response times and potential lower dilution and attenuation of a contaminant, Zone A represents a critical area of highest potential impact on the Queen Lane intake (PWD 2002). Zone A continues upstream of the intake to river mile 31 at Valley Forge, and consists of almost the entire Wissahickon Creek watershed and the direct drainages to the Schuylkill River, to directly upstream and including portions of Valley Creek.

Zone B encompasses 1,271 square miles of the Schuylkill River watershed and represents the area between the 5-hour and 25-hour time of travel of the Queen Lane intake. The delineated zone extends upstream of the intake to river mile 108, near Auburn, PA. Zone B includes all tributaries below the Maiden and Tulpehocken Creeks, about half of the Maiden Creek watershed, part of the Tulpehocken Creek watershed below Blue Marsh Reservoir, and part of the Little Schuylkill River up to Greenawald, PA.

Zone C consists of the area within the Schuylkill River watershed that has a time of travel greater than 25 hours. This zone encompasses the remainder of the Schuylkill River watershed, primarily including the headwaters of the Schuylkill River, most of the

Little Schuylkill River, the majority of the Tulpehocken Creek watershed, and the headwaters of Maiden Creek watershed. Figure 4-1 below illustrates Zones A, B, and C within the Schuylkill River watershed, as well as the location of the Queen Lane and Belmont drinking water intakes.

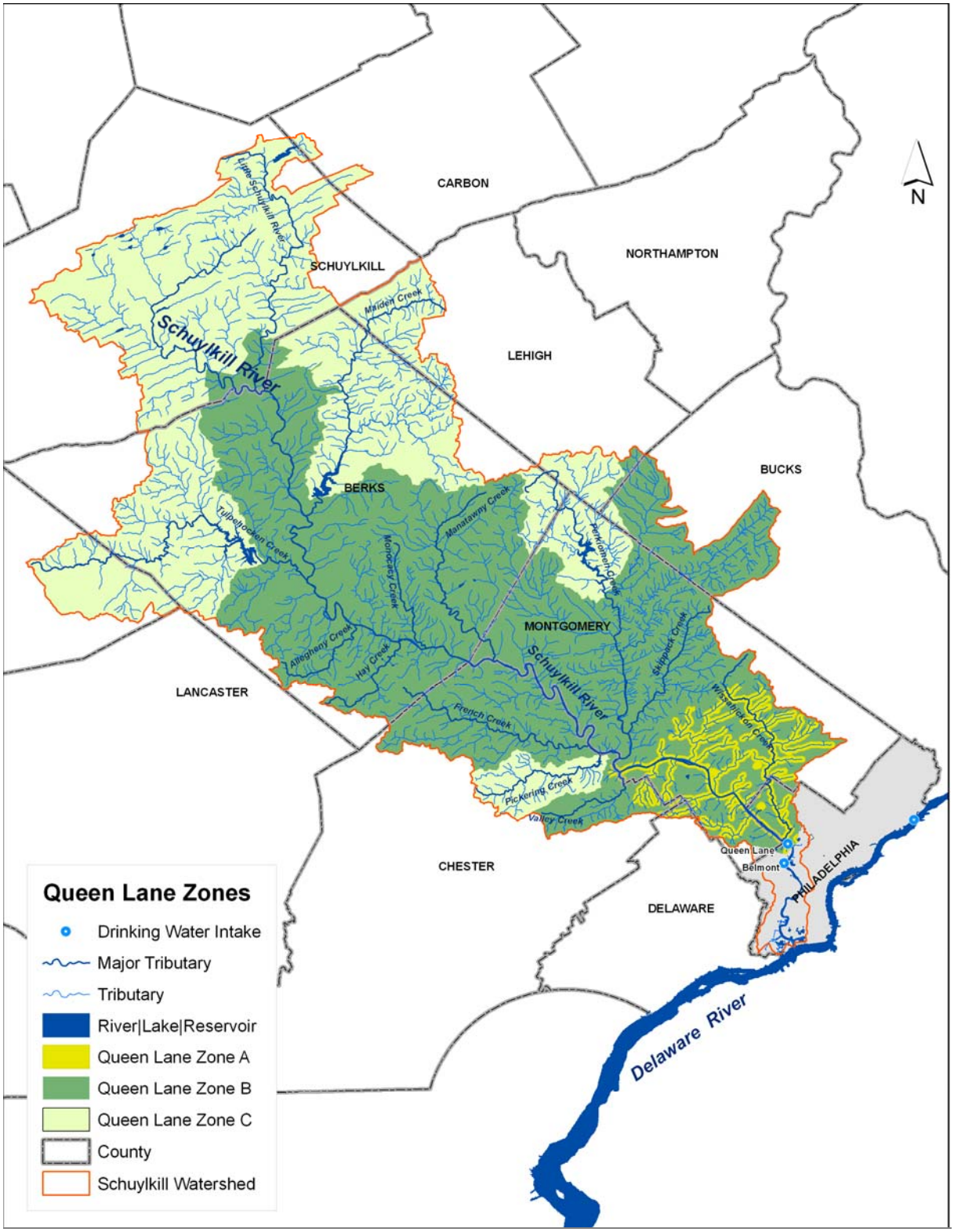

Figure 4-1 Zones A, B and C and PWD's Queen Lane and Belmont Intakes

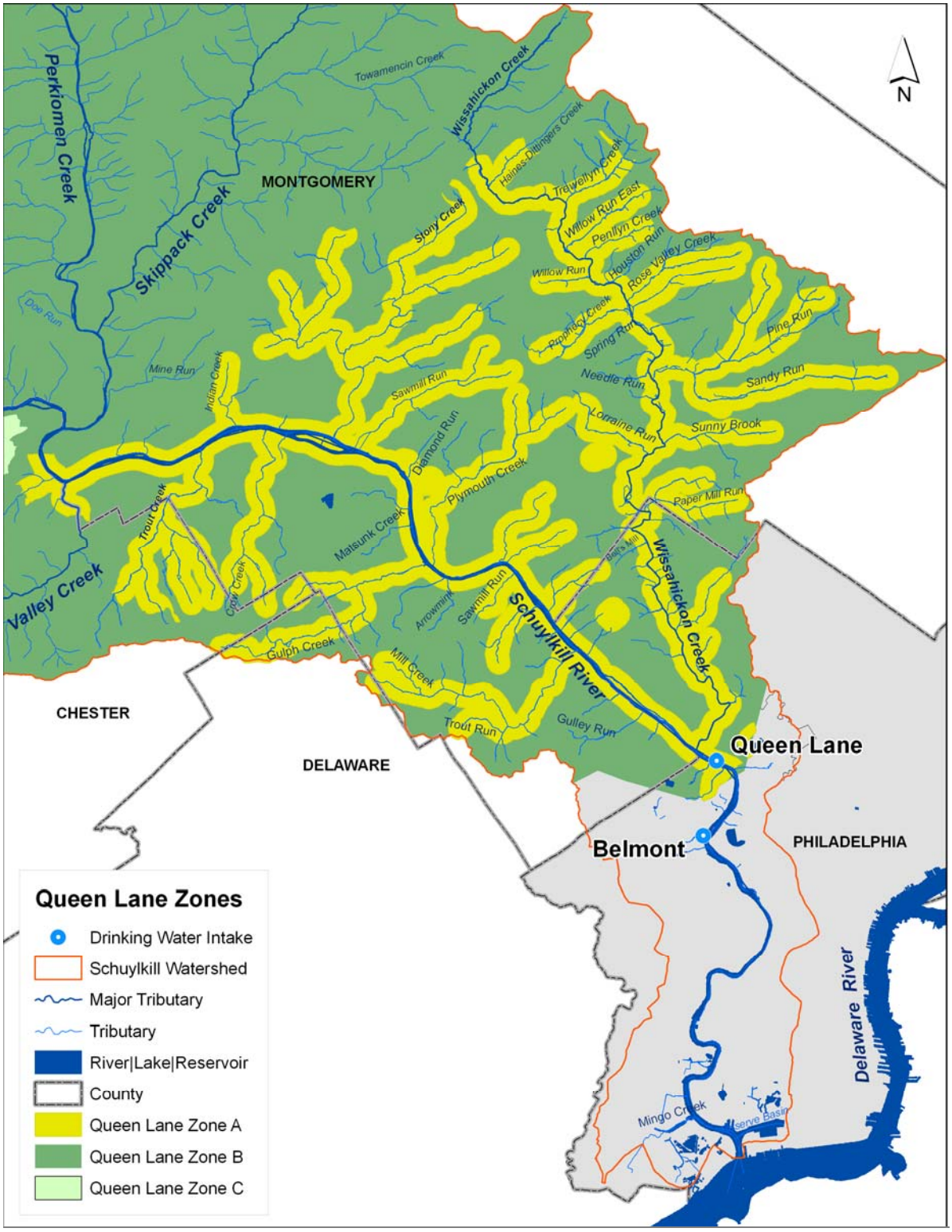

Figure 4-2 Zone A Relative to the Queen Lane and Belmont Intakes

Figure 4-2 above provides a more detailed look at Zone A, the zone of highest priority relative to the Queen Lane intake. Results from the zone delineation process were used

to create a ranking of all potential point and non-point sources, as well as a series of source prioritization rankings by contaminant category. The results from the prioritization of *Cryptosporidium* sources will be discussed later in this plan. Additional information regarding the transport of *Cryptosporidium* is available in *The Role of Wastewater Treatment in Protecting Water Supplies against Emerging Pathogens* (Crockett 2007). By focusing on the fate and transport of *Cryptosporidium* in wastewater treatment plant effluent, the research presented in this paper reveals that *Cryptosporidium* has the potential to travel throughout a large portion of the watershed, or area of influence, while maintaining its viability. The study first establishes that wastewater effluent can contain significant amounts of infectious and viable pathogens in its discharge while meeting regulatory permit standards. Upon reaching receiving waters, *Cryptosporidium* can survive from 30 to 176 days with upwards of 30 to 70% of the oocysts remaining viable beyond 100 days at temperatures of 21 and 4 degrees C, respectively. In addition, it was concluded that *Cryptosporidium* oocysts in wastewater discharge can travel 160 km, or 100 mi, in less than 7 days, retaining their viability upon withdrawal at a downstream water intake. Taking into account the extended survival of *Cryptosporidium*, the pathogen's potential to travel long distances downstream before significant die-off, the high degree of removal required by drinking water treatment, and *Cryptosporidium's* extremely low infectious doses, it is clearly evident that the entire Schuylkill River watershed should be considered an area of influence.

Designating the entire Schuylkill River watershed as the area of influence presents many challenges in regard to *Cryptosporidium* source prioritization and the implementation of watershed control plan measures. Several areas within the watershed have already been identified as sources of *Cryptosporidium,* especially the Wissahickon Creek sub-watershed, which is located in Zone A. The Wissahickon Creek flows into the Schuylkill River approximately 1,200 feet north of the Queen Lane intake on the east side of the Schuylkill River (Marengo & Weggle 1999). The creek itself is almost entirely WWTP effluent discharge during dry weather conditions, and it is also the receiving waters for stormwater runoff and discharges from industrial and farming operations. Due to the Wissahickon's close proximity to the intake and the characteristics of its watershed, this plan will take an in-depth look at the creek's influence on *Cryptosporidium* levels at Queen Lane. Although control measures are needed in the Wissahickon, the creek's watershed is not entirely located within Philadelphia's City boundaries. In fact, only 2.4% of the entire Schuylkill River watershed is located within the City. In order to implement watershed control plan measures, PWD will need to rely largely on stakeholder collaboration and its Schuylkill River watershed partnerships. Due to these circumstances, the Source Water Protection Program has placed a strong emphasis over the years on developing partnerships with upstream communities to achieve common goals while leveraging outside funds (Sham et al 2010). The specific partnerships that will be utilized during implementation of this WCP will be discussed in the following sections.

Since Philadelphia comprises such a small percentage of the Schuylkill River watershed, PWD has already begun to consider the potential impacts of future, upstream land use changes on water quality at the Queen Lane intake. PWD's Source Water Assessment characterizes existing land uses in the Schuylkill River watershed using the National

Land Cover Dataset, which originated in the early-mid 1990s, and updated data from the 2000 Census. To assess potential future land use changes, the Source Water Protection Plan developed and simulated a build-out scenario. The build-out analysis utilizes the U.S. EPA's Stormwater Management Model (SWMM) to estimate potential changes in runoff pollutant loads throughout the watershed. Available zoning data obtained on the county level were used to aid in projecting land cover changes. Where zoning was available, the remaining lands were developed to the maximum capacity provided in the zoning regulations. When zoning was not available, a rural low-density residential development was assumed for available open space (PWD 2006). Development restrictions such as delineated wetlands, preserved open space, and steep slopes were also considered in creating the build-out scenario.

Results from the build-out analysis reveal that the percentage of developed land (land used for residential, commercial, industrial, or institutional purposes) will increase from about 15% to as much as 68% under current zoning. Based on modeling estimates of percent imperviousness associated with each land use, the percent impervious land surface is estimated to increase from 10% at existing conditions to 18% at full build-out. It should be noted that the approach used to perform the build-out scenario will tend to overestimate development because all developable agricultural and forested lands were assumed to convert to low-density residential in the absence of zoning guidelines. The scenario also predicts a drastic increase in the percentage of developed areas, because zoning would allow the high-density residential classification to more than triple and commercial/industrial/transportation land uses to more than double.

As a result of projected changes in land use and impervious cover, the annual pollutant loading of *Cryptosporidium* is estimated to increase by approximately 24% (PWD 2006). This increase in *Cryptosporidium* loading does not take into account additional pollutant loads from point sources associated with the build-out scenario. Assuming that the new development occurs along with the construction of sewage collection and treatment systems, additional point source loads for *Cryptosporidium* could occur through the discharge of treated wastewater. Based on rough extrapolations of housing unit trends and population trends from the last few decades, it could take anywhere from 50 to 150 years for this "worst-case" build-out scenario to occur if recent trends continue indefinitely (PWD 2006). The potential impact of future development on *Cryptosporidium* loading further stresses the importance of PWD's partnerships and the department's ability to collaborate with upstream partners when making land use planning decisions and identifying effective control measures.

Section 5 Identification of Potential and Actual Sources of Cryptosporidium

5.1 Identification of Potential and Actual Sources

5.1.1 SWA Methodology

Identifying potential and actual sources of *Cryptosporidium* in the Schuylkill River watershed is the initial step in determining what control measures will prove most effective. Using various methods, PWD has identified several sources that affect *Cryptosporidium* levels at the Queen Lane intake. Methods of source identification and prioritization include the approaches outlined in PWD's Source Water Assessment (SWA), source tracking research projects in collaboration with Lehigh University, a Schuylkill Action Network (SAN) survey focusing on the impacts of WWTP effluent, and the development and implementation of in-City defective lateral abatement programs. Through these various approaches, PWD has developed a thorough understanding of the Schuylkill River Watershed's highest priority sources and the control measures that will most effectively reduce oocyst levels at the Queen Lane intake.

PWD's SWA identified point and non-point sources of *Cryptosporidium* that are most likely to influence water quality conditions at the Queen Lane intake. All potential sources were first inventoried, then screened and ranked. Two types of rankings were conducted. The first prioritized sources across 10 priority contaminants, including *Cryptosporidium*. The second, and more relevant ranking for this Watershed Control Plan, prioritized sources for each contaminant. The second contaminant-based method of prioritization consisted of the three steps described below.

Step 1: Point Source Inventory and Screening
Point source data was compiled from various State and Federal databases available on the Internet, as well as from self-assessment data provided by water suppliers. The following Federal databases were accessed for point sources in the Schuylkill River Watershed:

- Permit Compliance System (PCS);
- Resource Conservation and Recovery Act Information System (RCRIS);
- Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS); and,
- Toxic Release Inventory (TRI).

Regulated aboveground storage tanks (ASTs) were also compiled from the PADEP Storage Tank Program to supplement available RCRA data. The inventory contains more than 3,000 potential point sources within the 1,900 square mile Schuylkill River watershed and includes information on the most common types of sources and the zones in which they are concentrated (PWD 2002).

Sources that are not located within Zones A and B were eliminated. Individual site contaminants were downloaded, where available, for all remaining facilities. *Cryptosporidium* calculations for point source facilities were based on estimated values from literature. Each contaminant was associated with one of 10 categories. These categories, including *Cryptosporidium*, were generally based on contaminant groups described in the PADEP SWAP guidance document.

Following the geographic screening, point sources were further screened to produce the following universe of sites for *Cryptosporidium*:

- PCS Database: Approximately 50 sites (all discharges of greater than 1 million gallons per day)
- RCRA: 11 sites (all sites located within a floodplain)
- TRI and AST: 20 sites each (top 20 sites ranked according to the potential concentration of the contaminant at the intake from that source)
- CERCLA: No sites selected

Step 2: Non-Point Source Inventory and Screening
A non-point source runoff screening process was also performed prior to the final ranking of *Cryptosporidium* sources. In order to identify those non-point sources that were to be included in a final ranking, a Runoff Loading Summary was developed to estimate storm runoff loadings to the river for all 10 pollutant categories, excluding volatile organic compounds, throughout the watershed (PWD 2002). The Schuylkill River SWA Partnership developed the Schuylkill River Runoff Loading Model (SRLM) in order to estimate the pollutant loads from rainfall runoff. SWMM, EPA's Stormwater Management Model, was used to simulate rainfall runoff quantities and quality at specified inlet locations. For each sub-watershed, the surface runoff from a particular land use predicted by SWMM was multiplied by an Event Mean Concentration (EMC) to yield a loading rate for each land use type. Land use categories were based on the USGS's National Land Cover Dataset and updated with 2000 Census data for residential and commercial areas.

Results of the loading calculations for *Cryptosporidium* within Zones A and B indicate that the highest pollutant loads are from the Perkiomen and Upper Schuylkill watersheds, through which the mainstem Schuylkill River flows. The Wissahickon and Middle Schuylkill watersheds also have high estimates of *Cryptosporidium* loads from runoff. The Tulpehocken and Upper Schuylkill watersheds have the highest daily loads per area. This is due to the fact that both sub-watersheds encompass a relatively small area, and a high percentage of the land area is characterized as pasture or hay, which has the highest EMC for *Cryptosporidium* (PWD 2002).

Following the runoff loading analysis, sub-watersheds were ranked for *Cryptosporidium* according to the potential concentration of the contaminant at the intake from that source. The 30 highest-ranked sub-watersheds passed through to the final ranking.

Step 3: Final Combined Point and Non-Point Source Ranking
The final prioritization of point and non-point sources used the six criteria listed below.

- Relative Impact at Intake (weight 40%) – This criterion is based on the concentration of contamination potentially caused by the source at the intake.
- Time of Travel (weight 5%) – This is a criterion calculated as the time of travel from source to intake, based on high flow velocity.
- Potential for Release/Controls (weight 20%) – This is a qualitative criterion based on "Very High" to "Very Low" scoring.
- Violation Type/Frequency (weight 15%) – This is a qualitative criterion based on "Low" to "High" scoring.
- Location (weight 5%) – This is a qualitative criterion based on GIS analysis of the following categories:
    - In the Floodplain – 3 points
    - In Zone A – 2 points
    - In Zone B – 1 point

Final ranking results were broken down into six major categories according to the PADEP's SWA Plan. These categories are designated A through F, with A representing sources of highest protection priority and F representing sources of lowest protection priority. Sources that are considered potentially significant sources of contamination fall into categories A through C.

Table 5-1 below shows the results of the ranking for estimated sources of *Cryptosporidium*. The table indicates that the only high-priority sources of *Cryptosporidium* are either NPDES dischargers or stormwater runoff from agricultural or urbanized watersheds. Most sources appear to be relatively minor contributors. Geographically, a large number of sources are from relatively far upstream, in the Reading and Berks County areas.

Table 5-1 Contaminant Category Ranking for *Cryptosporidium*, SWA 2002

Source ID	Source Name	Database Used	Sub-watershed	Zone	Time of Travel	Relative Impact (%)	Priority
781	Montgomery County Sewer Authority	NPDES	Perkiomen Creek	Flood Plain	10.5*	0.009	Highest - A
1613	Upper Gwynedd Twp	NPDES	Wissahickon Creek	Flood Plain	12.5	0.009	Highest - A
465	Whitemarsh Twp Sew Auth	NPDES	Schuylkill River	Zone A	3.5	0.009	Highest - A
666	Norristown Municipal Waste Authority	NPDES	Schuylkill River	Flood Plain	5.5	0.009	Highest - A
795	Abington Twp WWTP	NPDES	Sandy Run	Zone A	11.3	0.009	Highest - A
664	E. Norritown/Plymouth/ Whitpain Joint Sewer Auth	NPDES	Schuylkill River	Flood Plain	5.5	0.009	Highest - A
2503	Berks Montgomery Municipal Authority	NPDES	Swamp Creek	Flood Plain	23.1	0.009	Highest - A
821	Ambler Borough WWTP	NPDES	Wissahickon Creek	Zone A	8.7	0.009	Highest - A
2491	Reading City	NPDES	Schuylkill River	Zone B	29.5	0.009	Highest - A
464	Conshohocken STP	NPDES	Schuylkill River	Zone A	3.5	0.009	Highest - A
2470	Birdsboro Borough Municipal Authority	NPDES	Schuylkill River	Flood Plain	24.8	0.009	Highest - A
2455	Pottstown Borough	NPDES	Schuylkill River	Zone B	19.5	0.009	Highest - A
2547	NGK Metals Corp	NPDES	Laurel Run	Zone B	34.1	0.009	Highest - A
2509	Wyomissing Valley JMA	NPDES	Wyomissing Creek	Zone B	31	0.009	Highest - A

665	Upper Merion Municipal Utility Authority	NPDES	Trout Creek	Zone A	8	0.009	Highest - A
535	Upper Merion Twp Authority - Matsunk WPCC	NPDES	Schuylkill River	Zone B	5	0.009	Highest - A
2492	GPU Generation Inc Titus Generating Station	NPDES	Schuylkill River	Zone B	28.6	0.009	Highest - A
2574	Hamburg Municipal Authority	NPDES	Schuylkill River	Zone B	41.8	0.009	Highest - A
2453	Upper Gwynedd-Towamencin Municipal Authority	NPDES	Towamencin Creek	Zone B	16.5	0.009	Highest - A
792	Phoenixville Borough STP	NPDES	Schuylkill River	Zone B	11.5	0.009	Highest - A
2521	Penn Ridge Waste Water Treatment Authority	NPDES	East Branch Perkiomen	Flood Plain	25.4	0.009	Highest - A
2480	Crompton & Knowles Corp Gibraltar Plant	NPDES	Schuylkill River	Flood Plain	26.2	0.009	Highest - A
1614	Limerick Twp Municipal Authority	NPDES	Schuylkill River	Flood Plain	15	0.009	Highest - A
2474	Exeter Twp WWTP	NPDES	Schuylkill River	Flood Plain	25.7	0.009	Highest - A
780	Valley Forge Sewer Authority	NPDES	Schuylkill River	Zone B	10	0.009	Highest - A
2485	Borough of Souderton	NPDES	Skippack Creek	Zone B	18.5	0.009	Moderately High - B
2752	120 Old Philadelphia	NPDES	Schuylkill River	Flood Plain	22.8	0.009	Moderately High - B
2510	Antietam Valley Municipal Authority	NPDES	Antietam Creek	Zone B	28.6	0.009	Moderately High - B
2524	Carpenter Technology Corp	NPDES	Schuylkill River	Zone B	31.5	0.009	Moderately High - B

2516	Spring Twp Municipal Authority	NPDES	Cacoosing Creek	Zone B	35.3	0.009	Moderately High - B
509	Lukens Steel Co	NPDES	Schuylkill River	Zone A	4.5	0.009	Moderately High - B
2473	Lower Frederick Township Treatment Plant	NPDES	Perkiomen Creek	Flood Plain	16.6	0.001	Moderately High - B
2723	Sinking Spring Borough Municipal Authority	NPDES	Cacoosing Creek	Flood Plain	36	0.009	Moderately High - B
1734	Borough of North Wales	NPDES	Wissahickon Creek	Flood Plain	13.2	0.001	Moderately High - B
2747	Leesport Borough Authority	NPDES	Schuylkill River	Flood Plain	37.1	0.001	Moderately High - B
2460	Schwenksville Borough Authority	NPDES	Perkiomen Creek	Flood Plain	16.1	0.001	Moderately High - B
2677	Spring City Borough Sewage Plant	NPDES	Schuylkill River	Flood Plain	14.5	0.001	Moderately High - B
622	Bridgeport Borough	NPDES	Schuylkill River	Flood Plain	5.5	0.001	Moderately High - B
2454	North Coventry Municipal Authority STP	NPDES	Schuylkill River	Flood Plain	19.5	0.001	Moderately High - B
2459	Stanley G. Flagg & Co. Inc.	NPDES	Schuylkill River	Zone B	20.9	0.001	Moderately High - B
2536	Oley Township Municipal Authority	NPDES	Manatawny Creek	Flood Plain	29.8	0.001	Moderately High - B
2476	Allegheny E. Conf. Assoc. 7th Day Adventists	NPDES	Manatawny Creek	Flood Plain	23.1	0.001	Moderately High - B
1068	Peco Energy Co-Cromby Generating	NPDES	Schuylkill River	Flood Plain	13.5	0.001	Moderately High - B
2556	Maidencreek Township Authority	NPDES	Willow Creek	Zone B	37.6	0.001	Moderately High - B

2720	Fleetwood Borough Authority	NPDES	Willow Creek	Zone B	40.7	0.001	Moderately High - B
2626	Lower Salford Twp Authority	NPDES	Indian Creek	Zone B	20.5	0.001	Moderately High - B
2639	Lower Salford Twp Authority	NPDES	West Branch Skippack Creek	Flood Plain	16.5	0.001	Moderately High - B
2505	Baldwin Hardware MFG Corp	NPDES	Schuylkill River	Zone B	30	0.001	Moderately High - B
2631	Telford Borough Authority	NPDES	Indian Creek	Zone B	23.6	0.001	Moderately High - B
2719	General Battery Corp. Reading Smelter Div.	NPDES	Bernhart Creek	Flood Plain	33	0.001	Moderately High - B
2715	Brush Wellman Inc.	NPDES	Schuylkill River	Zone B	38.7	0.001	Moderately High - B
2627	Upper Dublin Twp	NPDES	Wissahickon Creek	Zone B	8.7	0.001	Moderate - C
90008	Wissahickon Creek - 008	NP	Wissahickon Creek	Zone A	8.1	0.002	Moderate - C
90024	Stony Creek - 024	NP	Stony Creek	Zone A	7	0.002	Moderate - C
90020	Schuylkill River - 020	NP	Schuylkill River	Zone A	4.5	0.001	Moderate - C
90283	Irish Creek - 283	NP	Irish Creek	Zone B	37.6	0.003	Moderate - C
90282	Schuylkill River - 282	NP	Schuylkill River	Zone B	36.1	0.002	Moderate - C
90009	Sandy Run - 009	NP	Sandy Run	Zone A	8.7	0.001	Moderate - C
90209	Plum Creek - 209	NP	Plum Creek	Zone B	34.6	0.002	Moderate - C

90289	Schuylkill River - 289	NP	Schuylkill River	Zone B	40.7	0.002	Moderate - C
90060	Pleasant Spring Creek - 060	NP	Pleasant Spring Creek	Zone B	27.3	0.001	Moderate - C
90238	Schuylkill River - 238	NP	Schuylkill River	Zone B	31.5	0.001	Moderate - C
90287	Mill Creek - 287	NP	Mill Creek	Zone B	40.7	0.002	Moderate - C
90193	Schuylkill River - 193	NP	Schuylkill River	Zone B	25.2	0.001	Moderate - C
90047	Skippack Creek - 047	NP	Skippack Creek	Zone B	17	0.001	Moderate - C
90059	East Branch Perkiomen Creek – 059	NP	East Branch Perkiomen	Zone B	26.1	0.001	Moderate - C
90164	Schuylkill River - 164	NP	Schuylkill River	Zone B	20.5	0.001	Moderate - C
90286	Pigeon Creek - 286	NP	Pigeon Creek	Zone B	39.2	0.001	Moderate - C
90061	Morris Run - 061	NP	Morris Run	Zone B	29.2	0.001	Moderate - C
90243	Willow Creek - 243	NP	Willow Creek	Zone B	37.1	0.001	Moderate - C
90295	Schuylkill River - 295	NP	Schuylkill River	Zone B	47.1	0.001	Moderate - C
90058	Mill Creek - 058	NP	Mill Creek	Zone B	26.1	0.001	Moderate - C
90294	Pine Creek - 294	NP	Pine Creek	Zone B	47.6	0.001	Moderate - C
90202	Wyomissing Creek - 202	NP	Wyomissing Creek	Zone B	31	0.001	Moderate - C
90207	Cacoosing Creek - 207	NP	Cacoosing Creek	Zone B	33.9	0.001	Moderate - C

90205	Tulpehocken Creek - 205	NP	Tulpehocken Creek	Zone B	31.5	0.001	Moderate - C
90285	Lesher Run - 285	NP	Lesher Run	Zone B	40.2	0.001	Moderate - C

* Time of Travel based on PWD estimate of stream velocity. Estimates were made independent of the study to establish zones.
Source: PWD Source Water Assessment, 2002

Updates to SWA Methodology

The contaminant category ranking for *Cryptosporidium* point and non-point sources is based on information that was gathered and evaluated prior to 2002, when the SWA was published. In order to update the methodology originally set forth in the SWA, a series of steps were taken to confirm the status of A and B priority point source dischargers. A plan to re-evaluate the original prioritization of non-point sources is also presented in this section.

Updating High-Priority Point Sources

Updating the original ranking of priority dischargers in the Schuylkill River watershed, Zones A and B, required the following steps: identifying those dischargers that no longer exist or have changed names or ownership; compiling information regarding updates or improvements made to existing high-priority dischargers; and identifying recently proposed or constructed permitted facilities within the watershed. Information pertaining to NPDES permits in the Schuylkill River watershed is accessible through several databases. The following sources were used for this analysis:

- PADEP's eFacts database;
- EPA's Envirofacts database, including the Multi-system, PCS, and Enforcement Compliance History Online (ECHO) queries;
- PADEP database of all NPDES dischargers in Pennsylvania available at: http://www.depweb.state.pa.us/ ; and,
- PWD database containing all dischargers to the Schuylkill River.

Information concerning improvements made to existing facilities and planning initiatives for new facilities was primarily obtained from the Pennvest and American Recovery and Reinvestment Act (ARRA) websites. Additional information was gathered from relevant news releases and a 2009 Schuylkill Action Network (SAN) Pathogen Compliance Workgroup document summarizing improved NPDES compliance and reduced discharges in the Schuylkill River watershed. Through careful comparison of the information included in the above sources, several tables were created to provide an overview of relevant updates and changes made to priority point sources within the watershed. Beginning with Table 5-2 below, several NPDES dischargers have undergone significant changes in status since the original SWA prioritization. These changes in status relate to either a change in ownership or a termination of plant or company operations.

Table 5-2 Changes in Status of A & B Priority Dischargers

Original SWA Facility	Current Status
NGK Metals	No longer has active NPDES permit at Reading facility (originally had permitted NPDES discharges to Laurel Run tributary)
GPU Generation Inc. Titus Station	Still in operation - facility now owned by RRI Energy Inc.
Crompton and Knowles Corp. - Gibraltar Plant	No longer in operation - bought by Sensient Technologies in 2002; plant has since closed
120 Old Philadelphia	Site not identified
Lukens Steel Co	Still in operation - the former Lukens Steel is now owned by ArcelorMittal
Stanley G. Flagg & Co. Inc.	No longer in operation
General Battery Corp. Reading Smelter Div.	Still in operation - facility now owned by Exide Technologies; active NPDES permit, discharging to Schuylkill River; currently under a COA to construct a stormwater treatment facility

Sources: PADEP eFacts, EPA Envirofacts, PADEP NPDES 2009 Database, PWD Database, Google, Shawn Arbaugh (PADEP, Southcentral)

In addition to the changes listed above in Table 5-2, several originally prioritized NPDES dischargers have either undergone, or are approved to undergo, upgrades and improvements to their treatment facilities. A majority of these improvements are funded by recently approved Pennvest loans. A detailed list containing update and improvement information is presented below in Table 5-3.

Table 5-3 Upgrades and Improvements Made to the Source Water Assessment's A & B Priority Dischargers Since 2000

Facility	County	Priority	Upgrades/Improvements	Approval Date (*Start Date)	Source	Project Status
Montgomery County Sewer Authority (aka Lower Perkiomen Valley Reg. Sewer Authority - Oaks)	Montgomery	A	expansion of the Oaks WWTP from 10.5 MGD to 14.25 MGD; Upper Pottsgrove Twp-Farmington Ave & Regal Oaks Pump Station (dismantle package STP and pump station installations)	9/14/2005; 6/22/2009* (end date: 8/01/2010)	Pennvest; ARRA	Final Amortization
Upper Gwynedd WWTP	Montgomery	A	RFP will be made this Jan to construct an UV machine for use at WWTP; will allow twp. to reduce chlorine residual impacts	RFP Jan 2010	SAN Pathogens/ Compliance Workgroup 2009	Proposed
Sinking Spring Borough Municipal Authority	Berks	B	WWTP Upgrade/Expansion from 1 MGD hydraulic capacity to 1.25 MGD	4/20/2009; 7/1/2009* (end date: 6/30/2010)	Pennvest; ARRA	Permit issued; construction not yet complete

Note: Only those WWTP upgrades relating to the A & B priority facilities from the Source Water Assessment are included.

Information regarding recently proposed or newly constructed treatment facilities in the Schuylkill River Watershed was also compiled and summarized in table format. These facilities, which should potentially be considered during future prioritization efforts, are listed below in Table 5-4.

Table 5-4 New and Proposed Water Treatment Facilities and Expansions in the Schuylkill River Watershed Since 2002

Facility	County	Description	Source	Project Status
Maxatawny Twp STP	Berks	$9.5 million STP would serve 250 homes and businesses that have malfunctioning on-lot sewage disposal systems	SAN Pathogens/ Compliance Workgroup 2009	NPDES Part I Permit has been issued; construction not yet begun
Rolling Hills Landfill - Earl & Oley Townships	Berks	landfill owned by Del. County Solid Waste Authority - improperly managed leachate resulted in requirement to build new WWTP	SAN Pathogens/ Compliance Workgroup 2009	In construction
Alsace Manor Sewer Collection & Treatment System	Berks	construction of sewage collection & treatment system, including 70,000 GPD extended aeration STP	Pennvest - 7/18/2006	Completed
Bethel Twp Sanitary Sewer System	Berks	construction of a 72,400 GPD extended aeration STP and collection system to serve Village of Frystown & 205,000 GPD extended aeration STP and collection system to serve Village of Bethel	Pennvest - 4/17/2007	Completed
Lenhartsville Boro STP	Berks	construction of a 42,300 GPD extended aeration sewage collection facility	Pennvest - 3/24/2004	Completed
Richmond Twp - Walnuttown Sewage Collection System	Berks	construction of 23,900 ft of gravity sewers; force main interceptor; sewer laterals and 2 pump stations; purchase of capacity for treatment at Fleetwood Mun Auth STP	Pennvest - 3/23/2005	Completed
Strausstown Boro - Sanitary Sewer Collection & Treatment System	Berks	construction of sanitary sewer collection system with 65,000 GPD activated sludge, extended aeration STP	Pennvest - 10/23/2007	Completed

West Pikeland Twp	Chester	new public sewage system needed for approx. 80 homes with malfunctioning on-lot sewage disposal systems	SAN Pathogens/ Compliance Workgroup 2009	Proposed
New Norristown STP (approximately 2000 ft downstream of existing plant)	Montgomery	Montgomery County received $3.7 million for new STP through H2O PA grant program	SAN Pathogens/ Compliance Workgroup 2009	Proposed
Upper Pottsgrove Twp - Farmington Ave. & Regal Oaks Pump Station	Montgomery	dismantling package STP and pump station; various installations; treatment capacity purchase from Pottstown Borough Auth	Pennvest - 4/20/2009	Disbursement
Upper Salford Township	Montgomery	plan calls for creating sewer districts requiring property owners to connect to a new public sewer plant serving the villages of Woxall, Salfordville, and Salford (plant cost: approx. $6 million)	News Release 2/1/2010- Act 537 reimbursements	Proposed
Lower Milford Twp STP	Lehigh	loan & grant received to construct new sewer mains, install grinder pumps, and construct new 35,000 GPD re-circulating sand filter WWT facility	Rendell Announcement & Pennvest - 10/27/2009	Loan Closing
Port Clinton Sewage Plant	Schuylkill	plans to construct a collection system and a pump station and connect to Hamburg's STP	SAN Pathogens/ Compliance Workgroup 2009	Proposed
New Ringgold Sewer Collection & Treatment System	Schuylkill	construction of new sewage collection system of about 10,000 lf and treatment facility of 40,000 gallons	Pennvest - 3/23/2005	Final Amortization

Note: No Pennvest proposals for new facilities prior to 2000 are included in the above list.
Source: PADEP eFacts, EPA Envirofacts, PADEP NPDES 2009 Database, PennVest website

As a final step, EPA's ECHO database was reviewed for any possible violations at the SWA's highest-priority NPDES dischargers. Dischargers with either a significant violation or a violation requiring formal enforcement action within the last five years were identified. Table 5-5 below lists the dischargers that met either one or both of these criteria.

Table 5-5 Violations and Enforcement Actions Against SWA High-Priority Dischargers

Facility	Alleged Current Significant Violations	Formal Enforcement Action (5 years)
Ambler Boro STP	D*	2
Birdsboro WWTP	no	1
Conshohocken Boro STP	D*	none
Hamburg WWTP	no	1
Reading WTP	no	1
U. Gwynedd Twp WWTP	E*	1

Source: EPA ECHO Database, January 26th, 2010
**see explanation below*

The current significant violations column indicates violations by a point source discharger of sufficient magnitude or duration to be a regulatory priority (US EPA 2010c). Significant violations reported under "D" represent a reporting violation having to do with non-receipt of a discharge monitoring report (DMR). Violations reported under "E" indicate effluent violations of monthly average limits. The second column displayed in Table 5-5, formal enforcement action, indicates the number of enforcement actions that have been taken against a facility within the last five years. It should be noted that not all violations receive formal enforcement action. Minor violations, or violations that are short in duration or quickly corrected by the facility, may not warrant formal action. Those dischargers that are listed as receiving formal enforcement action but do not have any listed significant violations were all found to have at least two quarters in non-compliance in the last three years. For more detailed information on specific violations and enforcement actions, the EPA ECHO database can be accessed at http://www.epa-echo.gov/echo/. Information on the database is updated monthly.

The Ambler Boro STP, Conshohocken Boro STP, and Upper Gywnedd Township WWTP all had significant violations that resulted in formal enforcement action within the last five years. According to Table 5-5 above, no upgrades or improvements are planned at the Ambler or Conshohocken WWTPs. However, according to the Schuylkill Action Network's Pathogens/Compliance Workgroup, the Upper Gwynedd WWTP is requesting bids for construction of UV disinfection mechanisms that would enable the township to reduce chlorine residual impacts. UV treatment, at comparatively low doses, is also known to successfully deactivate *Cryptosporidium* in such a way that the oocysts cease to be infectious (Rose et al 2004).

Updating High-Priority Non-Point Sources

Although the majority of priority dischargers in Zones A and B consist of NPDES facilities, the SWA's runoff loading analysis revealed that runoff from several Schuylkill River sub-watersheds is a potentially significant source of *Cryptosporidium.* As

previously explained, the loading analysis is based on two variables: the event mean concentration (EMC) and the sub-watershed's land use category. Land use categories were identified for each sub-watershed using the USGS's National Land Cover Dataset (NLCD), and were updated with 2000 Census data for residential and commercial areas (PWD 2002). Assuming that the EMC remains constant, an update of non-point priority sources would involve a re-evaluation of land use within the Schuylkill River watershed. The observations made about watershed land use from the 2000 estimates in the SWA will be used in this analysis. Direct comparison between the 1992 NLCD and 2001 NLCD has been discouraged by USGS, leading PWD to consider alternate approaches that would avoid the uncertainty and possible inaccuracy associated with projecting changes in land use since the SWA.

PWD chose an alternate approach that focuses on changes in the numbers of certain livestock in each county located within the watershed. This approach was deemed appropriate since contamination from animal feces is the primary source of *Cryptosporidium* in agricultural runoff. In fact, an infected calf or lamb is capable of producing more oocysts per day than 1,000 infected immuno-compromised people (Crockett & Haas 1997). PWD's simple quantitative analysis focuses on the changing numbers of cows/calves, sheep/lambs, and hogs/pigs over the course of two decades, from 1987 to 2007. The data from each county's animal inventory was multiplied by the percentage of the county actually located within the watershed to provide a more accurate representation of the number of animals within the Schuylkill River watershed. The data for this analysis was provided by the USDA's Census of Agriculture, which is published every five years and can be accessed at http://www.agcensus. usda.gov/.

The livestock data are displayed in Table 5-6 below. The table presents the data by county and includes the percent differences from 1987 to 2007. It should be noted that Berks and Montgomery counties contain more than 80% of their land area within the Schuylkill River Watershed, and together they constitute nearly 61% of the entire watershed.

Table 5-6 Summary of Certain Groups of Livestock for Counties Located in the Schuylkill River Watershed, 1987-2007

	Number of Cattle/Calves					% Difference 1987-2007
	1987	**1992**	**1997**	**2002**	**2007**	
Berks	60149	56892	55066	52481	58368	-2.96
Bucks	1421	1191	1189	917	769	-45.91
Carbon	24	24	31	19	20	-13.39
Chester	12475	11635	11603	9592	9322	-25.27
Delaware	16	5	6	1	--	--
Lancaster	--	--	33	33	35	--
Lebanon	7058	7168	7688	7731	8345	18.23
Lehigh	1116	803	967	737	721	-35.34
Montgomery	9650	6447	7550	5915	3523	-63.49
Philadelphia	--	--	--	--	--	--
Schuylkill	4463	5171	5640	4469	4985	11.69
Total	**96372**	**89336**	**89773**	**81895**	**86087**	**-10.67**
	Number of Hogs/Pigs					**% Difference 1987-2007**
	1987	**1992**	**1997**	**2002**	**2007**	
Berks	41095	54973	56062	53631	62072	51.04
Bucks	553	204	83	185	47	-91.57
Carbon	24	23	18	5	3	-87.62
Chester	2980	2715	540	2946	4198	40.87
Delaware	--	--	0	--	--	--
Lancaster	42	48	45	49	45	7.40
Lebanon	7257	10973	13529	16575	14691	102.43
Lehigh	2424	1693	1367	585	833	-65.63
Montgomery	8050	5571	7633	3974	6536	-18.81
Philadelphia	--	--	--	--	--	--
Schuylkill	5978	9609	8073	9079	8356	39.79
Total	**68405**	**85809**	**87349**	**87028**	**96782**	**41.48**
	Number of Sheep/Lambs					**% Difference 1987-2007**
	1987	**1992**	**1997**	**2002**	**2007**	
Berks	2377	2100	1671	1725	2165	-8.91
Bucks	208	307	173	229	276	32.64
Carbon	5	4	10	5	11	114.80
Chester	702	784	493	654	694	-1.14
Delaware	--	2	--	1	2	--
Lancaster	1	1	1	1	1	-20.89
Lebanon	335	273	184	240	259	-22.55
Lehigh	202	235	187	208	250	23.33
Montgomery	607	653	662	1400	802	32.24
Philadelphia	--	--	--	--	6	--
Schuylkill	395	208	51	129	179	-54.77
Total	**4833**	**4566**	**3432**	**4593**	**4645**	**-3.88**

Source: USDA Census of Agriculture, 1987, 1992, 1997, 2002, 2007

Trends in animal inventory data vary greatly depending on the group of animals being considered. Cattle/calves and sheep/lambs, which are the greatest known sources of *Cryptosporidium* oocysts (Crockett & Haas 1997), have decreased in number in the watershed by 10.7% and 3.9%, respectively. Hogs/pigs are the only group of animals demonstrating an increase in number throughout the entire watershed, with a calculated increase of 41.5% from 1987 to 2007. Cattle/calves have decreased in number in both Berks County and Montgomery County, with a considerable total decrease of 66.5%. Sheep/lambs have decreased in Berks County by approximately 8.9%, but have increased in Montgomery County over the past two decades by approximately 32.2%.

Figure 5-1 below summarizes the results for each group of livestock in the Schuylkill River Watershed for the 1987 through 2007 USDA Census of Agriculture.

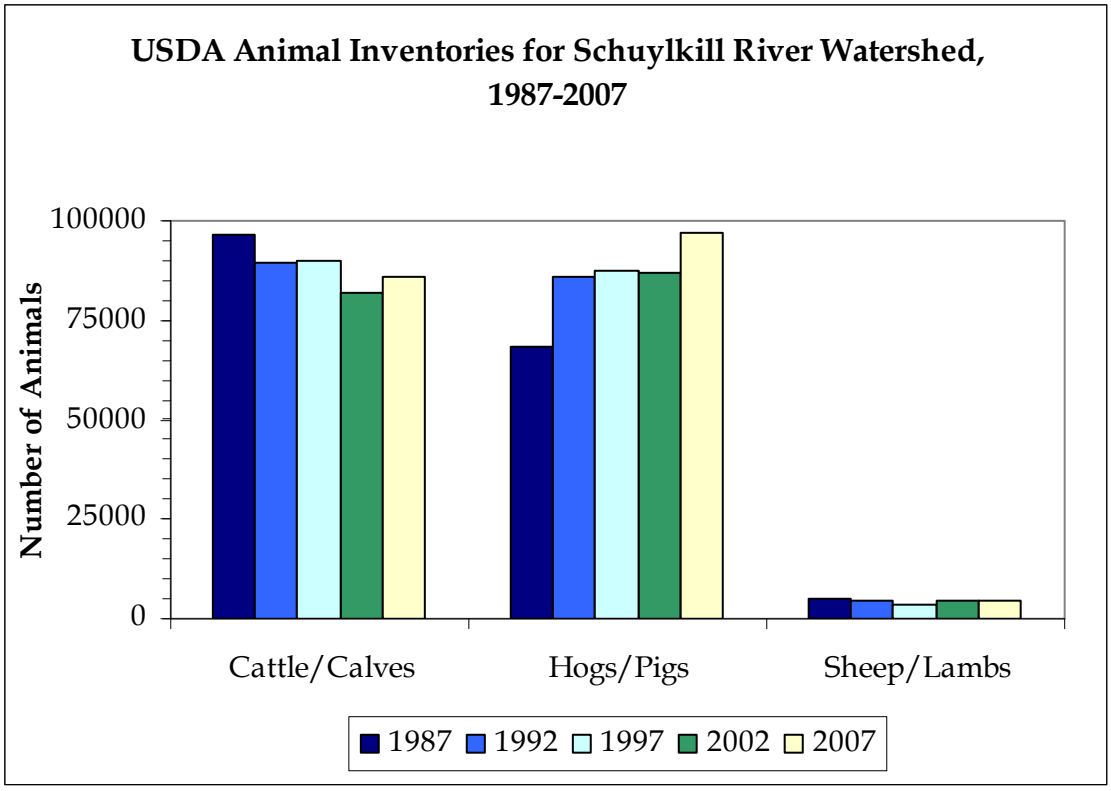

Figure 5-1 Number of Livestock by Year in the Schuylkill River Watershed
Source: USDA Census of Agriculture, 1987, 1992, 1997, 2002, 2007

Results from the USDA animal inventories broadly indicate that agricultural activity is either remaining relatively constant or decreasing throughout the watershed. Cattle/calves and sheep/lambs, which are perhaps the most important animals to consider when accounting for sources of *Cryptosporidium* contamination, have been decreasing in number over the past two decades. In addition, land use data analyzed for the SWA estimates that developed lands in the Schuylkill River watershed have increased by more than 30% from 1982 to 1997 (PWD 2002). During that time period, agricultural lands decreased by 14% and forested lands decreased by 5%. It is clear that

control measures aimed at reducing the impact of livestock and agricultural lands on *Cryptosporidium* levels are of primary importance. However, there is reasonable evidence to conclude that agricultural activity, and the threat it poses to our waterways, has decreased as development has increased.

Agricultural activity in regard to Animal Feeding Operations, AFOs, is a concern in regard to pathogen contamination due to the potentially high number of livestock that can be housed at these facilities. EPA defines an AFO as a facility where animals are confined for 45 days or more per year and where no vegetation grows in the area of confinement (US EPA 2008). AFOs are considered Concentrated Animal Feeding Operations (CAFOs) when a certain number of a specified animal type is confined or stabled. For example, an AFO would be considered a large CAFO if 700 mature dairy cows or more are stabled or confined at the farm site. Currently, the EPA requires all CAFOs that either discharge or propose to discharge to apply for a NPDES permit. Permitted CAFOs must also develop Nutrient Management Plans (NMPs) to address manure handling, storage, and land application. A NMP may include plans to ensure adequate manure storage, install riparian buffers where manure is applied, and limit the manure land application rate. While these plans focus on the implementation of BMPs that will reduce phosphorus and nitrate contamination, the same management practices can also reduce the risk of *Cryptosporidium* contamination (US EPA 2008).

According to PADEP data, there are currently 24 permitted CAFOs in the Schuylkill River watershed, a majority of which are located in the Maiden and Tulpehocken watersheds. The type of livestock varies by farm, and includes beef and dairy cattle, swine, chicken and other poultry. There are approximately 12,767 animal equivalent units (AEUs), or 1.28×10^7 pounds of animal weight at all farms combined (T. Juengst, personal communication, December 10, 2010).

5.1.2 Source Tracking Projects – Results

Wissahickon Creek, May 2005-April 2008

The SWA's source prioritization methodology is only one of several approaches employed by PWD to identify actual and potential sources of *Cryptosporidium*. Recent source tracking projects have improved PWD's understanding of not only the sources, but also the vectors, of oocyst contamination throughout the watershed. These projects are led by Lehigh University, with PWD providing support in terms of sampling, elution and general project management.

The first of two extensive source tracking projects focused on *Cryptosporidium* sources within the Wissahickon watershed. Objectives of the project included "…determining the frequency of *Cryptosporidium* presence in the Wissahickon Creek, determining the genotypes and likely sources of *Cryptosporidium* in the watershed, and identifying the times of year when oocysts, particularly those genotypes associated with human disease, are prevalent in the Wissahickon Creek" (Jellison et al 2009). Given that the Wissahickon Creek flows into the Schuylkill River less than 0.5 miles upstream of the intake, Wissahickon water quality characteristics heavily influence conditions at Queen Lane.

Throughout the duration of the study, from May 2005 to April 2008, 129 samples were analyzed from Wissahickon Creek, 83 samples were analyzed from wastewater treatment plants, and 240 fecal droppings were analyzed from throughout the watershed. Samples were taken from two locations in Wissahickon Creek, WISS 410 and WISS 140, and from three treated WWTP effluents. WISS 410 is heavily impacted by five WWTP dischargers. WISS 140, which is located farther downstream than WISS 410, is within city limits and is located downstream of Fairmount Park. Results from the study indicate that oocysts were detected in 22% of Wissahickon Creek samples, 5% of WWTP samples, and 7% of fecal samples. Outcomes from the study also reveal that oocysts were detected year round, independent of wet-weather events and with no apparent seasonal trend (Jellison et al 2009). Figure 5-2 below illustrates the location of WISS 140, WISS 410, and the three WWTP sampling locations in relation to the Queen Lane intake.

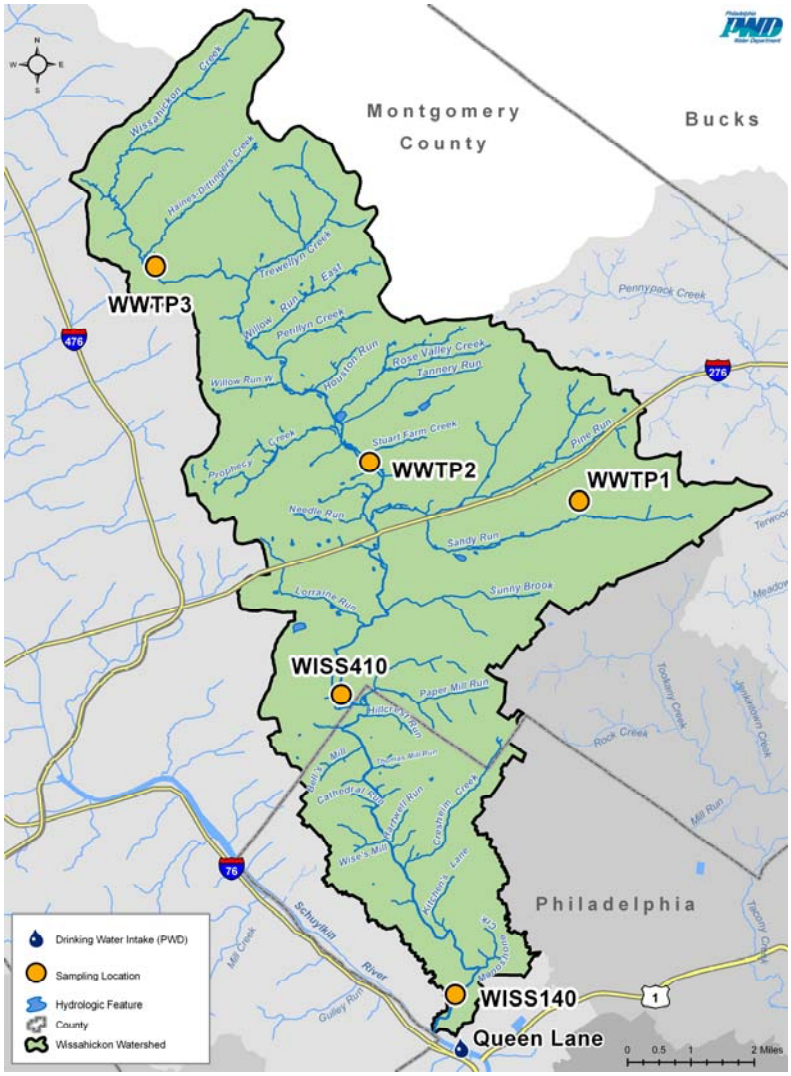

Figure 5-2 ***Cryptosporidium*** **Source Tracking Sampling Locations in the Wissahickon Watershed**

The *Cryptosporidium* genotypes in each sample were identified using the polymerase chain reaction (PCR) method. Human infectious genotypes were identified in 65%, 88%, and 64% of the *Cryptosporidium* sequences collected from Wissahickon Creek, WWTP, and fecal samples, respectively (Jellison et al 2009). A slightly higher percentage of human-infectious genotypes were found at WISS 410 than at WISS 140, implying that human health risk may be reduced as water travels downstream through the lower watershed. In addition, the genotypes detected in the WWTP effluent samples were closely related to those genotypes detected in Wissahickon Creek, suggesting that WWTPs are a source of *Cryptosporidium* oocysts. In regard to fecal sampling results, several genotypes were detected in a single deer or goose fecal sample, and multiple unusual genotypes, including *C. parvum* and a *C. hominis*-like genotype, were detected across numerous positive samples.

Queen Lane and Wiss 140, September 2008-May 2010

To expand upon the results of the Wissahickon Creek source tracking study, Lehigh University and PWD collaborated on a second *Cryptosporidium* detection and genotyping study, which ran from September 2008 to May 2010. The objectives of this second study focus on water quality conditions at the Queen Lane Intake. Goals include identifying the frequency of *Cryptosporidium* at Queen Lane and Wiss 140 and determining the public health risk associated with the detected genotypes (Jellison 2010a). This study also included a genotyping analysis of goose feces collected from the Philadelphia area (Pennypack Creek, Valley Green and Kelly Drive) and the Lehigh area (Monocacy Creek and Saucon Valley Park). Unlike the Philadelphia area, the Monocacy Creek is negligibly impacted by treated wastewater. Samples from both areas were compared to determine if geese generally transmit human-infectious *Cryptosporidium* spp. genotypes, or if geese are serving as vectors of human-infectious genotypes that originate from WWTP effluent.

Two detection methods were used in this study: PCR and Fluorescent *in-situ* hybridization (FISH). The primary difference between the PCR and FISH methods is that FISH detects, but does not differentiate between, two species of viable, human-infectious oocysts, *C. hominis* and *C. parvum*. PCR will detect and differentiate any species or genotype of *Cryptosporidium* in a sample but will not differentiate between viable and nonviable oocysts. In addition, FISH provides a quantitative oocyst count while the PCR method only provides information on oocyst presence/absence (Jellison 2010b).

Results from this study indicate that oocysts were detected at the Queen Lane intake on 5 (16.1%) of 31 days since September 2008 and at Wiss 140 on 2 (20.0%) of 10 days since September 2009 (Jellison 2010a). The detection frequency for this study is very similar to the detection frequency in the previously described Wissahickon Creek study that ran from May 2005-April 2008. However, the phylogenetic analysis shows that the *Cryptosporidium* sequences removed from the Queen Lane intake samples were not identical to the sequences recovered from the Wissahickon study, indicating that sources outside of the Wissahickon Creek watershed are contributing to oocyst levels at the intake. Both of the *Cryptosporidium* genotypes detected at the intake, *C. hominis* and *C. suis*, are human-infectious genotypes that may pose a public health risk.

Oocyst detection during this study was not identical among filters collected on the same day at a specified sampling location (Jellison 2010a). Discrepancies were also present between the results of the PCR genotyping analysis and the FISH assay. FISH results yielded a significantly higher rate of oocyst detection, suggesting that viable human-infectious oocysts may be present at the intake more frequently than previously indicated by the genotyping analysis. The reason for the discrepancy between PCR and FISH results is still being investigated at this time.

In addition to sampling at the intake and Wiss 140, a total of 217 goose fecal samples were analyzed for this study since July 2008. No oocysts were detected in the goose samples from the Lehigh area. Conversely, 11 (7.5%) of the 147 goose samples from the Philadelphia area (including Pennypack Creek, Valley Green, and Kelly Drive), which is influenced by WWTP effluent, were positive for *Cryptosporidium*. *C. parvum* and *C. hominis*-like genotypes were detected in 8 of 11 geese. *C. parvum* and *C. hominis* are the primary genotypes associated with human illness (Nichols 2008).

Lehigh University, in partnership with PWD, is also looking into additional, alternative methods for watershed detection of *Cryptosporidium*. One such method involves the use of FISH, which is described above, to provide increased recovery and detection of *Cryptosporidium*, as well as the ability to differentiate between human and non-human infective oocysts. A new approach is also being evaluated to qualitatively compare *Cryptosporidium* loading at specific sites using biofilm samplers. This approach, which is considerably less expensive than filtering samples, may allow for the identification of high impact reaches in a watershed.

5.1.3 SAN Cryptosporidium Survey - Results

The results from the source tracking studies clearly indicate that there are multiple sources of *Cryptosporidium* impacting conditions at the Queen Lane intake. The most constant of these sources is WWTP effluent. During dry weather conditions, discharges from WWTPs can make up 65-100% of the flow of the Wissahickon Creek, which, as previously stated, directly affects conditions at the intake (Crockett & Haas 1997).

To further investigate the influence of WWTP effluent on *Cryptosporidium* levels in the Schuylkill River, the Schuylkill Action Network (SAN) Pathogens Workgroup conducted a *Cryptosporidium* monitoring program in 2006 and 2007. The monitoring program took one sample per facility per year, between May and June at 71 sewage treatment plants and one duck CAFO. The effluent samples captured at each facility were analyzed by Clancy Environmental Consultant (CEC) labs. In addition to the two-year monitoring program, a plant operator survey was conducted at 69 facilities in 2007 to identify the range of treatment technologies and other operational characteristics of each plant (Duzinski 2008).

The SAN sampling program intended to provide a reference of *Cryptosporidium* concentrations in wastewater treatment plant discharges across the Schuylkill River watershed in order to inform how future sampling programs should be designed. Although not a comprehensive study of *Cryptosporidium* in wastewater discharge, the

SAN sampling program observed that *Cryptosporidium* levels varied widely between the two years, with oocysts detected at 8 of the 71 plants in 2006, and 22 of the 71 plants in 2007. The results of the plant operator survey found that 54 plants use some form of chlorination disinfection, while only 14 plants employ UV disinfection. Sixty-one plants are designed for secondary treatment only, and 5 plants include tertiary treatment.

5.1.4 In-City Influences – Defective Laterals

Another potential source of *Cryptosporidium* is the untreated sewage released by defective laterals. To address this problem, the City of Philadelphia has been effectively operating a Defective Lateral Detection and Abatement Program. The program was developed under the City's Municipal Separate Storm Sewer System (MS4) permit initially signed in 1995 and further refined under a Consent Order & Agreement (COA), reached with the Pennsylvania Department of Environmental Protection (PADEP) on June 30th, 1998. The COA was officially terminated on March 18th, 2004, but the City has remained faithful to the terms of that agreement.

The program is comprised of several initiatives that aim to detect, investigate, and prevent illicit discharges. The prevention of illicit discharges is primarily achieved through sewer and lateral inspections. Investigative aspects of the program include ranking MS4 outfalls according to their priority for corrective actions, and investigating dry weather flows to identify sewer lateral defects. Outfalls are ranked using information from the City's stormwater outfall monitoring system, which is in compliance with the MS4 permit issued by the PADEP. Outfalls identified as priority outfalls under the MS4 permit are sampled quarterly. The City also investigates all potential reports of illicit discharges from the stormwater system through either the Industrial Waste Unit or the Sewer Maintenance Unit. The success of the program's outfall investigation efforts is reflected in the number of abated cross connections; from FY 2005 to FY 2009, a total of 325 residential and 29 commercial cross connections were abated. Defective laterals that drain into the Schuylkill River include those identified at Monastery Avenue, Monoshone Creek, and Manayunk Canal, with 16, 92, and 59 abatements occurring at these locations, respectively. The identification and subsequent abatement of these cross connections has occurred as of June 30th, 2009 (PWD 2009b).

5.2 Qualitative Assessment of the Relative Impact of Contamination Sources on Water Quality at the Queen Lane Intake

5.2.1 PWD's SWA & SWPP- Implications

Results from the SWA prioritization indicate that NPDES dischargers and runoff from non-point sources, or sub-watersheds, have the greatest potential to impact *Cryptosporidium* levels at the Queen Lane intake. A large number of these priority sources are located relatively far upstream, in the Reading and Berks County areas. To further confirm the impact these two primary sources have on *Cryptosporidium* levels not only at the intake, but throughout the entire watershed, a qualitative loading analysis was completed for the SWA.

The SWA's qualitative loading analysis is only meant to provide some very general indications about the impacts of various sources of contaminants. Each type of source was rated in the loading analysis as having either low, medium, or high impact on ambient river concentrations (PWD 2002). The qualitative loading data used to determine the impact ratings were then compared with actual water quality data from research studies. For *Cryptosporidium*, the comparison of data suggests that during storm events, elevated levels of oocysts are most likely due to stormwater runoff (PWD 2002). During non-rainfall periods, however, it appears that NPDES discharges, in particular from WWTPs, are the main source of daily concentrations observed in the Schuylkill River. Therefore, the implications of results from both the SWA prioritization and the qualitative loading analysis signify that efforts to reduce mean daily concentrations of *Cryptosporidium* in the river should focus on reducing the impacts from wastewater discharge, while efforts to reduce peak concentrations should focus on mitigating stormwater runoff. Background concentrations of *Cryptosporidium* can also develop when oocysts accumulate in riverbed sediment and become re-suspended during storm events. The re-suspension of oocysts is discussed in further detail later in this section.

According to the SWA, runoff from agricultural land characterized as pasture/hay has an EMC of 1 oocysts/100 mL, the highest EMC compared to all other land uses. Agricultural runoff is of particular concern in the Wissahickon watershed, where there are two farms located along the lower reaches of the tributary. Erdenheim Farm, the larger of the two farms, encompasses 450 acres and has approximately 118 cattle, including calves, and 143 sheep (C. Reeves, personal communication, July 6, 2010). In addition, a park system surrounds a large portion of the Wissahickon Creek, and contains wildlife that could be sources of protozoa. Implementing control measures in the Wissahickon watershed will very likely reduce peak concentrations of *Cryptosporidium* at the intake.

PWD's Source Water Protection Plan (SWPP) expands upon the SWA's prioritization method by re-examining the highest-ranked sources and further prioritizing them according to their impact on the entire watershed (PWD 2006). The SWPP found that high-priority sources for *Cryptosporidium* are located primarily along the mainstem of the Schuylkill River, between Reading and Norristown, with a large cluster of priority sources located just downstream of Norristown. The high-priority non-point source sub-watersheds are located in the Lower and Middle Schuylkill sub-watersheds and in the Tulpehocken and Maiden Creek sub-watersheds.

Results from the SWPP's prioritization process also support conclusions from the SWA which indicate that *Cryptosporidium* is found in both point source discharges and runoff. In regards to agricultural land uses, *Cryptosporidium* is directly linked to the waste of young animals, especially calves.

5.2.2 Source Tracking Projects – Implications

Wissahickon Creek, May 2005-April 2008

The source tracking projects led by Lehigh University provide valuable information about the sources and vectors of *Cryptosporidium* in the Schuylkill River Watershed. Oocysts were detected across all types of samples, including creek, WWTP, and fecal samples. The 2005-2008 Wissahickon study found that the distribution of oocysts and oocyst genotypes can vary between sample locations within the same watershed, as was the case with the oocysts detected at WISS 410 and WISS 140. Previous studies focusing on the distribution of *Cryptosporidium* genotypes in several New York watersheds (Jiang et al 2005) and the Potomac River watershed (Yang et al 2008) attributed this variance in distribution to different land uses within the same watershed. The implications of land use are apparent in the Lehigh University study as well, where five WWTPs discharge upstream of WISS 410, while the land upstream of WISS 140 is wooded and designated for wildlife and recreational uses.

Results from the Wissahickon source tracking project also found that multiple oocyst genotypes can be present in a single sample, suggesting that more than one source can impact a single location, and a single source, such as WWTP effluent or an animal host, can release multiple oocyst genotypes into the environment (Jellison 2009). Consequently, WWTPs and animal hosts such as deer and geese are appropriate targets for source water protection in the Wissahickon Watershed. If, in fact, animal hosts serve as the primary vectors of *Cryptosporidium* oocysts, as this study suggests, then further identification and control of the vectors that transfer oocysts from host to water sources may prove to be just as important as the identification and control of original oocyst sources.

Queen Lane & Wiss 140, September 2008-May 2010

The Queen Lane and Wiss 140 source tracking study, which served as a follow-up to the Wissahickon study, had various implications concerning the contamination sources affecting the intake. Oocysts were detected in 16.1% of the Queen Lane samples since September 2008 and in 20.0% of Wiss 140 samples since September 2009 (Jellison 2010a). Although oocyst detection frequencies were similar between the two studies, the sequences recovered from the Queen Lane intake samples were not identical to any of the sequences recovered from the Wissahickon study. Therefore, sources outside of the Wissahickon watershed are impacting *Cryptosporidium* levels at the Queen Lane intake. It should also be noted that all of the sequences detected at Queen Lane, Wiss 140, and from the geese (with the exception of a goose I genotype found in a Pennypack goose and a goose at Kelly Drive) have been associated with human infection and may represent a potential public health risk.

A total of 217 goose fecal samples were analyzed for this study since July 2008 (Jellison 2010a). Analysis of these samples revealed important information regarding the influence of WWTP effluent on the intake's water quality. *C. parvum* and *C. hominis*-like genotypes were detected in 8 of the 11 positive goose fecal samples in the Philadelphia area. No positive samples were detected from the geese samples from the Lehigh area, which is negligibly influenced by WWTP effluent. Two conclusions can be drawn from

these sampling results: 1) geese are not the primary sources of *C. parvum* and *C. hominis*, but instead serve as vectors of human-infectious genotypes, and 2) it is very likely that human infectious genotypes are originating from other point sources, specifically, treated WWTP effluent and watershed wildlife. Findings from this study support the conclusion from not only the Wissahickon study, but also the SWA and SWPP, that WWTP effluent and animal hosts are primary sources of *Cryptosporidium* at the Queen Lane intake. Source water and goose sampling in other watersheds upstream of the intake would further validate this hypothesis.

5.2.3 SAN Cryptosporidium Survey - Implications

The SAN monitoring program provides further evidence that WWTP effluent is a consistent source of *Cryptosporidium* oocysts within the Schuylkill River watershed. Future monitoring programs with more frequent sampling would be necessary to determine which particular WWTPs regularly release the highest levels of *Cryptosporidium*.

The survey portion of the SAN study indicated that the majority of WWTPs in the watershed are capable of secondary treatment only. Secondary treatment may achieve 0.7-2.0 log removal, as opposed to tertiary treatment systems, which can achieve a log removal of 2.4-3.3 (Crockett 2007). These numbers reflect the high likelihood that WWTPs using traditional, secondary treatment processes will pass *Cryptosporidium* oocysts into receiving waters. In addition, disinfection processes such as chlorination and UV disinfection simply deactivate oocysts, without physically removing them from treated water. The viable and non-viable oocysts are then both accounted for when determining detection rates using EPA method 1623, as is required by LT2 regulations. Therefore, drinking water providers such as PWD are faced with the challenge of reducing *Cryptosporidium* at their intakes when it is known that the treatment processes at WWTPs do not always effectively remove the pathogen.

5.2.4 Influence of City-owned infrastructure on intakes - Implications

The influence of City-owned infrastructure on the Queen Lane intake is minimal and confined to a very small portion of the area of influence. Only 2.4% of the Schuylkill River watershed, Queen Lane's entire area of influence, is located within the City. Within Philadelphia's portion of the watershed, there are a limited number of sources that may represent a contaminative threat. Since no PWD WWTPs are located upstream of the intake, the only point source of concern are the City's defective laterals, which are systematically identified and abated through the City's Defective Lateral Detection and Abatement Program, described above. From FY 2005 to FY 2009, a total of 325 residential and 29 commercial cross connections were abated.

In terms of non-point sources, limited stormwater and agricultural runoff have the potential to impact water quality conditions at Queen Lane. In-City initiatives to address stormwater include PWD's Stormwater Permit, required under the National Pollutant Discharge Elimination System, and the City's stormwater ordinance in compliance with Pennsylvania's Stormwater Management Act (Act 167). Both permits provide the State with an overview of stormwater pollution control measures and measures to control flooding problems. Agricultural runoff from the Philadelphia

portion of the watershed is minimal and is currently being addressed through a series of agricultural best management practices (BMPs) that are discussed in more detail later in this plan.

The cumulative impact of Philadelphia's point and non-point sources are effectively minimized through the City's control measures and management programs. It can therefore be concluded that the influence of City-owned infrastructure on water quality conditions at Queen Lane is a relatively minor and manageable concern.

5.3 Role of Fate and Transport

It is critical to consider the role of fate and transport when determining what sources are capable of influencing *Cryptosporidium* levels at the Queen Lane intake. The SWA methodology identifies the highest-priority sources as those located in Zones A and B, within a 5-hour and 25-hour time of travel of the intake. This Watershed Control Plan assumes that sources within Zones A through C have the potential to impact conditions at the Queen Lane intake. Zone C includes the area beyond the 25-hour time of travel of the intake and incorporates the remainder of the Schuylkill River watershed.

It is necessary to designate the entire watershed as the area of influence due to the observed survivability of viable oocysts. It has been found that oocysts are capable of surviving in river waters from 30 to 176 days with upwards of 30% and 70% of oocysts remaining viable after 100 days at temperatures of 21°C and 4°C, respectively (Sattar et al 1999). Using travel time estimates, it has also been concluded that *Cryptosporidium* oocysts can travel 160 km, or 100 miles, in less than 7 days, at which point they will remain viable upon withdrawal at a downstream intake (Crockett 2007). The entire length of the mainstem Schuylkill River, running from Pottsville to Philadelphia, is only 128 miles (www.schuylkillriver.org).

Cryptosporidium oocysts initially introduced to the river from point or non-point sources can also accumulate in high concentrations in riverbed and streambed sediment. These oocysts are re-suspended during hydrologic or physical disturbances, and can have a significant effect on water quality that may not always be observed during low-flow periods (Crockett 2004). The conditions found on a riverbed may also lengthen the survival time of oocysts. Pathogens, even bacteria that generally die off by more than 50 to 90% within only 1 to 3 days in the environment, can survive up to several weeks if they are attached to particulate matter and exposed to colder water or shielded from sunlight (Novotny & Olem 1994; Thomann & Mueller 1987).

As concluded in Section 4, it is clearly evident that several factors, including *Cryptosporidium's* extended survival periods and its potential to remain viable after traveling long distances downstream, confirm that point and non-point sources throughout the entire Schuylkill River Watershed need to be considered when assessing water quality at Queen Lane.

Section 6. Analysis of Control Measures

Section 5 identifies NPDES discharges, particularly WWTPs, and runoff from sub-watersheds associated with agricultural land use, as the primary point and non-point sources, respectively, of *Cryptosporidium* contamination at Queen Lane. Extensive research efforts have also revealed that certain animals can serve as vectors, transferring viable oocysts from original hosts to Philadelphia's source waters. Efforts to reduce mean daily concentrations of *Cryptosporidium* in the river should therefore focus on reducing the impacts from wastewater discharge, while efforts to reduce peak concentrations should focus on mitigating agricultural runoff. In addition, further identification of animals that serve as mechanical vectors is imperative to fully understand and control sources of oocyst contamination. The objective of this section is to identify those control measures that will prove most effective at reducing *Cryptosporidium* contamination in the Schuylkill River watershed, with the ultimate goal of lowering oocyst levels at the intake. The feasibility of implementing control measures on a watershed-wide basis will also be discussed.

6.1 Potential Control Measures

6.1.1 Point Sources

Treated WWTP effluent from NPDES discharges is the highest priority point source for *Cryptosporidium* in the Schuylkill River watershed. Subsequently, the most effective point source control measures will involve treatment process modifications that achieve a higher level of removal and/or inactivation of *Cryptosporidium* oocysts. As stated in Section 4, a majority of WWTPs in the Schuylkill River watershed use secondary treatment. While secondary treatment may only achieve a log removal of 0.7-2.0, plants employing tertiary treatment can potentially achieve 2.4-3.3 log removal (Crockett 2007). It has been estimated that through the use of alternative treatment technologies, such as UV light disinfection and filtration, wastewater dischargers may be able to achieve 6 log combined removal and inactivation of emerging pathogens (Crockett 2007). Modifying treatment disinfection processes with alternative technologies like UV will not only improve pathogen removal/inactivation, but will also create ancillary recreational benefits and the opportunity to address risk compliance regulatory requirements for reducing chlorine residuals. The appropriateness of implementing UV disinfection for *Cryptosporidium* removal/inactivation should be evaluated by balancing the costs and overall effectiveness against other potential watershed control plan measures.

Additional control measures and management practices are necessary to address discharges of raw sewage resulting from inadequate or failing sewerage systems and septic systems. During wet weather, separate sewer overflows (SSOs) and combined sewer overflows (CSOs) release untreated sewage upstream of Queen Lane. SSOs are often the result of infiltration and/or inflow. Sources of infiltration can include cracked pipes, loose joints, cracked or open pipes or manholes in stream, and root intrusion (SAN 2010b). Inflow can result from loose, open or perforated manholes, direct downspout and sump pump connections, and a cross connection of a stormwater pipe to a sewer pipe. During wet weather, CSOs result when the combined sewer system

becomes overloaded, releasing a combination of sewage and stormwater into receiving waterways. Dry weather overflows can be caused by blockages (tree roots, grease, etc.) due to poor collection system maintenance, or by defective sewer lateral connections. Wildcat sewers, illegal sewers that discharge raw sewage directly to the river, have also been identified throughout the watershed. PWD's Schuylkill River Source Water Assessment concludes that sewer system capacity and integrity, as well as treatment plant capacity during wet weather periods, represent the greatest and most difficult sewerage-related issues in the watershed (PWD 2002).

Control measures that address issues contributing to inadequate or improperly managed sewerage systems include the following:

- infrastructure improvements and modifications specifically related to collection system and plant capacity expansions;
- identification and abatement of defective lateral connections and wildcat sewers; and,
- regular enforcement activities throughout the watershed that ensure proper functioning and maintenance of sewerage and septic systems.

PWD and its watershed partners have already started to address several of these issues through various programs and initiatives, which will be discussed in further detail in Section 7. By addressing sewerage-related issues on a watershed-wide scale, the Schuylkill River may see considerable reductions in pathogen loadings.

6.1.2 Non-Point Sources

Stormwater runoff is a regular non-point source of water pollution that introduces *Cryptosporidium* and a host of other contaminants into Philadelphia's source waters. Agricultural runoff is of particular concern when considering pathogen contamination. As previously described, runoff from pasture lands has the highest event mean concentration (EMC) for *Cryptosporidium* of all land use types in the watershed. It can therefore be inferred that *Cryptosporidium* loadings in runoff will be reduced through the implementation of agricultural best management practices (BMPs). Examples of BMPs that may effectively reduce oocyst levels in the Schuylkill River and its tributaries are listed below.

- stream bank fencing for livestock containment
- stream crossings for livestock
- manure containment sites
- fencing and re-vegetation for the control and containment of animal vectors (especially geese)
- riparian buffers

- other BMPs, such as stormwater wetlands, that are located on or near agricultural land and have the potential to divert and filter contaminated stormwater flow

The above-listed BMPs serve to reduce impacts from livestock activity and pasture runoff on the Schuylkill River. In addition to mitigating the potential for pathogen contamination, agriculture BMPs also reduce nutrient and sediment loadings, which are additional causes of stream impairment in the Schuylkill River watershed. Section 7 will discuss the specific projects and initiatives that PWD has undertaken to address *Cryptosporidium* contamination from non-point sources throughout the watershed.

6.2 Analysis of the relative effectiveness of control measures in reducing Cryptosporidium loadings to source water

PWD's ability to reduce *Cryptosporidium* levels at the intake will depend on both the feasibility and long-term effectiveness of the control measures that are selected for implementation. A primary component of effective BMP implementation is location. The most effective control measures will be those that address *Cryptosporidium* contamination directly at its source, whether that source is located within close proximity to or relatively far upstream of the intake. PWD's assessment methods and research initiatives outlined in Section 5 provide substantial evidence as to what sources of contamination need to be addressed. Section 7 will provide additional information as to where, based on the Source Water Assessment land use analysis, certain BMPs should be located.

6.2.1 Point Sources

Treatment process modifications at priority NPDES dischargers have the potential to greatly reduce routine releases of *Cryptosporidium* to the Schuylkill River. PWD's Source Water Protection Plan estimates that of the total *Cryptosporidium* loading to the Schuylkill River, 83% is from NPDES dischargers and the remaining 17% is from non-point sources. As stated earlier in this section, upgrading a plant from secondary to tertiary treatment will increase oocyst removal by approximately 1 log. Modifications made to improve the filtration and disinfection processes of a treatment system will also increase a plant's ability to effectively remove or inactivate *Cryptosporidium* oocysts. For example, a secondary treatment plant employing UV could achieve a *Cryptosporidium* combined log inactivation/removal of > 6, whereas under the plant's current operation, without the use of UV, it may only achieve a log removal of 2 (Crockett 2007). Plants should consider what combination of treatment processes will achieve maximum oocyst removal for public health protection while also effectively addressing competing environmental regulatory requirements (Crockett 2007).

Additional control measures and management practices are necessary to reduce discharges of untreated sewage to the Schuylkill River. Infrastructure improvements for adequate wastewater collection and treatment systems are needed to address system capacity issues, such as overloading caused by infiltration and inflow. Addressing hydraulic overloads will reduce the frequency of raw sewage events, such as overflowing manholes into downstream water supplies (PWD 2002). The identification

and abatement of defective lateral connections and wildcat sewers are also effective means of reducing the frequency of raw sewage discharges. By using these control measures to minimize the discharge of untreated sewage, public health risks associated with pathogen contamination will be effectively reduced.

6.2.2 Non-Point Sources

Agriculture is one of the leading causes of impaired stream miles in the Schuylkill River watershed. More than 70% of agriculturally impaired stream miles are located within Berks County, the state's fifth-leading county in agricultural production at the time of the land use characterization for the Source Water Assessment (PWD 2002). Despite the potential for significant negative water quality impacts by agricultural activities, agricultural lands also represent some of the simplest and cheapest areas for reducing *Cryptosporidium* contamination. It should be noted that only agriculture projects, not urban stormwater projects, are included in the scope of implementation for the Watershed Control Plan. This decision is based on the fact that agriculture BMPs that address high-impact sources are easier to implement, less expensive, and have a greater probability of reducing watershed loads than urban stormwater BMPs. Stormwater projects are also already implemented through a variety of other programs, including on the local level through stormwater ordinances and MS4 permits.

A number of farms in the Schuylkill River watershed have already installed agriculture BMPs, including specially designed cattle crossings and streambank fencing to reduce the impacts of cattle on streams. Other farms have established riparian buffers to protect streambanks and to filter out harmful contaminants. The specific agriculture projects PWD has been involved with will be outlined in Section 7.

While agricultural BMPs directly address known sources of *Cryptosporidium*, very little performance monitoring has occurred to quantify the efficacy of BMPs at removing pathogens from runoff. Lack of performance monitoring can be attributed to the high cost of *Cryptosporidium* monitoring, as well as the limited availability of certified lab technicians trained in the analytical techniques used to process samples.

Although BMPs in the Schuylkill River watershed have not been monitored for *Cryptosporidium* removal, studies elsewhere in the nation have attempted to quantify the oocyst removal capabilities of certain BMPs. Vegetated buffer strips, in particular, are advocated by the U.S. Department of Agriculture for pathogen removal. A study published in 2002 entitled *Transport of Cryptosporidium parvum Oocysts through Vegetated Buffer Strips and Estimated Filtration Efficiency* aims to provide basic design criteria for on-farm vegetated buffers that can remove > 99.9% (> 3 log) of *Cryptosporidium parvum* oocysts from agricultural runoff (Atwill et al 2002). At the time of this study, optimal design criteria for on-farm vegetated buffer strips did not exist for removing pathogens. Based on the study's observations and data analysis, vegetated buffer strips of soils with bulk densities between 0.6 and 1.7 g/cm^3, < 20% slope, and with a width of at least 3 meters should achieve 3 log removal of *C. parvum* oocysts from stormwater flow generated during events with an intensity less than 4 cm/hr. These design criteria assume that the vegetated buffer strips are properly maintained over time.

The study also points to other factors that can increase the efficacy of BMPs, including maintaining a large distance between livestock activity (i.e. feedlots, calf housing, etc.) and source waters. It was also found that as the bulk density of soils is decreased, a greater number of oocysts are removed from the surface flow passing through a buffer strip. These results imply that land practices that compact soil and reduce its porosity subsequently increase the number of oocysts transported to surface waters by reducing the infiltration capacity of runoff.

A second study performed in the Tomales Bay watershed in California in 2008 assessed the performance of several agricultural BMPs at 35 cattle lots on five dairy farms over a two-year period. This study expands upon the results of the previously described study by implementing vegetated buffers in a working farm setting. The goals of the California study were to "1) evaluate factors associated with *Cryptosporidium* oocysts in runoff from dairy high use areas and 2) evaluate the efficacy of BMPs to reduce the *Cryptosporidium* load in storm runoff from treated dry lots compared to adjacent control dry lot sites" (Miller et al 2008). Sampling over the two-year period, between November 2002 and March 2004, produced a total of 350 stormwater samples. *Cryptosporidium* oocysts were detected at four of the five dairy farms, however, only oocysts resembling *C. parvum* were used in the analysis.

The study found that cattle age class, cumulative seasonal precipitation, and 24-hour precipitation all significantly affected oocyst levels in stormwater runoff, as did the implementation of straw mulch and vegetated buffer strips on land used for cattle activity (Miller et al 2008). *Cryptosporidium* concentrations and loading rates revealed that the oocyst levels in runoff from areas housing young calves were 2100 and 728 times greater, respectively, than oocyst levels in runoff from areas housing adult cows. These findings suggest that implementing BMPs that directly address calf areas may be an extremely effective way to reduce oocyst concentrations in runoff. The impact of cattle, especially calves, is evident in the estimated human shedding equivalent. A human shedding equivalent is defined as the number of people shedding oocysts equivalent to the same number of organisms per day from a particular animal or source (Crockett & Haas 1997). One infected calf or lamb is capable of shedding more oocysts per day than 1,000 immuno-compromised people. In comparison, a 10 MGD discharge of raw sewage into a stream or river is comparable to the loading of approximately 200 immuno-compromised people shedding *Cryptosporidium* oocysts.

Oocyst concentrations were also found to be highest early in a storm event and even early in the storm season, when runoff is first contaminated with accumulated fecal matter. In terms of BMP implementation, both vegetated buffers and straw mulch application were found to act as barriers capable of trapping oocysts and removing them from runoff. Based on the study's results, "…each 10% increase in straw mulch application to dairy high-use areas resulted in the oocyst concentration decreasing by a factor of 0.73" (Miller et al 2008). Each additional meter of vegetated buffer strip decreased the oocyst concentration by a factor of 0.97. The efficiency of oocyst removal in buffer strips was notably lower than the results from the previous study, a difference which may be attributable to several factors including soil type, storm intensity, buffer

composition, and the hydrologic behavior of runoff—factors that can be controlled in an experimental setting.

The results from the two abovementioned studies suggest that certain agricultural BMPs effectively trap oocysts in runoff before they contaminate surface waters. The degree to which BMPs are effective appears to be a combination of environmental factors and the design and placement of the BMP itself. As PWD and other partnerships and organizations move forward with implementing agricultural BMPs in the watershed, the results of research studies should be taken into account, and careful consideration should be given to the location and method of BMP construction.

6.3 Analysis of the feasibility of control measures

PWD's ability to implement a watershed-wide control plan depends largely on the level of cooperation and collaboration that can be achieved between Philadelphia and its upstream partners. As stated in Section 4, the entire Schuylkill River watershed is considered the area of influence for *Cryptosporidium* contamination at Queen Lane. Philadelphia's jurisdiction encompasses a very small portion of the entire watershed—a little more than 2%. The degree to which Philadelphia can influence water quality conditions at Queen Lane while only acting within the city's jurisdictional boundaries is quite limited. For this reason, PWD has expended considerable effort developing partnerships with a diverse group of watershed organizations, government agencies, academic institutions, and businesses. PWD's commitment to watershed-wide collaboration is evident in the seven objectives outlined in the Schuylkill River Source Water Protection Plan. These objectives, listed below, allow PWD to ensure the integrity and affordability of the region's water supply.

1. Establish the Schuylkill Action Network (SAN) as a permanent watershed-wide organization charged with identifying problems and prioritizing projects and funding sources to bring about real improvement in water quality throughout the Schuylkill River watershed.
2. Create a long-term, sustainable fund to support restoration, protection, and education projects in the Schuylkill River watershed.
3. Increase awareness of the Schuylkill River watershed's regional importance as a drinking water source.
4. Initiate changes in policies and decision-making that balance and integrate the priorities of both the Safe Drinking Water Act and the Clean Water Act.
5. Establish the Early Warning System as a regional information sharing resource and promote its capabilities for water quality monitoring and improving emergency communication.
6. Reduce point source impacts to water quality.
7. Reduce non-point source impacts to water quality.

The following section will discuss in detail the projects that PWD has implemented to achieve these objectives, and the importance of watershed partnerships as the City works toward fulfilling its source water protection goals.

Section 7 Statement of Goals and Specific Actions

7.1 Goals

PWD fully recognizes its responsibility to protect the water quality for its approximately 1.1 million customers supplied with water from the Schuylkill River watershed (PWD 2006). Within the City's jurisdictional boundaries, PWD is able to directly implement source water protection measures. Outside of Philadelphia, PWD enables source water protection through the watershed-wide initiatives of various partnerships. Addressing potential and actual sources of *Cryptosporidium* and reducing oocyst levels at Queen Lane will require a collaborative effort between PWD and its partners. Regardless of whether or not contaminative threats originate from a nearby source to Queen Lane or are located farther upstream, potential sources need to be addressed throughout the entire area of influence.

Within City limits, PWD's goal is to adequately address all high priority sources of *Cryptosporidium*. Extensive control measures and management practices have already been implemented within Philadelphia to minimize the risk of pathogen contamination at Queen Lane. PWD has implemented several agricultural projects to divert and detain contaminated runoff before it reaches surface waters. The City is also working to reduce raw sewage discharges through innovative combined sewer overflow (CSO) and stormwater management techniques. PWD has made it a priority to educate city residents as to various source water protection issues, including pathogen contamination, and to support research initiatives that will further develop PWD's understanding of the role of animal vectors in the fate and transport of *Cryptosporidium* throughout the watershed. WWTP effluent, the *Cryptosporidium* point source of highest concern according to the Source Water Assessment's prioritization for Queen Lane, cannot be directly addressed by Philadelphia since PWD's WWTPs are not located above the intake.

In addition to meeting pathogen reduction goals within the city, PWD is committed to supporting and helping ensure the realization of this goal throughout the entire watershed. PWD recognizes that in a watershed of the Schuylkill River's size, partnerships are necessary so that the combined expertise of various organizations and stakeholders can be used to achieve cumulative water quality improvements. (PWD 2006). High priority protection areas for improving overall water quality conditions at Queen Lane include the mainstem of the Schuylkill River, between Reading and Philadelphia, the Wissahickon Creek, and the Perkiomen Creek. The Valley Creek, French Creek, and Tulpehocken Creek have secondary protection priority (PWD 2002). Table 7-1 below outlines the location of priority sources for *Cryptosporidium* contamination at Queen Lane.

Table 7-1 General Locations of Priority *Cryptosporidium* Sources

Priority Source	Priority Area
Treated Sewage	Reading to Philadelphia
Untreated Sewage	Bridgeport, Norristown, and Schuylkill County
Urban/Residential Runoff	Reading to Philadelphia
Agricultural Runoff	Perkiomen Creek & Tulpehocken Creek

Source: PWD Schuylkill Source Water Protection Plan, 2006

As is evident from the priority locations listed above, priority point and non-point *Cryptosporidium* sources are located outside of Philadelphia. The specific partnerships and organizations that PWD works closely with to address these sources will be described in more detail later in this section.

Through PWD's Source Water Protection Program, significant strides have been made to reduce the risk of pathogen contamination. The City's commitment to maintain existing control measures is equally as important as the commitment to develop future initiatives and management practices. The proceeding section will identify those action items already implemented by PWD through an assessment of both in-city and watershed-wide projects. This comprehensive project assessment will reveal what vulnerabilities remain when all existing and proposed control measures are considered. The remaining vulnerabilities will provide a framework for moving forward with implementation of this plan as PWD strives to minimize the threat of *Cryptosporidium* contamination at Queen Lane.

7.2 Existing actions and their contributions to specific goals

The Queen Lane Source Water Assessment and Source Water Protection Plan emphasize Philadelphia's need to look farther upstream to protect source water quality and to educate, engage, and involve members of upstream communities as well as its own residents. PWD's Source Water Protection Program objectives for Queen Lane, outlined in Section 6, relate to a series of initiatives and projects that are primarily led by PWD and its largest watershed partner, the Schuylkill Action Network (SAN).

In-city PWD projects that address priority sources of pathogens in Philadelphia fall into the categories of wastewater discharges/compliance, agricultural land use/runoff, animal vector control, and education and outreach. While some projects directly address known sources of *Cryptosporidium*, others act as preventive measures to address potential contaminative threats before they become a reality. Table 7-2 below outlines the in-city PWD projects. A brief description of each project follows Table 7-2.

Table 7-2 In-City Project Assessment

Vulnerability Addressed:		
Wastewater Discharges/Compliance		
Project	**Status**	**Primary Partners**
Cryptosporidium and Microbial Source Tracking Studies	ongoing	Lehigh University, Drexel University, PWD
Defective Lateral Detection and Abatement Program	completed; monitoring ongoing	PWD
Monoshone Assessment	completed; monitoring ongoing	PWD
Main and Shurs Elimination	ongoing	PWD
PWD's Combined Sewer Management Program	ongoing	PWD
PWD's Stormwater Management Program	ongoing	PWD
Early Warning System Reporting	completed; ongoing reporting/monitoring	PWD, DRBC, EWS subscribers (water utilities and industrial users)
Agricultural Land Use/Runoff		
Project	**Status**	**Primary Partners**
Northwestern Stables Manure Containment	completed	PWD, PADEP, USDA, Resource Conservation & Development Council, City of Philadelphia Public Properties
Belmont Stables	completed	PWD, PADEP, USDA, Resource Conservation & Development Council
Courtesy Stables Runoff Treatment Project	completed; additional streambank restoration ongoing	PWD, Friends of the Wissahickon (FOW), Fairmount Park, Natural Resources Conservation Service, Delaware Estuary Grant from National Fish & Wildlife Foundation
Monestary Stables Stormwater Diversion and Detention Project	completed	PWD, FOW, Fairmount Park, Boarders and Stewards of Monastery (BSM), Philadelphia Saddle Club (PSC)
W.B. Saul High School	completed	PWD, Fairmount Park, EPA, Philadelphia School District
Animal Vectors		
Project	**Status**	**Primary Partners**
Belmont Meadow Extension/Intake Project	completed	PWD, Fairmount Park, EPA, Drexel University, Philadelphia University, US Fish & Wildlife Service
Goose Control Programs	ongoing	PWD, USDA

Education/Outreach		
Project	**Status**	**Primary Partners**
Philly RiverCast	ongoing	PWD, EPA
Expanded Annual Water Quality Report	ongoing	PWD
Water Quality Council (formerly Citizens Advisory Council, CAC)	ongoing	PWD, PADEP, EPA, Philadelphia Horticultural Society (PHS), DRBC, PDE, School District of Philadelphia, Delaware Valley Regional Planning Commission (DVRPC), Drexel University, Schuylkill Navy, and other watershed organizations
Fairmount Park Partnership	ongoing	PWD, Fairmount Park
Fairmount Waterworks Interpretive Center (FWWIC)	ongoing	PWD, Fairmount Park, PDE, DRBC, PADEP, PEC, EPA, PA Department of Conservation and Natural Resources, and others listed at www.fairmountwaterworks.org
Dog Waste Control Program	ongoing	PWD, PDE

7.2.1 In-City Initiatives

7.2.1.1 Wastewater Discharge/Compliance

Cryptosporidium and Microbial Source Tracking Studies
Recent source tracking projects have improved PWD's understanding of both the sources and vectors of oocyst contamination throughout the watershed. These projects are led by Lehigh University, with PWD providing support in terms of sampling, elution and project management and oversight. See Section 5 for a detailed description of the Wissahickon Creek and Queen Lane *Cryptosporidium* source tracking studies.

Defective Lateral Detection and Abatement Program
Philadelphia's Defective Lateral Detection and Abatement program was developed under the City's initial Municipal Separate Storm Sewer System (MS4) permit signed in 1995 and further refined under a Consent Order & Agreement (COA) reached with the PADEP on June 30th, 1998. On March 18th, 2004, the COA was officially terminated. However, the City has remained faithful to the terms of the agreement and many of the COA requirements have now been incorporated into the City's new MS4 permit.

The Defective Lateral Detection and Abatement Program is comprised of several initiatives that aim to detect, investigate, and prevent illicit discharges. The prevention of illicit discharges is primarily achieved through sewer and lateral inspections. Investigative aspects of the program include ranking MS4 outfalls according to their priority for corrective actions, and investigating dry weather flows to identify sewer lateral defects. Outfalls are ranked using information from the City's stormwater outfall monitoring system, which is in compliance with the MS4 permit issued by PADEP. Outfalls identified as priority outfalls under the MS4 permit are sampled quarterly. The City also investigates all potential reports of illicit discharges from the stormwater system through either the Industrial Waste Unit or the Sewer Maintenance Unit. The success of the program's outfall investigation efforts is reflected in the number of abated cross connections; from FY 2005 to FY 2009, a total of 325 residential and 29 commercial cross connections were abated. Defective laterals that drain into the Schuylkill River include those identified at Monastery Avenue, Monoshone Creek, and Manayunk Canal, with 16, 92, and 59 abatements occurring at these locations, respectively. The identification and subsequent abatement of these cross connections has occurred as of June 30th, 2009 (PWD 2009b).

Monoshone Assessment
In conjunction with the Defective Lateral Detection and Abatement Program, in FY 2006 PWD conducted and completed an analysis of 82 defective lateral abatements and sewer relining work performed in the sewer-shed of outfall W-068-04/05, which discharges to the Monoshone Creek in the Wissahickon Creek watershed. The purpose of this analysis was to determine the water quality improvements achieved as a result of the abatement and relining work and to compare this improvement with the additional water quality benefits anticipated from the Saylor Grove Wetland BMP, also located in the Monoshone.

It was found that significant reductions were achieved in fecal coliform concentrations and loadings in outfall W-068-04/05 as a result of defective lateral abatements, sewer relining, and the Saylor Grove Stormwater Wetland BMP (PWD 2009b). Monitoring for fecal coliform concentrations currently occurs three times per month at outfall 5, mentioned above, and at Rittenhouse Town, a more downstream site on the Monoshone. PWD relays these monitoring results to the community through a quarterly Monoshone Creek water quality report. In addition to monitoring results, the update also includes information to raise public awareness of problems that contribute to pollution of the Monoshone Creek, including defective laterals.

Main and Shurs Elimination

The Main Interceptor Sewer, which is located along the Schuylkill River adjacent to the Manayunk Canal in the northwest section of Philadelphia, conveys sewage from collection systems which serve the northwest section of the City. During extreme wet weather events, the Main Interceptor Sewer exceeds its capacity and overflows occur at a relief point into a storm sewer upstream of stormwater outfall S-052-5. To abate the hydraulic overload conditions in the Main Interceptor Sewer, PWD has proposed construction of a 3 million gallon offline storage tank, which will capture and store excess flows, thereby eliminating surcharges and preventing overflow conditions at the relief point. The storage tank will accommodate SSO/CSOs that currently average approximately 10 million gallons of untreated wastewater each year and will return it to PWD's Southeast WWTP (PWD 2009b).

PWD's Wet Weather Management Programs

There are several initiatives and projects under Philadelphia's wet weather management programs, which consist of the combined sewer management program and the stormwater management program, that reflect PWD's commitment to maintaining and ensuring the adequacy of the City's sewer infrastructure. These programs fulfill the requirements of the City's CSO and Stormwater Permits. Although Philadelphia does not have any CSO outfalls upstream of the Queen Lane intake, the CSO management program's monitoring and maintenance procedures serve as sewerage-related control measures. The CSO Management measures occur both in the combined sewer areas and in the separate sewer areas of Philadelphia. Listed below are aspects of the CSO and Stormwater Management programs that are considered pertinent to this plan.

Combined Sewer Management Program

Sewer Assessment Program (SAP)

PWD has implemented a comprehensive sewer assessment program (SAP) to provide for continued inspection and maintenance of the collection system using closed circuit television (CCTV). The SAP program was developed by PWD and consultants and was finalized in March 2006. The SAP is one of the tools used to identify and remediate areas of infiltration and inflow (I & I) as well as guide the capital improvement program to ensure that the existing sewer systems are adequately maintained, rehabilitated, and reconstructed. Any infiltration that is observed during the on-going CCTV sewer inspection is categorized based on a range of 5 levels: Weepers, Drippers, Light Runners, Heavy Runners, or Gushers. All occurrences of Heavy Runners or Gushers are

immediately reported to PWD's Water Conveyance Leak Detection Unit for investigation.

Comprehensive Monitoring and Modeling Program
PWD maintains an extensive monitoring network through the combined sewer system, a majority of the separate sewer system, rain gauges, pump stations and connections from all adjacent outlying communities (PWD 2009b). The monitoring network in conjunction with the US EPA's Storm Water Management Model (SWMM) was used to develop a watershed-scale model for the PWD combined sewer system. The identification and quantification of rainfall dependent inflow/infiltration (RDII) into sanitary sewers contributing to the City of Philadelphia's service area is a key component of this program.

PWD also actively conducts infrastructure assessments to inventory and prioritize sewage infrastructure potentially affected by either infiltration or exfiltration through spatial data collection for all points that either hydraulically alter the flow of the creek or infrastructure points that are affected by stream migration. Corrective actions are taken when points of concern are identified (PWD 2009b).

Evaluation of the Collection System to Ensure Adequate Transport Capacity for Dry and Wet Weather Flow
System-wide hydrologic and hydraulic models have been developed in support of the City's Long Term Control Plan Update (LTCPU). Model evaluations have been performed to evaluate the system performance benefits of various system improvements. PWD has analyzed the utilization of in-system storage and storm flood relief through various in-City projects, and continues to evaluate the collection system to ensure adequate transport capacity for dry and wet weather flows (PWD 2009b).

Interceptor Relining
Planning and design is underway for relining several segments of interceptor within Philadelphia. Benefits of sewer relining include: decreased pollutant loads to surface water by decreased exfiltration; decreased flow in sewer system by decreased inflow/infiltration; and, increased efficiency of the sewer system (PWD 2009b).

Stormwater Program
Pollution Migration/Infiltration to the MS4 System
The Industrial Waste Unit (IWU) within PWD responds to all citizen complaints of liquid, solid, or gaseous pollutants within Philadelphia, and continues to be the lead organization for inspecting and enforcing pollution discharges to the separate storm sewer system (PWD 2009b). The IWU coordinates with neighboring communities in the event that a pollutant may drain into the Philadelphia MS4 system. Using a variety of pollution sensing, testing, and removal techniques, the IWU mitigates the impacts of spills to the MS4 system, combined system, and receiving waters.

Sanitary Infiltration Controls
Investigate, Remediate and Report Sanitary Infiltration
As part of the City's Stormwater Permit, PWD employs interventions that prevent the degradation of surface and groundwater by the inadequate treatment of sewage or site runoff, provides oversight for the construction and operation of individual On-Lot Sewage Disposal Systems (OLDS), and provides an immediate response to all reports of unintentional spills, to prevent their entrance into surface or ground water. Inspection, education and consultative services as well as review of citizen reports of degraded water quality issues will be managed (PWD 2009b).

In addition, the Collector System within PWD maintains and manages a database called the Sewage Pollution Incident & Location Log (SPILL) which reports information about unintentional sanitary discharges including date reported, problem location, spill type, description, and abatement date.

Inspection and Remediation of on-lot septic/disposal systems
The On-Lot Sewage Disposal System program allows for the supervision of the design and installation of new systems to prevent sewage from being discharged onto the ground and also entails the identification, evaluation, and recommendation of remedial actions where available to homeowners with malfunctioning systems. This program also enables permitting and monitoring of storage tanks and portable toilets. A liaison is maintained with the PADEP, PWD and City Planning Commission concerning the prevalence of malfunctions within certain geographical areas in the City. An extension of the municipal sewerage system is recommended to PWD for those areas where homes are experiencing malfunctions and no practical means are available for their correction (PWD 2009b).

The Source Water Protection program's 2009 Water Budget Report estimates that the total discharge to septic systems in the Schuylkill River watershed, which is the summation of the public water supply discharge to septic systems and the private domestic supply discharge to septic systems, is approximately 17.4 MGD. A majority of the daily discharge to septic systems, 15.6 MGD, is from private domestic supply (PWD 2009c).

Early Warning System
The Early Warning System (EWS) is a web and telephone system that facilitates communication among water suppliers and industrial intakes about spills and other incidents in the Schuylkill and lower Delaware watersheds. Recent enhancements to the system include the following:

- integrating industrial users with intakes into the EWS partnership and designing an industrial user fee based on withdrawal and position in the watershed;
- adding the City of Philadelphia Office of Emergency Management (OEM) as an EWS member as part of a pilot expansion of the EWS partnership to include county OEMs;

- creating the Spill Model Analysis Tool, which allows users to test the travel time of a spill without generating an event that notifies other users. This effort included incorporating the National Hydrologic Data stream network into all EWS mapping functionality, resulting in more accurate calculations of spill paths and travel times;
- creating a simplified report, making it easier for users to supply hazard information;
- adding a confidentiality disclaimer to all emails generated by the EWS; and,
- adding telephone testing to existing administrator tools and allowing users to subscribe or unsubscribe to telephone notifications generated by test events.

In addition to the above changes, there are two additional projects on the EWS development agenda. One project would support the development of a tidal spill model for the Delaware River, the other would support the programming changes required to switch the EWS GIS infrastructure to ESRI ArcGIS (PWD 2009b).

The system's recent enhancements have strengthened its power as a communication tool for various types of incidents, which can be categorized as sewage, oil, chemical, black fly spray, flood/reservoir, or other. Of the 173 original incidents (not including updated and duplicate reports) reported from January 2005 to February 2010, 38, or approximately 22%, of the reports were sewage-related. Sewage events represented the largest category. Reported incidents included raw sewage discharges resulting from force main ruptures, WWTP malfunctions, and SSOs. Approximately 20 SSO events were reported during this time frame. PWD continues to encourage the reporting of these events so as to provide downstream intakes with the information necessary to gauge appropriate response measures.

7.2.1.2 Agricultural Land Use/Runoff

Northwestern Stables

At Northwestern Stables in Fairmount Park, an uncontained manure pile was located behind the barn, contributing manure-laden stormwater runoff to the nearby Wissahickon Creek. The contaminated runoff was addressed through construction of a reinforced concrete manure containment pad; installation of bollards to protect the concrete walls and barn; excavation of a basin and drainage swale to capture any runoff from the containment pad; and, construction of roll curbing and a 10-foot infiltration trench. The containment facility now confines the manure pile to a small area, and prevents nutrients and pathogens from entering the Wissahickon Creek. Roll curbing and an infiltration trench capture and divert runoff that would formerly have flowed into the barn.

Belmont Stables

A manure storage area beside the barn at Belmont Stables in Fairmount Park was contributing manure-laden stormwater runoff directly into a tributary of the Schuylkill River. Stormwater was also forming a large puddle in the parking area behind the barn. These problems were addressed through construction of a reinforced concrete manure containment pad; installation of bollards to protect the concrete walls; excavation of a basin and diversion swale; and construction of a protective post and rail fence around

the basin. The containment facility confines the manure pile to a small area and prevents nutrients and pathogens from entering the Schuylkill River. The diversion swale and basin capture, divert, and infiltrate storm flows that would have otherwise formed a puddle in the parking lot.

Courtesy Stables Runoff Treatment Project
This project's aim was to correct a suite of problems contributing to contaminated stormwater that flows from the barnyard at Courtesy Stables through an adjacent wetland and into a tributary of the Wissahickon Creek. Stormwater was rerouted from the barnyard and surrounding area into a grassed waterway/filter strip where nutrients and sediment are now removed and a portion of the water is infiltrated into the ground before reaching the wetland. Flow from a springhouse was rerouted directly to the wetland, serving as a continuous source of clean water, rather than through the riding ring, where it adsorbs nutrients and creates muddy conditions. Invasive plant species onsite were removed and replaced with Philadelphia-native trees and shrubs and educational signage was erected, linking the nutrient runoff reduction to the improvement of the Delaware Estuary.

Monastery Stables Stormwater Diversion and Detention Project
PWD partnered with the City's Department of Parks and Recreation, previously known as the Fairmount Park Commission (FPC), to address stormwater and agricultural runoff at this FPC property along the Wissahickon Creek. Lack of proper stormwater management controls, a sloping topography towards the bordering creek, and the intensity of horse activity on the site make Monastery Stables a source of contamination to the Wissahickon watershed. Before implementation, rainfall collected in the paddocks and discharged toward the Wissahickon Creek through several eroded gullies, carrying sediment, nutrients, and harmful pathogens. The project introduced stormwater management controls, including subsurface storage tanks and vegetated swales to increase stormwater infiltration and direct and treat stormwater runoff, thereby reducing sediment, nutrient, and harmful pathogen loadings to the Wissahickon Creek.

W.B. Saul High School
In FY 2004, PWD utilized a PADEP Growing Greener Technical Assistance Grant to complete a conceptual design to implement stormwater BMPs at this Agricultural High School in the Wissahickon watershed. The W.B. Saul High School project combines urban stormwater and agricultural BMPs to reduce the harmful impact of the school's runoff on the water quality of the Wissahickon Creek. Prior to discharging into the storm sewer, which then flows to the Wissahickon, agricultural runoff from the livestock and farming practices, as well as stormwater runoff from the school's roofs and parking lots, is now captured and treated through a series of long pools connected by wetland swales. This project also adds an educational component to the curriculum of Saul High School, already one of the nation's premier agricultural high schools, by demonstrating proper management of agricultural runoff.

7.2.1.3 Animal Vectors

Belmont Meadow Extension/Intake Project

PWD's Belmont intake is located on the Schuylkill River downstream from several parking lots in Fairmount Park. The parking lots have historically been places where humans feed the large population of non-migratory Canada Geese. Consequently, the stretch of riverside parkland has been severely eroded and Belmont's source water quality negatively impacted by the presence of these geese.

The goal of the Belmont Meadow Project, which took place in two phases, was to deter non-native Canada geese from dwelling and feeding around the Belmont intake. This was achieved by installing fencing along Peter's Island, installing educational signage, and planting trees, shrubs, and two meadows. The new plantings create an inhospitable environment by obstructing the sight of the geese and increasing their fear of predators, while also serving as a buffer zone to filter polluted runoff from the parking area. The project began in 1999 with the implementation of the Phase I meadow, and was completed in 2004 with the Phase II extension meadow.

Results from the project indicate significant reductions in the number and impact of geese on land and water quality near the intake. The average number of geese observed in Project Area I, or the Phase I area, has been reduced by 97%, from 17 to less than one goose per site visit. Project area II has resulted in goose populations decreasing from 35 per visit in 2000 to less than five per visit in 2005, indicating a reduction of 88%. It has been estimated that each year, 25 tons of goose manure are diverted from the immediate park area above the intake as a result of Phase I and Phase II, reducing the threat of *Cryptosporidium* contamination in the Schuylkill River. Educational signs have also successfully reduced feeding and encouraged the relocation of the local goose population to downstream of the intake. Approximately $35,000 in capital funds have been invested in the Belmont Goose Project to achieve the present fecal removal rate. At this time, there remains a need to address the goose nesting problem on Peter's Island, where the fencing proved to be ineffective (PWD 2007).

Goose Control Programs

PWD has entered into a contract with the USDA's Animal and Plant Health Inspection Services (APHIS) to implement an integrated waterfowl management program to reduce and prevent damages caused by Canada geese to PWD's drinking water treatment and wastewater treatment plants. The program includes the components listed below (USDA 2009).

- The USDA's Wildlife Services (WS) will provide oversight and instructional assistance in the application of visual and audible deterrents and chemical repellents and the implementation of habitat modification and exclusion measures.
- PWD will institute a no feeding of wildlife policy and actively enforce the policy.
- APHIS WS will conduct treatment of nests and eggs of Canada geese at approximately 7-10 day intervals for the 8 week nesting season. Nests and

eggs will be collected and disposed of following the 28-30 day incubation period.
- WS will conduct non-lethal waterfowl harassment (i.e., visual deterrents, use of lasers, chasing with remote controlled vehicles, pyrotechnics, recorded distress calls, etc.) at PWD facilities when deemed necessary.
- WS may conduct Canada goose round-ups at PWD where deemed necessary by WS and provided for through permitting of the PA Game Commission. PWD will be responsible for providing documented proof that a direct threat to human health and safety exists on PWD facilities where roundups are requested. Should the round-ups take place, Canada geese will be humanely captured, euthanized, and processed for human consumption.
- WS will be available to provide pyrotechnics training to PWD staff, enabling them to conduct harassment during other times when WS is not onsite.
- WS will review landscaping/habitat modification plans at the request of PWD to ensure that long-term habitat modifications are appropriate for an integrated waterfowl damage management program.

The egg addling and non-lethal harassment techniques described above were implemented at several plants in the Spring of 2010; the lethal round-up technique is still under consideration. PWD's overarching goal is to have the USDA program implemented at the Queen Lane , Belmont and Baxter DWTPs, as well as PWD's three WWTPs, for not only geese, but also deer and groundhogs (J. D'Agostino, personal communication, January 4, 2010).

7.2.1.4 Education/Outreach

The in-city Education and Outreach components of PWD's source water protection program serve several main objectives:

- communicating the risk of pathogen ingestion to all customers, particularly those most vulnerable from a health perspective, and explaining how to decrease potential exposure to *Cryptosporidium*;
- communicating PWD's research and implementation of watershed protection strategies to better understand and mitigate the threat of *Cryptosporidium* contamination; and,
- promoting public awareness and engaging support for source water protection measures that can be practiced on various scales, including on an individual basis.

Although Philadelphia is able to fulfill these objectives within the City, PWD's upstream partners enable the City to fulfill the same objectives on a watershed-wide scale. Consequently, building relationships with upstream partners to ensure that source water protection measures are implemented throughout the Schuylkill River watershed is an imperative aspect of PWD's education and outreach efforts. Specific watershed partners will be discussed in the watershed-wide project assessment. The following initiatives occur within Philadelphia and support one or more of PWD's education and outreach goals.

Philly RiverCast
RiverCast is the first operable web-based recreational warning system in the United States. Using real-time flow, precipitation, and turbidity data, RiverCast predicts bacteria levels within a section of the Schuylkill River heavily used by the public for swimming, rowing and boating. RiverCast translates the predicted bacteria levels into one of three ratings, each of which corresponds to suggested guidelines for recreation. High bacteria levels, for example, translate to a "red" rating, in which RiverCast advises against any direct or indirect contact with the river. More than 300,000 users have visited RiverCast since it became operable in June 2005 (PWD 2010). The site, which can be accessed at www.phillyrivercast.org, enables PWD to promote public awareness of water quality concerns and indirectly engages support for source water protection measures.

Expanded Annual Water Quality Report
PWD publishes an annual drinking water quality report. The report is mailed to every city resident and contains a wealth of information regarding the source, safety and contents of the City's drinking water. Annual water quality reports, or consumer confidence reports, are mandated by the 1996 Safe Drinking Water Act amendments. According to the EPA, the information contained in a water quality report should raise consumers' awareness of their drinking water sources, describe the process by which safe drinking water is delivered to their homes on a daily basis, and educate consumers about the importance of source water protection measures to protect their drinking water supply (US EPA 2010b).

PWD's annual water quality report is a comprehensive document that includes an educational statement for vulnerable populations about avoiding *Cryptosporidium*, and details the monitoring and research work that PWD has undertaken to ensure a safe drinking water supply. The report also outlines numerous other source water protection efforts, including PWD's collaboration with upstream communities and the state of PA to ensure regulations are enforced at wastewater treatment plants; management of the Early Warning System (EWS); and implementation of the City's goose control measures. Consumers are also made aware of actions they can take to help protect source water, such as conserving water, keeping trash out of storm drains, and avoiding feeding geese and other wildlife, especially near waterways. Information concerning PWD's Source Water Assessment and Source Water Protection Plan is also provided in the report, which is available year-round at the City's website, www.phila.gov. Because the water quality report is distributed throughout the entire City of Philadelphia, it is an ideal document for communicating the risks associated with *Cryptosporidium* contamination and PWD's efforts to reduce these risks.

Water Quality Council (formerly Citizens Advisory Council)
In 2001, the Water Quality Citizens Advisory Council (CAC) was formed by a merger of the Stormwater and the Drinking Water Quality CACs. Over the past few years, source water protection has become a primary concern for maintaining drinking water quality. The Drinking Water CACs focus has been drawn naturally toward non-point source pollution, a focus traditionally undertaken by the Stormwater CAC. The merger of the two CACs into what is now referred to as the Water Quality Council complements the

new, holistic approach to water quality issues adopted by PWD, PADEP and the EPA. The Partnership for the Delaware Estuary (PDE) currently facilitates the Water Quality Council committee meetings (PWD 2009b). Moving forward, PWD will seek feedback from this committee to help strengthen its LT2 Watershed Control Plan.

Fairmount Park Partnership

Fairmount Park is located throughout Philadelphia. The city park system consists of 9,200 acres with 77 primary parks ranging in size from one acre to more than 1,600 acres. The park system protects the streams and rivers that supply Philadelphia's drinking water. Fairmount Park's mission is to:

- preserve, protect, and maintain the open space, street trees, and natural and cultural resources of Philadelphia's parks for the recreation and enjoyment of residents and visitors;
- educate the public on the environment, history, and use of the Fairmount Park system; and,
- promote, celebrate, and enhance the uniqueness and value of the Fairmount Park system and its economic impact on the City, region, and state.

The Department of Parks and Recreation, previously known as the Fairmount Park Commission (FPC), and PWD initiated a partnership in 2003 to improve the environmental quality of the City's parks and streams. Through this partnership, Parks and Recreation assumed responsibility for more than 200 acres of land dedicated to the City for stormwater management purposes. The land is used to further the vision of developing "watershed parks," creating natural connections between neighborhoods and existing park areas. In exchange, PWD fields the Waterways Restoration Team (WRT), a crew dedicated to removing large trash—cars, shopping carts, and other short dumped debris—from the 100 miles of stream systems that define City neighborhoods. This crew is also restoring eroded streambanks and streambeds around outfall pipes and removing sanitary debris at these outfalls. WRT works in partnership with the Parks and Recreation staff and various Friends of the Parks groups to maximize resources and positive impacts to communities. This partnership focuses on the core strengths of both agencies. Parks and Recreation continues to improve landscape management of the City's parks and dedicated lands, while PWD focuses its efforts on water quality improvements, a mandate it has under its state and federal water quality related permits. Examples of stormwater management projects, such as sediment control projects and gully repair projects resulting from the partnership are located at various park sites: Lloyd Hall, Wissahickon Environmental Center, Concourse Lake, Centennial and Japanese House, Edgewood Lake/FDR Park, Blue Bell Meadow to Rittenhouse Town, Walnut Lane Path, Hartwell Lane and Cherokee Street, and Southern Tacony (Boulevard to Juniata Park).

In furthering the integral connections and responsibilities between Fairmount Park and PWD, the two entities entered into a memorandum of understanding (MOU) in 2008 to enable PWD to pursue its Clean Water Act obligations and to cooperate fully with Fairmount Park in accordance with their shared environmental and community values.

Fairmount Water Works Interpretive Center (FWWIC)
The FWWIC is PWD's renowned education center, located on the banks of the Schuylkill River in Philadelphia. The mission of the center is to "educate citizens to understand their community and environment, especially the urban watershed, know how to guide the community and environment in the future, and understand the connections between daily life and the natural environment." "Water in our World" is the theme that unites the innovative exhibits and interactive educational programs at the Fairmount Water Works. These exhibits and programs meld the history, technology and science of providing water to a regional urban watershed, while illustrating the impacts of human actions on our water supply. The center is able to emphasize the importance of source water protection through hands-on learning and various school and life-long learning programs. The center's exhibits serve the entire Philadelphia region, and the Interpretive Center has been recognized by the PADEP as the Delaware River Basin's official Watershed Education Center (PWD 2009b).

Dog Waste Control Program
Through a pilot project in Delaware, the Partnership for the Delaware Estuary (PDE) found that most dog owners are completely unaware of the connection of dog waste to water pollution. A similar project has been initiated by PWD, where 5,000 "Bags on Board" and educational tip cards were produced and purchased for distribution at the Fairmount Water Works Interpretive Center (FWWIC) and various public events in 2007. "Bags on Board" is a roll of 15 dog-waste collection bags that conveniently clips onto a dog leash. The educational tip card not only explains the effects of dog waste on local waterways, but also provides a list of other daily actions that can be modified slightly to reduce stormwater runoff pollution (PWD 2009b).

In addition, PWD has included a section dealing with pet waste in the *Homeowner's Guide to Stormwater Management.* The guide details how pet waste can negatively affect our waterways and what pet owners can do to clean up and dispose of the waste. PWD has estimated that approximately 10,000 guides have been distributed to date.

7.2.2. Watershed-Wide Initiatives

In addition to PWD's extensive list of in-city projects, Philadelphia has been involved in numerous other projects and initiatives elsewhere in the Schuylkill River watershed. The Schuylkill Action Network (SAN) is a particularly important partner in PWD's watershed control plan approach to reducing *Cryptosporidium* at Queen Lane. SAN's mission, as stated on the partnership's website, www.schuylkillwaters.org, is to improve the water resources of the Schuylkill River watershed by working with state agencies, local watershed organizations, businesses, academics, water suppliers, local and state governments, regional agencies, and the federal government to transcend regulatory and jurisdictional boundaries in the strategic implementation of protection measures. The SAN seeks to achieve this mission through the objectives listed below.

- Support existing efforts and implement actions to restore and protect water quality in the Schuylkill River watershed.

- Promote the long-term coordinated stewardship and restoration of the watershed and educate others regarding their roles in protecting the watershed and water supplies.
- Transfer the experience and lessons learned to other communities.
- Enhance intergovernmental communication and coordination by working together on the identification and resolution of environmental issues with shared regulatory responsibility.

SAN's objectives are achieved through several workgroups consisting of a collaboration of stakeholders, including federal and state agencies, water suppliers, local officials, conservation districts, community members, academics and industries (SAN 2008). PWD continues to be an active participant in each workgroup, helping to address water quality issues of high concern in the watershed. The following list outlines the general, overarching goal of each SAN workgroup.

Abandoned Mine Drainage Workgroup
Goal: To maximize reduction and/or treatment of abandoned mine drainage (AMD). AMD is the leading cause of pollution in the Schuylkill River headwaters, producing metal-laden and sometimes highly acidic discharges in telltale orange and silver plumes, easily visible in the surface waters. Acidity and metals interfere with vegetative growth, aquatic life, and both ground and surface drinking water resources.

Agriculture Workgroup
Goal: To maximize reduction and/or prevention of agricultural impacts to water quality. According to a federal report, agricultural runoff is now considered the primary source of pollutants in streams and rivers in the U.S. Approximately 37% of land use in the Schuylkill Watershed is agricultural, and 258 miles of streams are considered agriculture-impaired.

Education and Outreach Workgroup
Goal: To improve public support for watershed protection actions. SAN believes that an educated public can be the most valuable resource tool in restoring the health of an entire watershed. Ideally, education efforts foster an appreciation and awareness of local water resources, inspiring stewardship and meaningful changes in daily actions.

Pathogens/Compliance Workgroup
Goal: To prevent drinking water related outbreaks of gastrointestinal illness by improving NPDES compliance and reducing discharges from un-sewered communities.

Storm Water Workgroup
Goal: To maximize reduction and/or prevention of stormwater runoff pollution. Stormwater runoff contains chemicals, fertilizers, pesticides, bacteria, road salt, engine fluids, eroded soils, and debris, and creates 30% of all water quality impairments in the Schuylkill watershed.

Watershed Land Protection Workgroup
Goal: To promote a sustainable landscape in the Schuylkill River watershed through strategic conservation and efficient land resource use to protect the integrity of water supplies for future generations.

In addition to partnering with SAN, PWD is actively involved in a number of Schuylkill River watershed partnerships, including the Wissahickon Watershed Partnership. The implications of land use in the Wissahickon watershed and the creek's impacts on water quality at Queen Lane have already been established. The Wissahickon Watershed Partnership was convened in 2005 for the purpose of guiding the development of a watershed-wide Integrated Management Plan (IWMP). The partnership has accomplished a significant amount in the watershed, but the opportunity exists to more closely align partnership work with drinking water protection efforts related to LT2 compliance. A more detailed description of the Wissahickon Watershed Partnership is provided later in this section.

The Schuylkill Watershed Initiative Grant (SWIG) and Other Funding Sources for Watershed Projects
Partnerships such as SAN enable PWD to facilitate implementation of projects upstream of Queen Lane and outside Philadelphia's jurisdictional boundaries. Project implementation is only feasible, however, when the partnerships are able to secure adequate funding. A large number of SAN initiatives were implemented with funding from the US EPA's Targeted Watershed Initiative Program. This EPA program seeks to demonstrate how water pollution can be managed on a watershed basis through the use of studies, demonstrations, and education/outreach activities. PWD received a $1.15 million grant, the Schuylkill River Watershed Initiative Targeted Watershed Grant (SWIG), in 2005 as part of this program. The funding enabled PWD and the Partnership for the Delaware Estuary (PDE) to initiate more than 40 individual projects to improve water quality in the Schuylkill River. From 2005 to 2008, PDE and PWD worked with more than a dozen partners to complete seven suites of projects that address the issues from each major SAN workgroup: abandoned mine drainage, agricultural runoff, stormwater runoff, and education of key constituents and audiences.

In addition to the SWIG, PWD and its partners have received funding for project implementation from several other sources, which include the following: EPA, Pennsylvania's Growing Greener program, Exelon and the Schuylkill River Restoration Fund, and the William Penn Foundation. Funds for agricultural projects have also been leveraged from other agencies, including Berks County Conservation (BCC) and the National Resources Conservation Service (NRCS).

NRCS funding in the Schuylkill River watershed is provided through conservation programs under the 2008 Farm Bill, which builds on the conservation gains made in the 1985, 1996 and 2002 Farm Bills. Two specific NRCS programs, the Environmental Quality Incentives Program (EQIP) and the Conservation Reserve Program (CRP), have already funded several projects in the Schuylkill River watershed. These programs address issues related to cropland conservation, water quality improvement and wildlife

management. The water quality improvement goals of the EQIP program, for example, are focused on reducing non-point source pollution, including nutrients, sediment and pesticides, as well as reducing point source pollution, such as contamination from animal feeding operations (PA NRCS 2010). Agricultural BMP projects funded under these programs may include livestock exclusion, riparian buffers, streambank protection and manure containment structures. Many of the BMPs that are funded to improve water quality also serve as drinking water protection control measures that will simultaneously reduce pathogen contamination. Projects funded under these programs serve many benefits, and present the opportunity for drinking water protection to become a high priority issue for funding allocation.

Table 7-3 below provides an inventory of projects that PWD has partnered on in the Schuylkill River watershed, with funding provided by a combination of the sources described above. The projects, which all address pathogen contamination, fall under the categories of Wastewater Discharges/Compliance, Agricultural Land Use/Runoff and Education/Outreach. A brief description of each project is provided below Table 7-3.

Table 7-3 Watershed-wide Project Assessment

Vulnerability Addressed:		
Wastewater Discharges/Compliance		
Project	**Status**	**Primary Partners**
Infectivity/Viability Study	completed	PWD, Clancy Environmental
Sewage Facilities Self-Assessment Program	ongoing	PWD, SAN, EPA, municipalities
Early Warning System Reporting	ongoing	PWD, DRBC, EWS subscribers (water utilities and industrial users)
Act 537 Planning Workshops	ongoing	PADEP, SAN, EPA, municipalities
Schuylkill River Water Quantity Analysis	completed	PWD
Identification and Abatement of Wildcat Sewers	ongoing	SAN
Agricultural Land Use/Runoff		
Project	**Status**	**Primary Partners**
Conservation Plans	completed	SAN, Berks County Conservation District
Parcel Prioritization, Riparian Buffer Planting, Streambank Fencing & Cattle Crossings	completed; upkeep ongoing	SAN, Berks County Conservation District (BCCD), USDA, farming community, Berks County Conservancy (BCC)
Education/Outreach		
Project	**Status**	**Primary Partners**
Farm Awards and Certification	completed	SAN, Penn State Cooperative Extension
Environmental Advisory Councils (EACs)	ongoing	PWD, Pennsylvania Environmental Council (PEC), municipalities, League of Women Voters, EPA Region 3, PADEP, SAN, Partnership for the Delaware Estuary (PDE)
SAN Website	ongoing	SAN, Partnership for the Delaware Estuary
SAN Pathogens Workgroup	ongoing	PADEP, EPA, PWD
SAN Agricultural Workgroup	ongoing	PWD, PADEP, EPA, BCCD, BCC
Schuylkill Restoration Fund	ongoing	Schuylkill River Heritage Area, PDE, Exelon, DRBC, EPA, PADEP

Wissahickon Watershed Partnership	ongoing	PWD, PADEP, Wissahickon Valley Watershed Association (WVWA), PEC, Friends of Wissahickon, various townships
Partnership for the Delaware Estuary	ongoing	PDE, PWD, additional partners listed at www.delawareestuary.org
Golf Course Certification Program	completed	PWD, SAN, Audobon International, representatives from participating golf courses in the watershed

7.2.2.1 Wastewater Discharges/Compliance

Infectivity/Viability Study

In 2004, PWD undertook a study to evaluate the potential effectiveness of ultraviolet light disinfection to inactivate *Cryptosporidium* in wastewater. Influent and effluent samples following UV treatment were collected on a monthly basis at the Abington WWTP from February to June 2004. Samples for *Cryptosporidium* were sent to Clancy Environmental for processing and analysis.

Results from the study do not provide adequate evidence of the correlation between UV disinfection and oocyst inactivation. The study's inconclusive results indicate the need to perform additional monitoring at WWTPs upstream of the Queen Lane intake. In regard to the efficacy of UV disinfection, peer-reviewed literature establishes a concrete correlation between UV disinfection doses and *Cryptosporidium* inactivation (Crockett 2007). The benefits of UV disinfection justify future development of strategies to upgrade upstream WWTPs with UV machines.

Sewage Facilities Self-Assessment Program

EPA led this project through the SAN Pathogens/Compliance Workgroup to identify municipal dischargers for a voluntary capacity management self assessment project. Dischargers were provided with a self assessment form to answer questions about their facility regarding sewer collection capacity, maintenance, operation, and management. The assessment took place on a sub-watershed basis, and the Pathogens/Compliance Workgroup used the results to obtain a better understanding of how sewage facility operations impact the water quality of the Schuylkill River (PWD 2006).

Early Warning System (EWS)

For a description of PWD's Delaware Valley Early Warning System, please see page 56 of this plan.

Act 537 Planning Workshop

The SAN Pathogens/Compliance Workgroup will consult with PA's Act 537 planning program to understand issues surrounding failing septic systems and where to target the promotion of federal voluntary management programs for on-site and decentralized wastewater treatment systems (septic situations) to implement an educational program throughout the watershed. The workgroup will also host a series of workshops on the sewage management program, which will discuss the benefits of implementing a

sewage management program, funding and financing of sewage systems, and lessons learned from local officials actively implementing management programs (PWD 2006).

Schuylkill River Water Quantity Analysis
The Schuylkill River Water Quantity Analysis is a continuation of the Source Water Assessment and Protection Planning processes. The analysis specifically focuses on the factors that influence the water budget of the Schuylkill River (PWD 2009c). The project's aim is to identify the sustainable yield of the Schuylkill River as a drinking water source to the Queen Lane and Belmont WTPs. Schuylkill River water quantity is examined by calculating water budgets using multiple methods and analyzing how the results inform Philadelphia water supply sustainability and regional water resource management. This analysis will identify how, where, and in what amounts water is used throughout the watershed. The study also identifies periods of low flow when the percentage of flow comprised of WWTP discharge is more than 50%. Due to the downstream location of Philadelphia, it is critical that PWD can relate how water is used upstream to the amount of water needed for Philadelphia drinking water, industries and assimilative capacity.

The analysis indicates the degree to which WWTP effluent can affect Philadelphia's source waters based on the percentage of flow comprised of WWTP discharge. This is an important consideration when implementing LT2 control measures, since WWTP effluent has been identified as a high-priority source of *Cryptosporidium*.

Identification and Abatement of Wildcat Sewers
SAN's Pathogen/Compliance Workgroup has led efforts to identify and abate wildcat sewers within the Schuylkill River watershed, a large number of which are located in Schuylkill County. A wildcat sewer system collects wastewater but has no treatment facilities. The raw sewage is discharged into streams or abandoned mine areas. As a result of the partnership's efforts, 29 wildcat sewers have been successfully abated to date.

7.2.2.2 Agricultural Land Use/Runoff

Conservation Plans
The Berks County Conservation District (BCCD) and the SAN Agriculture Workgroup partnered on an initiative to draft 44 conservation plans at cooperating farms in the watershed. Conservation plans identify strategies for proper manure management, identify optimized use of fertilizer and prevention of farm erosion and runoff to streams, and allow farms to become eligible for Federal funding to implement the tenets outlined in the plan. Using the results of a farm prioritization process, farms were targeted for conservation planning assistance from the BCCD, with the goal of following up with the installations of BMPs by the Berks County Conservancy (BCC).

The SWIG conservation planning process included coordination with the BCC on initial outreach to farmers and development of a Conservation and/or Nutrient Management Plan by a qualified technical service provider, with assistance, oversight and approval by the BCCD. A nutrient management plan, as defined by the NRCS, documents the strategies and practices utilized by livestock operations to address natural resource

concerns related to soil erosion, livestock manure and disposal of organic by-products (PA NRCS 2010). As part of the planning process, BCCD completed several activities, including those listed below.

- Led the cooperation of agencies/organizations through the SAN Agriculture Workgroup for priority farmer contact.
- Developed a landowner information packet for dissemination to priority farms with potential interest in BMPs.
- Developed an agreement with the Reading Area Water Authority (RAWA) to provide participant farms with invasive removal assistance in fenced buffer areas and worked with RAWA to train staff on proper removal of invasive plants on BMP project farms.
- Provided planning/design consultation to the BCC for fencing, animal crossings, and buffer plantings on AG-2 project farms.
- Met with RAWA to submit grant request for Growing Greener funds to develop an Integrated Source Water Protection plan for the Maiden Creek/Lake Ontelaunee watershed and surrounding areas.

The BCCD, through the combination of SWIG and Growing Greener funds, was able to complete a total of 44 plans for farms in the Schuylkill River watershed, covering more than 3,000 acres and including 37 conservation plans, 2 nutrient management plans and 5 combination conservation and nutrient management plans.

Parcel Prioritization, Riparian Buffer Planting, Streambank Fencing, & Cattle Crossings
This project was designed as a two-phase study to examine the effectiveness of a coordinated prioritization approach to directing the implementation of a series of agricultural BMPs. The first phase was for the SAN Workgroup to establish a set of criteria and weightings that, when entered into a complex formula generated by EVAMIX software, determined the highest priority farms in the Schuylkill watershed (i.e., farms contributing most to agriculture impairments). The second phase was for primary partners to conduct outreach to farms and install BMPs, including stream bank fencing, cattle crossings, and riparian buffers at 15 of the highest priority farms determined during the parcel prioritization process. The highest priority farms are located on three clusters in two sub-watersheds: Lower Maiden Creek and Upper Maiden Creek (SWIG 2009).

As a result of the parcel prioritization process, BMPs were installed on 19 farms in the watershed, including three major clusters (Seidel, Hill, and Adams farms), where upstream and downstream monitoring data was collected (SWIG 2009). BMP implementation was possible on four additional farms from the original 15 highest priority due to the availability of additional SWIG funding. The 19 farms with BMPs are detailed below in Table 7-4.

Table 7-4 Summary of SWIG Agricultural BMPs, 2005-2009

Farm	Farm Acreage	Acreage Fenced	Fencing (ft)	Stream Length Restored (ft)	Trees	Shrubs	Crossings
R. Seidel	78.6	1	1956	978	109	185	2
C. Seidel (2)	121.2	6.7	8746	4373	184	335	4
D. Woolf	53	2.1	4017	2008	95	178	2
Adam	105.8	10.1	5270	2635	560	0	5
Dreibelbis	177	82	1465	835	-	-	1
B. Hill	44.8	0.4	653	326	10	0	1
J.Hill	26.1	0.5	852	426	36	0	1
Junge	174	1	1534	767	90	0	1
Epting	30.2	1.0	1978	1030	6	0	3
Atkinson	77.7	2.0	2685	1095	36	24	2
Derstine	200.9	-	-	300	25	0	0
Lesher	126.4	3.9	2045	125	-	-	1
Luft	203.5	3.3	1656	750	60	0	1
Schroeder	138.3	5.6	3350	3350	140	0	3
Rabenold	209.6	1.3	3012	1506	0	0	2
Smith	92.6	2.9	4478	2239	0	0	3
Guntz	126.1	10	3210	2240	16	0	2
Hoch	183.3	0	0	2150	0	0	0

Source: The Schuylkill River Watershed Initiative Targeted Watershed Grant Final Report, 2009

Figure 7-1 below illustrates modifications made at the Seidel Farm through stream bank fencing and planting.

Figure 7-1 Seidel Farm Stream Bank Fencing Project
Left, 2004 before stream bank fencing; and right, 2006 after stream bank fencing

In order to begin gauging the success of the SAN agricultural BMPs, water quality, biological and visual monitoring assessments were performed at the three project location clusters: Adams, Hill, and Seidel Farms. At each farm parcel location, benthic/habitat monitoring and dry weather chemical monitoring were performed above and below each parcel, and each parcel was visually assessed both pre- and post-implementation (SWIG 2009). Monitoring was performed for the following water quality parameters: TSS, nitrate, nitrite, ammonia, total nitrogen, total phosphorus, conductivity, pH, temperature, and fecal coliform. Due to the relatively short time frame between project implementation (some projects were completed as recently as fall 2008) and chemical sampling, the water quality data collected were insufficient to demonstrate any water quality changes resulting from BMP implementation. However, to preliminarily gauge the success of the BMPs, expected loading reductions were modeled for sediment, total phosphorus, and total nitrogen. For example, at Adams Farm, Hill Farm, and the Seidel Farm, sediment loadings were estimated to be reduced by 132 tons/year, 47 tons/year, and 181 tons/year, respectively, through the implementation of riparian buffers.

In addition to the agricultural BMPs listed in Table 7-4 above, SAN and the Schuylkill River Restoration Fund reported additional agricultural BMPs in the Schuylkill River watershed. The project sites and corresponding agricultural work are listed in Table 7-5 below.

Table 7-5 Additional Schuylkill River Restoration Fund Agriculture Projects

Farm	Location	Status	BMP Work Completed or In Progress
Shaak Farm	Mill Creek	In Progress	channel restoration, bank stabilization, riparian buffer plantings, cattle crossings, and 2, 500 ft. of stream bank fencing
Deitrich Farm	Maiden Creek	Completed	150 ft grass diversion, 5,000 ft streambank fencing, 150 ft of gutters and spouting, 5,000 sq. ft. of concrete heavy use barnyard area, 5,000 ft of animal walkways, 2 stream crossings, and 300 ft. underground storm outlet
Kutztown Borough Farm	Saucony Creek and Maiden Creek	Completed	5.8 acres moved from tilled crop production into grass buffer plantings, 3.9 acres of wellhead and riparian buffer established, 860 trees and shrubs planted

Sources: Tom Davidock, SAN Coordinator, Partnership for the Delaware Estuary; Tim Fenchel, Grant Coordinator, Schuylkill River Restoration Fund

NRCS Agriculture BMPs

The National Resources Conservation Service (NRCS) is also involved in the implementation of agriculture BMPs in the Schuylkill River watershed. In 2010, NRCS was responsible for installing 10 manure storage units in the Schuylkill River watershed. For the 10 waste storage units constructed in the watershed, manure is collected from approximately 625 animal units (AU), or on average 62.5 AU/storage unit. These projects have the potential to substantially reduce surface water contamination resulting from contaminated manure at farm sites (N. Ramsey, personal communication, January 19, 2011). The NRCS also implements other agriculture BMPs in the watershed, including animal stream crossings, riparian buffers and heavy use protection areas.

7.2.2.3 Education/Outreach

On a watershed-wide scale, PWD's Education and Outreach initiatives serve many of the same objectives as those initiatives implemented within the City. The extensive size of the Schuylkill River watershed highlights the importance of partners that share the same source water protection goals, and will work to further the City's objectives, specifically in regard to pathogens reduction. Moving forward with plan implementation, PWD's partners may provide valuable feedback for this watershed control plan based on their various perspectives and knowledge of the watershed. The initiatives below occur or have occurred in the Schuylkill River watershed and support one or more of PWD's education and outreach goals.

Farm Awards and Certification

The goal of this project was to provide an incentive for farmers in the Schuylkill Watershed to participate in the Pennsylvania Environmental Agricultural Conservation Certification of Excellence (PEACCE) program and institute recommendations on their land. The PEACCE program educates livestock producers about potential sources of water pollution, identifies areas on their farms that are having or could have negative water quality impacts, and recommends sensible solutions to these challenges (including

fencing, riparian buffers, manure management programs, and sound fertilizer and pesticide use for crops).

The PennState Cooperative Extension, which implements the PEACCE program, worked with the SAN Agriculture Workgroup to identify farms in the Schuylkill Watershed with the interest and capacity for undertaking the certification process. Project partners began promoting PEACCE certification by focusing on farmers that were already collaborating with the Workgroup to install fencing, plantings, and cattle crossings. The PEACCE certification process includes four main components:

- Environmental Awareness Course
- On-Farm Assessment
- County Conservation District On-Farm Checklist
- Maintaining Certification: Continuing Education and Follow-up Assessment

Five farms were identified and underwent the PEACCE assessment process, including the A. Martin Farm, the Eberly Poultry Farm, the El-Har Farm Poultry and Dairy Farm, and two Lehman Farms. These five facilities were subsequently certified as PEACCE farms, bringing the total number of PEACCE farms in Pennsylvania to 75. PEACCE farms are provided with recognition signage by PennState and are encouraged to maintain their certification with ongoing education and follow-up assessments.

As part of the assessment, additional BMPs were identified as actions that would be helpful for environmental improvements on the assessed farms. Cost estimates for project implementation were provided by Berks County NRCS staff (members of the SAN Agriculture Workgroup), and one of the farms was selected for BMP installation using remaining SWIG farm certification funds. As a result, curbing was installed by the BCCD at the A. Martin Farm to improve its water quality protection measures. Agricultural runoff is a priority source of *Cryptosporidium* contamination in the Schuylkill River watershed. The PEACCE certification process addresses this contamination source by increasing farmers' awareness of the impacts of agricultural activities on our waterways and promoting source water protection through BMP implementation.

Environmental Advisory Councils/Committees
In a Source Water Assessment by PWD, it was discovered that townships with active Environmental Advisory Councils generally had more environmentally friendly approaches to land management and development. The Pennsylvania Environmental Council (PEC) utilized SWIG funds to identify high-priority communities for EACs throughout the watershed; a list of 15 priority townships was established. PEC offered these communities training, funding and other services to those that wanted to create EACs. In the Schuylkill River watershed, there are at least seven more EACs as a result of this program. EACs help develop stewardship in local decision makers and create relationships in communities that could provide potential locations for future SAN projects. Ideally, these committees will continue to steer community decision makers, educate residents, and initiate on-the-ground projects to protect and improve water

quality throughout the watershed. EACs are a valuable forum to address drinking water issues, including pathogen contamination, on a community level.

SAN Website
The SAN website has been redesigned by a web consulting firm with input from PWD and the SAN Planning and Education and Outreach committees. The new website, www.schuylkillwaters.org, includes an internal component that allows for improved communication among SAN workgroup members, helping to facilitate on-the-ground work. It also includes a public component that conveys SAN's message about protecting and improving the Schuylkill River to outside audiences. The SAN website, together with phillywatersheds.org, provides data and reports from the source water assessments for the Schuylkill River. The information presented on this website increases public awareness of high-priority water quality issues, including pathogens contamination, and advances strategies to reduce the threat of certain water quality concerns through inter-workgroup communication.

SAN Pathogens/Compliance Workgroup
The Pathogens/Compliance Workgroup of SAN is primarily comprised of PADEP and EPA personnel working together to address compliance violation issues in the Schuylkill Watershed. Meetings are held quarterly between EPA, PADEP and PWD. The workgroup has been instrumental in supporting PWD's watershed-wide *Cryptosporidium* monitoring initiative by offering sample collection services.

The workgroup forum also enables PWD to raise important concerns with state and federal regulators with regard to the impacts of upstream WWTP discharges on drinking water treatment. This forum provides a valuable context for bringing attention to drinking water treatment concerns, including LT2 compliance, as they relate to WWTP policies. Improved compliance efforts upstream ensure greater protection against pathogens in Philadelphia rivers.

SAN Agriculture Workgroup
The goal of the SAN Agriculture Workgroup is to maximize the reduction and/or prevention of agricultural impacts to water quality. Meetings are held quarterly between EPA, PADEP, PWD, NRCS, and other conservancy and conservation district groups. The workgroup helps plan, implement and track agricultural BMPs in the Schuylkill River watershed, and will play an important role in the implementation of this watershed control plan.

Schuylkill Restoration Fund
PWD, in partnership with Exelon, is supporting SAN in creating a long-term Restoration Fund for continued implementation of priority projects in the Schuylkill River watershed. The fund will center on priority projects determined in partnership with the SAN technical workgroups. Coalitions of water suppliers, businesses and municipalities will contribute dues to a common fund. Other sources of funding may include supplemental environmental fines or new taxes. A sustainable restoration fund will enable long-term improvements to water quality in the Schuylkill River not possible through grants alone. Individual organizations can raise relatively small amounts of

funding with contributions from other groups to implement projects that fit their priorities. The SAN has set a goal of $500,000 as an initial fund amount. Establishment of this fund is an important step toward ensuring that source water protection initiatives continue to be implemented in the watershed.

Wissahickon Watershed Partnership

The Wissahickon Watershed Partnership was convened in 2005 to guide the development of a watershed-wide Integrated Watershed Management Plan (IWMP). Over the past three years, it has been determined that due to the complexity of regulatory obligations facing this drainage area, PWD would move forward with developing a watershed plan for the portion of the drainage area within its jurisdiction, while the upstream portion of the watershed concludes a number of ongoing initiatives. PWD will continue to convene the Wissahickon Watershed Partnership in the coming years to support a complementary implantation approach in order to realize a watershed-wide restoration vision (PWD 2009b).

In 2007, PWD initiated a watershed-wide goal setting process with the Wissahickon Partnership which resulted in a list of 23 stakeholder goals for the Wissahickon Creek watershed. A subset of 12 goals is directly relevant to the City of Philadelphia portion of the watershed. A significant effort was made to consolidate these goals into a set of overarching goals for IWMP implementation. As a result of this consolidation process, seven overarching goal categories were identified for the Philadelphia portion of the Wissahickon watershed: water quality and pollutant loads, in-stream flow conditions, streamflow and living resources, stream corridors, flooding, quality of life, and stewardship, communication, and coordination. PWD has determined that these overarching goals, because of their broadly worded nature, should be utilized to guide the City's IWMP planning process, objective development, and ultimately implementation commitments. The Philadelphia sub-goals and objectives that fall under the "water quality and pollutant loads" category are outlined below in Table 7-6.

Table 7-6 Proposed Water Quality Goals and Objectives for the Philadelphia Portion of the Wissahickon Creek IWMP

IWMP Goal for City of Philadelphia	Partnership Goal Subset	Measurable Objectives to Guide Implementation Process
Water Quality and Pollutant Loads. Improve wet and dry weather stream quality to reduce the effects on public health and aquatic life.	Protect drinking water quality	Continue to meet requirements of the LT2ESWTR
	Protect drinking water taste and odor	Limit geosmin concentrations to <10ng/L between April & May
	Improve and protect surface water quality	Meet state numeric criteria for bacteria in dry weather
		Meet state water quality standards for dissolved oxygen
		Meet state criteria for pH at all sites and times
		Remove Wissahickon Creek from the state list of impaired waters
	Eliminate untreated sewage discharges to Wissahickon Creek	Eliminate cross-connections of sanitary to storm sewers
		Eliminate sanitary sewer discharges to the stream in dry weather

Source: Wissahickon IWMP Draft, 2010

PWD will develop an IWMP document for the City of Philadelphia portion of the Wissahickon Creek watershed and will share this plan with the Wissahickon Watershed Partnership as a model for developing a complementary initiative in the upstream portion of the watershed. It should be noted that the Delaware Valley Early Warning System has been incorporated into the IWMP planning process as well. One of the overarching goals for the watershed is to foster community stewardship and improve inter-municipal, inter-county, state-local, and stakeholder cooperation and coordination on a watershed basis. To help achieve this, there are plans to increase preparedness for natural hazards, spills and discharges by obtaining agreements from the five WWTPs and industrial users in the watershed to sign up as members of the EWS reporting network.

Although the partnership's recent focus has not been geared toward drinking water issues, there is the potential to more closely align efforts of the IWMP implementation process with LT2 compliance in the future. PWD will work to incorporate key source water protection issues into the scope of partnership work during implementation of the Watershed Control Plan.

Partnership for the Delaware Estuary
The Partnership for the Delaware Estuary (PDE), established in 1996, is a non-profit organization dedicated to protecting and enhancing the Delaware Estuary. The organization is one of 28 congressionally designated National Estuary Programs throughout the coastal United States. PDE partners with other Pennsylvania organizations to increase awareness, understanding, and scientific knowledge about the estuary, while protecting and enhancing the estuary and its tributaries for future generations (PDE 2010).

PWD and PDE work closely together in several partnerships, including the Schuylkill Action Network (SAN). PDE currently facilitates Water Quality Council Meetings, and has worked with Philadelphia to provide education and outreach to communities in the watershed. An example of one outreach initiative was the publication of a student activity book, "Let's Learn about Water," that develops the concepts of a watershed, impact of non-point source pollution, and personal responsibility for protecting our water supply. The curriculum has already been used in a number of middle schools to meet state required science-based credits (PWD 2009b). Other PDE initiatives include a dog waste control program, piloted in Delaware and adopted by PWD, and development of stormwater inlet labeling.

Golf Course Certification Program
This annual workshop introduces golf course managers within the Schuylkill River watershed to the Audubon Cooperative Sanctuary Program for golf courses (SWIG 2009). The voluntary education and certification program of Audubon International provides education, conservation assistance, and positive recognition to golf course managers for improving environmental management practices and conservation efforts. There are approximately 79 golf courses in the Schuylkill River watershed, covering almost 1,200 acres, and surrounding more than 21 miles of stream. Golf courses are also the single largest privately owned pieces of land in the watershed, making it extremely important that they practice environmentally sound land management. By encouraging environmentally sensitive turf management, establishing stream bank vegetation and non-mow zones, avoiding toxic pesticides and herbicides, and minimizing nutrient loads from the golf course, this program provides the tools necessary to reduce the impacts of golf courses on water quality in the watershed, while also promoting biodiversity through increased habitat.

To date, PWD has held five annual workshops in different parts of the Schuylkill River watershed. The 5th annual workshop was held at the Bala Golf Course in Philadelphia in April 2008. Twenty golf courses from around the region sent representatives to participate in the workshop (PWD 2009b). Pesticide credits were offered by the Department of Agriculture for workshop participants and PWD recruited golf course managers and carried out logistics for the workshop. Follow-up with workshop participants was conducted to determine the impact of certification on everyday management activities, and participating golf courses were asked about the implementation of any changes on their courses resulting from the workshops. Because golf courses are the largest pieces of privately owned land in the watershed, their negative impacts on water quality can significantly decrease with proper land

management and control measure implementation. The possibility remains to incorporate pathogen reduction strategies into the golf course certification program through measures such as goose control.

7.3 Watershed Partners and their Roles

Please refer to the information presented in the above in-city and watershed-wide assessments for a description of PWD's primary watershed partners and how their work relates to PWD's source water protection efforts.

7.4 Other Accomplishments in the Schuylkill River Watershed

7.4.1 Enforcement

PWD's commitment to reducing the risk of pathogen contamination in the watershed, and supporting its partners in this effort, is clearly evident through the extensive list of projects above. Enforcement efforts on the part of municipal, county, state and federal regulators are also a critical component of PWD's goal to ensure a safe drinking water source for the City of Philadelphia.

At the end of 2009, the SAN Pathogens and Compliance Workgroup compiled a list of state highlights and accomplishments for the year. These accomplishments demonstrate the workgroup is fulfilling its mission to address pathogen contributions in the watershed through the following action items: improving reporting of sewage overflows; promoting self-assessment by local municipalities of sewer collection system capacity, maintenance, operation and management; and ensuring compliance with combined system regulation/requirements, targeted inspections, compliance assistance, and appropriate enforcement (SAN 2009). Table 7-7 below details the 2009 SAN Pathogens and Compliance Workgroup highlights.

Table 7-7 SAN Pathogens & Compliance Workgroup Highlights, 2009

Project Location	Description
Schuylkill Valley Sewer Authority (Schuylkill County)	As of June 2009, approximately 95% of the households in the following areas have been connected to public sewage treatment, eliminating partially treated and/or untreated wastewater discharges into the headwaters of the Schuylkill: Brockton, Mary-D, Tuscarora, Schuylkill Twp, Cumbola, Kaska, Silver Creek, Blythe Twp, Middleport, and New Philadelphia
Lansford Borough (Schuylkill County)	A $2.9 million project to separate stormwater from sanitary sewage lines is nearly complete. The project will results in a 40% reduction of stormwater into the WWTP shared with neighboring Summit Hill and Coaldale, thereby eliminating sewage overflows into Panther Creek. The state has imposed a moratorium on development in all three communities due to sewage overflows.
West Penn and Walker Township (Schuylkill County)	Work continues on updating the Act 537 Plan for West Penn and Walker Township to address malfunctioning on-lot sewage disposal systems and wildcat sewers in the areas of Reynolds and Clamtown, which impact the Little Schuylkill River. West Penn is under a mandate from EPA to correct illegal wildcat sewer systems that were identified in South Tamaqua and were found to be discharging directly into the Little Schuylkill River.
Lynn Township WWTP Expansion (Lehigh County)	PADEP has approved the municipality's Act 537 Plan to expand its overloaded WWTP. The expansion will double the capacity to 160,000 GPD. The plant serves approximately 450 customers, including the village of New Tripoli, properties along Route 309 and the Northwestern Lehigh School District's main campus; effluent is discharged into Ontelaunee Creek.
Sewage Plans for Maxatawny Township (Berks County)	After a decade of planning, Maxatawny Twp has submitted plans to PADEP for a $9.5 million STP. The facility would serve about 250 homes and businesses that have malfunctioning on-lot sewage disposal systems. The plant will be located on land owned by the Borough of Kutztown and is designed to handle 140,000 GPD. The Twp Municipal Authority received a $4.5 million H2O PA Grant in July and the balance will likely be funded through a loan.

City of Reading (Berks County)	Reading will miss the federal government's November 2012 deadline to open a new STP on Fritz's Island, and may face possible fines. The sewer plant is being built under a consent decree imposed on Reading in 2004. The City must also repair the conveyance system to the plant. The city is proposing to replace the existing force main with a $70 million 10-ft diameter tunnel. The existing main cracked open in January 2008, releasing an estimated 20 million gallons of raw sewage into the Schuylkill River.
Robeson and Union Townships Sewer Line Study (Berks County)	Robeson and Union township municipal authorities continue to study options for conveying sewage from the Geigertown area to the Birdsboro WWTP. The municipalities are under a PADEP mandate to provide public sewer service to 113 homes in Geigertown, where many on-lot systems have failed.
PADEP v. David Weiszer (Berks County)	Water Management Program staff in both the SE and SC Regional Offices worked jointly on an enforcement case involving unpermitted discharges of industrial waste from a poultry processor in Exeter Twp. The case specifically dealt with significant amounts of chicken waste that were being discharged directly into an unnamed tributary of the Schuylkill River. In January, PADEP filed a complaint for civil penalties under the Clean Streams Law in the amount of $176,000. On August 28th, the PADEP served defendant with a Request for Admissions and the defendant failed to respond. On November 2nd, the PADEP filed a Motion for Summary Judgment with the Board based upon the legal premise that all PADEP's Admissions are now deemed admitted by the Defendant, and no dispute of material fact exists as to the Defendant's liability for violations of the Clean Streams Law.
West Pikeland Twp (Chester County)	In the process of updating their Act 537, a special area of interest was identified in the lower end of the twp where public sewage is needed for approximately 80 homes that have malfunctioning OLDS. Recently the twp released a copy of a summary of sewage needs data compiled from a survey sent to residents. Earlier this year, twp officials estimated a new public sewage system for a portion of the twp would cost about $4.5 million. After reviewing the results of the survey and considering alternatives, the costs may be halved.

PADEP terminates East Norriton Order (Montgomery County)	PADEP has agreed to terminate a February 2007 consent order requiring the twp to reduce inflow and infiltration of sewer lines after it received the twp's 2009 Corrective Action Plan. Chronic I & I problems had caused major sewage overflows at the Germantown Pike sewage pump station into a tributary of Stoney Creek. In 2007, the twp required 251 homeowners to replace their sewer laterals.
Sewage issues close New Hanover campground (Montgomery County)	In February, eviction notices were sent to residents of the Hickory Park Campground. At the center of the dispute was a failing septic system. Over the several previous months, the system had been cited by the Montgomery County Health Department for violating health standards and by the PADEP for sending untreated sewage into Swamp Creek. The site was purchased by the twp to be utilized as a public park.
Perkiomen Creek Bacteria Sampling	The workgroup continues a partnership with the USGS and PWD to collect and analyze bacteria (fecal coliform and *E. coli*) at WQN Station 116 on the Perkiomen Creek. Quarterly sampling has been conducted for 5 years and the workgroup plans to evaluate the data in the upcoming year. Through the PADEP-SERO samples were also collected in 2008 for recreational use determination for this stretch of the Perkiomen; final results indicate the study area does NOT meet standards for recreational use.
Promotion of DelVal EWS and PAWARN	The workgroup continues to promote the DelVal EWS to WWTP operators throughout the Delaware watershed. The PADEP-SERO distributes an informational letter and the NERO encourages listing the System on the downstream notification call list. The workgroup also provides utilities information on PA's Water/Wastewater Agency Response Network (PAWARN).
Source Water Protection Plans	Although not a task of the workgroup, PADEP continues to work with public water suppliers in the watershed to develop and implement source water protection plans. Plans (surface water sources) were recently approved for Blythe Twp Municipal Authority (Silver Creek, Moss Glenn and Crystal Reservoir), Schuylkill County Municipal Authority (Kauffman, Indian Run and Mt. Laurel Reservoirs, Wolfe Creek, Eisenhuth and Pine Run), Minersville Municipal Authority (Dyer Run) and Schuylkill Haven Borough Water Authority (Silver Creek Reservoir/Tumbling Run); initial discussions were held with Boyertown Municipal Authority.

Wastewater Operation Certification Program	Montgomery County Community College and Reading Area Community College both offered a 180-hour certification program designed to help license new operators in the field of wastewater operation. The curriculum was developed by PADEP (Jennifer Fields). Upon completion of the program, enrollees are eligible to take the PADEP certification exam for their operator license. The SAN Pathogens & Compliance workgroup is working on modifying one of the course modules into an approved continuing education credit wet-weather/high-flow workshop for operators within the Schuylkill watershed.

Source: Joe Hebelka, PADEP, 2010

Enforcement efforts to reduce the risk of *Cryptosporidium* contamination extend beyond the accomplishments achieved through SAN initiatives. For example, Pennsylvania's conservation districts work in partnership with state and federal agencies to implement effective, locally led conservation programs. Conservation districts play a multi-faceted role in the watershed, from assisting county and municipal governments in land reviews and stormwater management plans to conducting educational programs related to soil and water conservation (PACD 2010). Within the Schuylkill River watershed, conservation district representatives participate in key partnerships, including SAN and the Wissahickon Watershed Partnership, to aid in project implementation, education and outreach.

On a municipal level, effective management of publicly owned treatment works (POTWs) upstream of the Queen Lane intake has contributed to the success of source water protection efforts in the Schuylkill River. POTWs must manage all aspects of their treatment system and processes in order to meet NPDES permit requirements. Developing pretreatment standards and implementing wet weather management procedures are just two examples of POTW management practices.

State and federal-level enforcement play a critical role in ensuring the adequacy of wastewater collection systems and treatment plants. Many wastewater-related issues are not within Philadelphia's jurisdiction to address; therefore, the State's efforts to oversee permit compliance at upstream communities are crucial to protecting water quality conditions, including *Cryptosporidium* levels, at Philadelphia's downstream intakes. The elimination/reduction of combined sewer overflows (CSOs) upstream of the intake is one such example. The implementation and enforcement of Long Term Control Plans (LTCPs) is critical to managing and reducing or eliminating combined sewer overflows. The Source Water Assessment identifies 11 upstream CSOs that represent sources of contamination at the Queen Lane intake. Two of these CSO communities, Bridgeport and Norristown, are located in Zone B and represent high-priority sources; the remaining CSOs are located farther upstream, in the Schuylkill County area. Norristown's LTCP was approved in March 2002, with the plan of eliminating CSOs through system separation. The sewer separation plan was completed in August 2007, which helped to decrease wet weather flows and eliminate one CSO area. Infiltration and inflow still need to be addressed to eliminate the remaining CSO area and treatment plant overloading (CDM 2009). Bridgeport's LTCP was approved in May 2004, with plans to address CSOs through presumptive measures and a partial separation of the system.

Additional issues requiring State-level enforcement are wet weather management and infrastructure maintenance. The state's efforts under the Act 537 program and 25 PA Code Chapter 94 address many sewerage-related issues that pose a threat to water quality in the watershed. The major provisions under the Act 537 program, or sewage facilities program, serve to correct existing sewage disposal problems and prevent future problems from occurring at both large, municipally owned sewage treatment plants and individual onlot sewage disposal systems (OLDS). The Act requires proper planning of all types of sewage facilities, permitting of individual and community OLDS, as well as uniform standards for designing OLDS (PADEP 2008).

Chapter 94, Wasteload Management, encompasses both collection system capacity and plant capacity issues (PA Code 2011). The goal of Chapter 94 compliance is to reduce wastewater volume and pollutant mass loadings through the application of pollution prevention practices to avoid hydraulic, organic and industrial wastewater overloads at sewerage facilities. The chapter specifically states the following objectives:

- Prevent the occurrence of overloaded sewerage facilities.
- Limit additional extensions and connections to an overloaded sewer system or a sewer system tributary to an overloaded plan.
- Improve opportunities to prevent or reduce the volume and toxicity of industrial wastes generated and discharged to sewerage facilities and where prevention and reduction opportunities have been maximized, and to recycle and reuse municipal and industrial wastewaters and sludges.

PADEP reviews Chapter 94 reports annually to track treatment plants and sewer collection systems that regularly experience hydraulic overloads. The causes behind frequent hydraulic overloads, such as SSOs due to infiltration/inflow, are assessed and actions taken to resolve these issues. PWD strongly values these enforcement efforts and plans to continue its work with government agencies, utilities and other organizations to continue to identify and address sources of pathogen contamination to aid in the enforcement process.

7.4.2 Policy Changes

In addition to Pennsylvania's enforcement actions, the state has developed policy changes that further address source water protection issues. An example of recent policy development includes the revisions made to Title 25 Pa. Code Chapter 102: Erosion and Sediment Control and Stormwater Management. According to the State, Chapter 102 serves to protect surface waters of the Commonwealth through the utilization of Best Management Practices (BMPs) that minimize accelerated erosion and sedimentation during earth disturbance activities, and manage post construction stormwater runoff after earth disturbance activities. A final-form rulemaking amended the existing regulation to achieve several objectives including: the incorporation of NPDES permit requirements for stormwater discharge from construction activities, long-term operations and maintenance requirements for post construction management stormwater BMPs, revisions to the agricultural planning and implementation requirements, updated erosion and sediment control requirements, and provisions for riparian buffers and riparian forest buffers (CWA 2010).

The revisions particularly relevant to this watershed control plan include those changes made to the agricultural section (Section 102.4 (a)). The regulations now call for an E&S plan to be developed for animal heavy use areas, in addition to the original requirement for agricultural plowing and tilling. The E&S plan must identify appropriate BMPs to minimize erosion and sedimentation. The new regulations under Chapter 102 may help reduce the impact of agricultural and livestock activity on water quality, including pathogen concentrations.

Another notable policy change is the 2008 EPA-issued rule on requirements for CAFOs that are applying for a NPDES permit (US EPA 2008). The final rule includes two main revisions. The first revision pertains to CAFO permitting, and asserts that only those CAFOs that discharge or propose to discharge must apply for permits. The revision requires a case-by-case evaluation of the CAFO's design, construction, operation and maintenance to determine whether the CAFO will discharge from its production site or land application area. The second revision adds a new requirement for permitted CAFOs. CAFOs that require permitting must now submit a Nutrient Management Plan (NMP) at the time of permit application, and the NMP must be incorporated into the CAFO's NPDES permit conditions. In addition, following review of the NMPs by the permitting authorities, the public must be provided with the opportunity for public review and comment (US EPA 2008).

7.5 Recommendations for future actions and their contributions to specific goals

By assessing the comprehensive list of projects and initiatives that contribute to reducing the risk of pathogen contamination in Philadelphia's source waters, PWD is able to evaluate areas of vulnerability that still exist. Listed in Table 7-8 below is a general evaluation of priority sources and whether or not they are adequately being addressed based on the in-city and watershed-wide project assessments.

Table 7-8 General Vulnerability Assessment of Priority *Cryptosporidium* Sources

Priority Cryptosporidium Sources	Currently Being Addressed	
	In-City	In Watershed
Treated WWTP Effluent	N/A	No*
Raw Sewage Discharges	Yes	Various**
CSOs	N/A	Various
Defective Laterals	Yes	Various
Wildcat Sewers	N/A	Various
SSOs	Yes	Various
Infrastructure Inspection/Main.	Yes	Various
Agricultural Runoff	Yes	Yes
Animal Vectors (specifically geese)	Yes	No

*When a priority source is listed as "No," not being addressed, there may exist select sites where the issues is currently being addressed, however, on a larger scale the source still represents a considerable vulnerability.
'"Various" indicates a source that is generally addressed through regulatory requirements and permit issuances. Whether or not these sources are adequately being addressed depends on the specific municipality or utility and the level of enforcement action in that area.

Throughout the watershed, vulnerabilities still exist in the areas of treated WWTP effluent, raw sewage discharges and animal vectors. Agricultural runoff is being addressed both in-city and in the watershed, however, PWD encourages expanding these efforts to further minimize the threat of oocyst contamination at the intake.

PWD proposes the following action items for the Schuylkill River watershed, with the hopes of achieving each initiative through the watershed control plan implementation process. The initiatives are presented by priority source category for both Philadelphia and the entire watershed, with ongoing initiatives in each category presented first, followed by future/proposed initiatives.

7.5.1 Wastewater Dischargers/Compliance

Treated effluent is a consistent source of *Cryptosporidium* contamination that is largely outside of PWD's role and jurisdictional rights to address. The following PWD initiatives aim to reduce the risk of *Cryptosporidium* contamination from treated WWTP effluent while minimizing the occurrence of raw sewage discharges.

Ongoing Initiatives:

In-City

- Continue to support Lehigh's *Cryptosporidium* source tracking study by providing support in terms of sampling, elution, and project management and oversight.

- Continue to regularly review and update Philadelphia's Act 537 Plan. The plan was last updated on February 27th, 2009.

- Continue to implement the initiatives outlined in the annual Combined Sewer Management and Stormwater Management Plans in order to fulfill the City's Stormwater and CSO permits. Ongoing initiatives include monitoring as part of the Defective Lateral Detection and Abatement Program and completion of the Main and Shurs Elimination project.

- Continue to maximize usage for the Early Warning System while maintaining the system's ongoing operations and maintenance needs.

Watershed-wide

- Continue to support efforts of the SAN Pathogens/Compliance Workgroup. The following strategies for the 2010 SAN Pathogens/Compliance Workplan are as follows: 1) Improve discharger/water supplier communication of events and use of the Delaware Valley Early Warning System and PAWARN, 2) identify priority wastewater discharges/issues in the watershed and formulate action plans to address them, 3) provide support (financial, information, expertise, collaborative problem-solving) for partners/communities to implement projects that reduce priority discharges, and 4) provide a forum for partner and agency communication and coordination around discharge issues and the formulation of creative new ideas and approaches for solving related problems (SAN 2010a).

- Continue to support SAN in its efforts to identify and abate wildcat sewers throughout the Schuylkill River watershed.

Proposed Initiatives:

In-City

- Develop a Source Water Assessment update for the Schuylkill River by revisiting priorities established in the 2002 assessment and updating water quality analyses with recent data.

Watershed-Wide

- Support/help develop an effluent monitoring plan for *Cryptosporidium* at major WWTPs in the Schuylkill River watershed. In conjunction with this effort, support incorporation of *Cryptosporidium* monitoring into NPDES permits by requiring the reporting of *Cryptosporidium* monitoring results in monthly DMRs. Monitoring should be performed using an approved and published standard method. Track the progress of these initiatives by continuing to attend SAN Pathogens/Compliance workgroup meetings.

- Through continued participation in the SAN Pathogens/Compliance workgroup, help ensure that high-priority areas requiring regulatory enforcement action are identified and addressed. Areas of concern may be identified using the following measures to track wastewater-related changes in the watershed.

    - Identify high-priority municipalities in need of updated Act 537 Plans in the Schuylkill River watershed. Municipalities with outdated plans located in Zones A and B of the area of influence are especially relevant.
    - Continue to align sewage facilities planning, or Act 537, enforcement with the wasteload management reports filed under Chapter 94.
    - In addition to the above two measures, track WWTP upgrades, new facilities and community sewer improvement projects (such as the sewering of new areas) by reviewing Part II Permits.
    - Track projects funded under government loan programs, such as PennVest.

- Coordinate with SAN to provide wet weather and high flow management education to WWTP operators in a workshop format. Include overview of information that should be included in I & I abatement and high-flow maintenance plans.

- Support future research initiatives surrounding the impact of WWTP effluent on *Cryptosporidium* surface water concentrations by partnering with research organizations and/or academic institutions. Possible research initiatives are outlined in further detail in Section 7.7 below.

7.5.2 Agricultural Land Use & Runoff

Within the City of Philadelphia, PWD has addressed agricultural runoff through the projects listed in the in-city assessment. The expanse of agricultural land within the city is obviously minimal, so future agricultural BMP efforts should be focused elsewhere in the watershed. The following initiatives aim to reduce the impact of agricultural activities on water quality in the Schuylkill River.

Ongoing Initiatives

In-City

- BMPs have been implemented at all agricultural sites within the City.

Watershed-Wide

- Continue to be an active participant in the SAN Agricultural Workgroup and support future efforts. The following strategies for the 2010 SAN Agricultural Workplan are as follows: 1) support implementation of projects that demonstrate best management practices and/or creative solutions for agriculture in priority areas (with funding, information, expertise, collaborative problems, solving, etc.), 2) provide a forum for partner and agency communication and coordination around agricultural impacts and issues and the formulation of creative new ideas and approaches for solving related problems, 3) promote agricultural best management practice successes and understanding of agricultural water quality issues and solutions to target audiences in the watershed through an educational/outreach program, and 4) monitor the impacts of agricultural BMP installations on stream water quality.

Proposed Initiatives

In-City

- Develop a maintenance plan for PWD's in-city agricultural BMPs, which include Northwestern Stables, Belmont Stables, Courtesy Stables, Monestary Stables and the WB Saul High School project.

- The National Lands Trust (NLT) is currently performing stream restoration on a tract of land on Erdenheim Farm, located in the Wissahickon watershed. The land is currently not being used for grazing, but may be used for this purpose in the future. PWD will consider future coordination with the NLT to install additional agricultural BMPs at the farm.

- As part of the Source Water Assessment update process, PWD plans to re-assess land use in the Schuylkill River watershed. To complete this update, the 2001 National Land Use Database will be used, along with more current information from the 2010 Census.

Watershed-Wide

- Coordinate with SAN to develop a maintenance and monitoring plan for the agricultural BMPs installed as a result of the parcel prioritization process. The maintenance plan may be centered on regular visual assessments to identify any problems or repair needs.

- PWD will explore the possibility of partnering with academic institutions on *Cryptosporidium*-related research. Relevant research may include monitoring to assess the efficacy of different agricultural BMPs at removing pathogens from runoff. PWD will also identify priority research needs that may be fulfilled in collaboration with Lehigh University. Potential future research initiatives are outlined in Section 7.7 below.

- Through involvement in the SAN Agriculture Workgroup, PWD will continue to work with partners and state and federal officials to identify priority projects and available funding sources. For funding programs that already exist within the watershed, such as the USDA/NRCS conservation programs outlined in the 2008 Farm Bill, PWD will promote drinking water protection, and *Cryptosporidium* contamination reduction, as a high-priority water quality improvement goal that requires adequate funding.

- Through the SAN Agriculture Workgroup, PWD will work with partners to identify CAFOs located in the Schuylkill River watershed and assess the status of their NPDES permits.

7.5.3 Animal Vectors

Wild animals throughout the watershed can serve as mechanical vectors of *Cryptosporidium,* transferring viable oocysts from original hosts to Philadelphia's source waters. Geese in particular were identified as vectors during the Lehigh-led source tracking studies. The following initiatives aim to reduce the impacts of geese near PWD's intakes and expand the implementation of animal vector control measures throughout the watershed.

Ongoing Initiatives

In-City

- Maintain plantings at the site of the Belmont Meadow Extension/Intake project. Continue to monitor goose activity around the Belmont intake.

- Continue education/outreach efforts concerning the threat of animal vectors and the role they play in the cycle of pathogen contamination. These efforts may include working with Fairmount Park to expand existing programs, such as the dog waste program, and developing new programs that focus on the relationship between geese and drinking water quality.

Watershed-Wide

- Continue to support Lehigh's source tracking research to further identify and understand the animals that serve as mechanical vectors of *Cryptosporidium* in the watershed.

Proposed Initiatives

In-City

- Identify and implement appropriate goose control measures at Fairmount Park properties, including Peter's Island, and incorporate educational signage in these areas.

- Complete implementation of the USDA waterfowl management program at the Queen Lane, Belmont and Baxter Water Treatment Plants along with PWD's three WWTPs.

Watershed-Wide

- As part of the Source Water Protection Program's education and outreach efforts, raise awareness of the threat animal vectors pose to our drinking water supplies. These efforts may focus on supporting Lehigh's efforts to publish scientific journal articles.

7.5.4 Education/Outreach

Education and outreach initiatives are a critical component of PWD's Source Water Protection Program since point source discharges and land uses throughout the entire Schuylkill River watershed are capable of impacting water quality conditions at Queen Lane. Many education and outreach initiatives are implemented through PWD's watershed partnerships. Therefore, a primary PWD goal is to maintain its watershed partnerships and continue to promote the importance of source water protection. There are no future initiatives listed below, however, PWD is committed to seeking opportunities that will expand partnership development and strengthen source water protection in the Schuylkill River watershed.

Ongoing Initiatives

In-City

- Remain an active participant in the watershed partnerships and begin integrating drinking water issues into the scope of work for the Wissahickon Watershed Partnership.

- Continue to submit a comprehensive annual water quality report that emphasizes critical source water issues and, in particular, educates customers as to the research initiatives and implementation strategies PWD is using to reduce the risk of *Cryptosporidium* contamination.

- Continue to convene the Water Quality Council (WQC) to address water quality issues on a holistic basis. Utilize the committee as a forum for providing feedback to strengthen the Watershed Control Plan.

- Continue to work with Fairmount Park to improve the environmental quality of the City's parks and streams through land management practices and BMP implementation.

- Continue to maintain the FWWIC and promote source water protection through the center's various exhibits and learning programs.

- Continue to operate Philly RiverCast and promote the web-based recreational warning system.

Watershed-Wide

- Continue to be an active member of the SAN Pathogens/Compliance and Agricultural workgroups and support initiatives outlined in the 2010 workplans.

- Continue to collaborate with the Partnership for the Delaware Estuary on various education and outreach initiatives, including the publication of guidance materials and organization of public programs and meetings surrounding water quality concerns.

- Continue to support the Schuylkill Restoration Fund to achieve implementation of best management practices at high-priority sites in the watershed.

Proposed Initiatives

In-City

- Fully implement in-city source water programs in the East Falls and Manayunk neighborhoods along the Schuylkill River. These programs will involve the implementation of stormwater management practices, storm drain labels and a dog waste control program. Through the programs, communities will become more involved in protecting their waterways as they develop a better understanding of the impacts of daily activities on their drinking water source.

7.5.5 Urban & Residential Runoff

Although urban and residential runoff is not as significant a source of *Cryptosporidium* as agriculture runoff and WWTP effluent in the Schuylkill River watershed, Philadelphia is addressing urban runoff through the City's 2009 Long Term Control Plan Update (PWD 2009a). On September 1st, 2009, PWD submitted the Green City, Clean Waters plan to the PADEP and EPA to detail how PWD will invest approximately $1.6 billion over the next 20 years to reduce CSOs substantially. To ensure this public investment not only results in clean and beautiful waterways, but also provides tangible, additional benefits to our citizens, PWD is dedicating a large portion of this plan to a green stormwater infrastructure approach.

PWD's definition of green stormwater infrastructure includes a range of soil-water-plant systems that intercept stormwater, infiltrate a portion of it into the ground, evaporate a portion of it into the air and, in some cases, release a portion of it slowly back into the sewer system. As a result, less stormwater enters the combined sewer system, ultimately reducing CSOs and the risk of pathogen contamination associated with these overflows. Integrating green stormwater infrastructure into a highly developed area like Philadelphia requires a decentralized and creative approach to planning and design.

Various tools can be implemented to accomplish this, including stormwater planters, rain gardens and green roofs. Implementing innovative green stormwater infrastructure throughout our City can maximize economic, social and environmental benefits for Philadelphia. The following benefits have been associated with green infrastructure implementation in the City:

- Reduced CSOs; approx. 5-8 billion gallons of CSOs avoided per year
- Enhanced groundwater recharge
- Additional habitat and recreation space
- Increased carbon sequestration
- Improved air quality
- Reduced energy and fuel demand
- Mitigation of urban heat island effect
- Higher property values

PWD encourages the use of innovative stormwater management in upstream communities to achieve similar benefits. Philadelphia is implementing green infrastructure on a relatively large scale, but even small-scale green infrastructure projects can have positive water quality impacts. PWD will continue its outreach efforts to educate communities on the innovative designs that can be used to address stormwater management.

Stormwater BMPs are not within the scope of this watershed control plan program. Therefore, the effectiveness of green infrastructure at reducing *Cryptosporidium* surface water contamination is not evaluated in this plan. Urban stormwater BMPs are usually not installed with the primary intention to capture pathogens in runoff. However, the benefits achieved in terms of nutrient and sediment reduction may produce ancillary benefits related to pathogen removal. The 2006 Pennsylvania Stormwater Best Management Practices Manual indicates that vegetated filter strips have a TSS removal efficiency of approximately 30%. Riparian buffer restoration can achieve a pollutant removal efficiency of approximately 65% (PADEP 2006). Turbidity can serve as an indicator of TSS, and the relationship between *Cryptosporidium* and turbidity is made explicit in the EPA LT2 regulations. Therefore, it is reasonable to conclude that the removal of sediment through the implementation of stormwater BMPs that infiltrate runoff may also reduce pathogen levels, including *Cryptosporidium*, in runoff.

7.6 Quantitative assessment of the relative impact of contamination sources and source water protection initiatives on water quality at the Queen Lane intake

The initiatives outlined in Section 7.5 above are included in this plan because they all have the potential to either directly or indirectly contribute to a reduction in the total *Cryptosporidium* watershed load. In order to quantitatively assess the impact of PWD projects and their potential to reduce the total *Cryptosporidium* load in the Schuylkill River watershed, a series of calculations were performed to: 1) provide an estimate of the total watershed load that is comprised of contributions from the priority sources outlined earlier in this plan and 2) provide estimates of the reduction in watershed load achieved through implementation of PWD projects.

Upon determining a total watershed load, a first attempt was made to establish a target reduction by comparing the observed average concentration of 0.076 oocysts/L at the Queen Lane intake during the LT2 monitoring period (2001-2003) to a desired Bin 1 concentration of 0.074 oocysts/L.

It should be emphasized that the calculations described below serve as a preliminary step in developing a quantitative method to assess *Cryptosporidium* loads from priority sources in the Schuylkill River watershed. The method outlined below is based on assumptions and values found in literature. Due to a lack of data and information available to support quantitative assessments of *Cryptosporidium* sources, the accuracy of this method cannot be determined, and the results should not be used to make any absolute conclusions. The uncertainties associated with quantifying *Cryptosporidium*

loads and the impact of priority projects only highlight the need for continued and expanded research.

The following summary provides a brief description of the quantitative approach used to determine both the watershed load and the project impact estimates. An explanation is also provided regarding the development of a target reduction for the watershed load.

7.6.1 Total Watershed *Cryptosporidium* Load

A total watershed load was calculated based on the potential contribution from *Cryptosporidium* sources in the Schuylkill River watershed. The watershed load is comprised of loading estimates for agricultural land use/runoff, WWTP effluent and stormwater runoff. Brief descriptions of the calculation method(s) used for each source are outlined below.

7.6.1.1 Agricultural Land Use/Runoff

Two different calculation methods were used to determine the contribution from agricultural land use/runoff to the total watershed load. The first method is similar to the approach used in the Source Water Assessment (SWA), in which a land use analysis, runoff volumes, and a *Cryptosporidium* event mean concentration (EMC) are used to calculate a total *Cryptosporidium* watershed load. The second method utilizes estimated infected livestock populations for the entire Schuylkill River watershed, as well as oocyst shedding rates for each category of livestock (C. Crockett, personal communication, December 2010).

7.6.1.2 WWTP Effluent

The method for calculating the contribution from WWTP effluent takes into account the treatment level (secondary or tertiary) of plants in the Schuylkill River watershed, as well as estimates for secondary effluent oocyst concentrations based on various sources of literature. The oocyst concentrations were each multiplied by the average daily flow rate at each of the 72 WWTPs in the Schuylkill River watershed to determine a total daily load. For the plants that have tertiary treatment systems, an additional 1 log, or 90% removal, was assumed for effluent oocyst concentrations.

7.6.1.3 Urban/Developed Stormwater Runoff

To calculate an estimate for the annual oocyst watershed load from stormwater runoff, an EMC/land use method was used. Land use categories and EMCs that encompass urban/developed lands were selected from the 2002 Schuylkill River Source Water Assessment for these calculations.

Results of the watershed loading estimates for each source described above are displayed in Table 7-9 below.

Table 7-9 Annual Watershed Loads for *Cryptosporidium* Sources in the Schuylkill Watershed

Cryptosporidium Source	Annual Watershed Load (oocysts/year)
Agriculture - Land Use Runoff	6.65×10^{12}
Agriculture - Infected Livestock	7.75×10^{14}
WWTP Effluent (average load)	2.38×10^{14}
Urban Stormwater Runoff	1.14×10^{12}

Summing the contributions from the sources listed in Table 7-9 yields the total watershed loads in Table 7-10 below. Since two methods are used to calculate the agriculture component (land use vs. livestock), there are two different total watershed loads.

Table 7-10 Estimates for the Annual Total Watershed Load of *Cryptosporidium* in the Schuylkill Watershed

	Livestock Population Method	Ag Land Use Method
Total Watershed Load (oocysts/year)	1.01×10^{15}	2.46×10^{14}

7.6.2 Target Reduction

The estimated *Cryptosporidium* watershed loads were used to develop a benchmark or target reduction number. There is no way to guarantee that achieving a target reduction will subsequently lower the oocyst concentration at the intake. However, a benchmark reduction still helps define a quantitative target for reducing the watershed load, and also provides a means to evaluate the impact of source water protection initiatives.

To calculate a benchmark reduction, the ratio of 0.074 oocysts/L, or a maximum Bin 1 concentration, to 0.076 oocysts/L, or the observed concentration at the intake, was used. Multiplying the ratio of 0.074/0.076 by the larger of the two estimates for the total watershed load listed above in Table 7-10 (1.01×10^{15} oocysts/year), yields a target total watershed load of 9.87×10^{14} oocysts/year. The target reduction is therefore 2.74×10^{13} oocysts/year, or the equivalent of a 2.7% reduction in the existing watershed load.

The higher of the two watershed load estimates is used to calculate the target reduction for several reasons. The higher watershed load is most likely an overestimate of the number of oocysts that reach surface waters in the Schuylkill River watershed. The overestimate is due to several assumptions made during the loading calculations for the individual sources. By overestimating the watershed load, a factor of safety is incorporated into the target reduction. Using a conservative target reduction is desired so that the impacts of additional factors are taken into account, including inconsistent sources of *Cryptosporidium* that are not included in the total watershed load, the existence of unknown delivery ratios that represent the number of oocysts that make it from source to stream, and the amplification of these and other influences over such a large area as the Schuylkill River watershed.

7.6.3 Project Impact Estimates

As projects are implemented under the LT2 watershed control plan program, their impact can be assessed using the same presumptive approaches used to estimate the total watershed load. The impact, or potential for reducing the total watershed load, can then be compared to the target reduction that is established above.

As an example of the potential for source water protection initiatives to influence the *Cryptosporidium* watershed load, an analysis was performed involving WWTPs in the Wissahickon watershed. A total of five WWTPs (Upper Gwynedd, Abington, Ambler, North Wales and Upper Dublin) currently discharge into the Wissahickon watershed. Of these plants, Abington and Amber already employ UV disinfection, while Upper Dublin currently uses CL2 gas. Upper Gwynedd currently uses hypochlorite for disinfection purposes, but has plans to install UV machines. North Wales is closing in 2013, and all of the plant's flow will be re-routed to Upper Gwynedd. Therefore, for these calculations, the average daily flow rate from North Wales is accounted for in the average daily flow rate for Upper Gwynedd.

Computing the total average daily loads from WWTP effluent in the Wissahickon watershed, the percent potential reduction/inactivation of *Cryptosporidium* oocysts from treated effluent was calculated as follows.

- Upper Gwynedd, Abington, and Upper Dublin were assumed to discharge with secondary treatment, while Ambler was assumed to discharge with tertiary treatment, in accordance with treatment level data from the 2008 SAN *Cryptosporidium* Survey. All four plants were assumed to discharge with secondary or tertiary treatment only (no UV disinfection) as the baseline.
- UV disinfection was then applied to the flows at Abington, Ambler and Upper Gwynedd, with each plant assumed to achieve an additional 3 log inactivation due to UV disinfection.
- Upper Dublin was assumed to remain at baseline conditions.

The UV disinfection dose for wastewater and reuse applications has traditionally ranged from 40-100mJ/cm^2, with up to 4 log inactivation achieved at a dose of 40 mJ/cm^2 (CH2MHill 2009). Assuming a conservative 3 log removal/inactivation for the three plants with UV disinfection, the number of infectious oocysts in the total flow from WWTPs in the Wissahickon is reduced from baseline conditions by approximately 91% through the use of UV.

In order to compare the reduction/inactivation number to the watershed load target reduction, the difference between the average load from the three plants before and after taking UV disinfection into account was calculated. Approximately 1.54x10^{13} oocysts/year are removed/inactivated when UV is employed at Upper Gwynedd, Ambler and Abington. This number accounts for approximately 56% of the target reduction of 2.74x10^{13}, highlighting the potentially large public health impacts if more WWTPs upgrade to UV in the Schuylkill River watershed. It should be emphasized that although UV disinfection inactivates *Cryptosporidium* oocysts, it does not physically remove oocysts in WWTP effluent. Therefore, although public health risks are substantially reduced through oocyst

inactivation, non-viable oocysts or empty oocyst shells will not be differentiated from viable and infectious oocysts under the current EPA monitoring methods used at drinking water intakes.

Project reduction estimates were also calculated for the SWIG agricultural BMPs installed throughout the Schuylkill River watershed. Only the WWTP reduction calculations, however, are included in this plan because the accuracy of the agricultural project reduction estimates is still largely unclear. WWTPs discharge directly to the river, implying that it is unnecessary to account for an overland delivery ratio. For both agriculture and stormwater projects, the reductions from implemented projects are difficult to estimate because the delivery ratio, or the percentage of "controlled" *Cryptosporidium* that never reaches a stream, is not known.

7.6.4 Conclusions Regarding the Quantitative Approach

Several conclusions can be drawn from the quantitative approaches developed for the LT2 Watershed Control Plan.

1) Estimating the impact of different sources of *Cryptosporidium* is only possible using a presumptive approach that relies heavily on values found in literature. The accuracy of this approach is unclear and most likely results in an overestimate of the number of *Cryptosporidium* oocysts that reach surface waters within the Schuylkill River watershed.
2) The Schuylkill River watershed is a large area to consider as the area of influence. While sources of *Cryptosporidium* throughout the entire watershed should be taken into account, the factors that affect the impact of contamination sources and the delivery ratio, or the percent of oocysts that travel from source to surface waters, are amplified many times over such a large area.
3) During the second round of LT2 monitoring, improvements in the analytical methods used to detect *Cryptosporidium* may affect the observed surface water concentrations at the intake. Therefore, the oocyst concentration at the intake during the second round of monitoring may reflect the improved analytical method, and not the impact or success of source water protection initiatives. Since the 1st and 2nd rounds of monitoring are not suitable for comparison due to changes in the recovery rates, evaluation of program success should focus on tracking the implementation of the source water initiatives outlined earlier in this plan. Any quantitative approach used to measure program success should focus on updating relevant calculations and modeling results as changes to priority point and non-point sources are identified and additional research is performed.
4) Moving forward, expanding data collection and research opportunities will be necessary to develop a better understanding of the sources of *Cryptosporidium* and the effectiveness of source water protection initiatives. PWD proposes several research initiatives for increasing the understanding of agriculture and WWTP effluent sources of *Cryptosporidium*. These initiatives are listed below in Section 7.7

7.7 Future Research Initiatives

The quantitative approaches used to calculate *Cryptosporidium* loads in the Schuylkill River watershed clearly indicate that more research is needed to not only improve the accuracy of future quantitative assessments, but also to increase PWD's understanding of the impact of specific *Cryptosporidium* sources on surface water concentrations at the Queen Lane intake.

It has been established that agricultural runoff and WWTP effluent both have a direct impact on source water concentrations of *Cryptosporidium*. PWD proposes several research initiatives that aim to improve the understanding of *Cryptosporidium* surface water contamination as it relates to agriculture sources and WWTP effluent. The proposed research initiatives and the mechanisms through which research and monitoring can be performed are described below.

7.7.1 Agriculture Related Research

Section 6, Analysis of Control Measures, describes projects elsewhere in the nation that attempt to quantify the oocyst removal capabilities of agriculture BMPs. The presumptive approach described above relies heavily on values from literature to provide quantitative estimates for the prevalence of infection in livestock populations and oocyst shedding rates. Although existing data are helpful in developing a general understanding of the impact of agriculture sources and the effectiveness of select control measures, many of these results are site-specific and not necessarily directly applicable to farms in the Schuylkill River watershed.

In order to increase the understanding of agriculture impacts in the Schuylkill River watershed, PWD proposes localized, long-term research efforts that focus on farms that have the potential to contribute to surface water contamination at the Queen Lane intake. Future focused research efforts may include the following components that are listed below.

- Increased monitoring at farm BMP sites in the Schuylkill River watershed.
- Increased monitoring upstream and downstream of farms in the Schuylkill River watershed.
- Assessing, in greater depth, agriculture sources of contamination in the subwatersheds listed in the Source Water Assessment's prioritization of Cryptosporidium sources.
- Evaluating farms within the Schuylkill River watershed and developing site-specific farm management practices that will reduce the risk of Cryptosporidium surface water contamination. Management practices could include containment and manure management of potentially infected calf populations.

Through research efforts similar to those listed above, PWD and its watershed partners may be able to gain a better understanding of the water quality impacts of specific agriculture sources as well as the most effective practices available to reduce these impacts within the Schuylkill River watershed.

7.7.2 WWTP Related Research

Treated WWTP effluent is generally a concern when it comes to protecting drinking water supplies; *Cryptosporidium* being one aspect of this concern. Using a presumptive approach based on results from pooled literature sources, PWD was able to estimate *Cryptosporidium* loads attributable to WWTP effluent in the Schuylkill River watershed. Moving forward, monitoring downstream of WWTPs in the Schuylkill River watershed will increase PWD's understanding of the relationship between treated effluent and *Cryptosporidium* surface water concentrations.

In collaboration with Lehigh University, PWD has already begun to explore possible research areas involving the impact of WWTP effluent. Lehigh is currently evaluating the efficacy of biofilms in capturing the presence of oocysts in surface waters. One proposed research area involves using biofilm samplers to capture the impact of WWTP effluent by installing samplers both upstream and downstream of WWTPs. In addition to focusing on the impact of WWTPs, this study also explores the use of biofilms as a significantly cheaper monitoring alternative to *Cryptosporidium* filters. Identifying new and less costly *Cryptosporidium* monitoring methods is an important area of research that, if expanded upon, could potentially increase the feasibility of collecting and analyzing *Cryptosporidium* monitoring data over larger areas of study and for longer periods of time.

7.7.3 Additional Research Opportunities and the Mechanisms through which Research can be Performed

PWD's partnerships with water research organizations and academic institutions create an opportunity to further *Cryptosporidium*-related research in the watershed. Organizations such as the Water Research Foundation (WaterRF) and the American Water Resources Association (AWRA) could be instrumental in leading *Cryptosporidium* research studies. PWD, as an active member of these organizations, can help identify priority research areas and support project planning efforts. In addition, PWD could expand its opportunities to partner with academic institutions as priority projects are identified.

In order to identify the highest priority research needs relating to *Cryptosporidium* and the threat it poses to our nation's drinking water supplies, PWD proposes the creation of a forum or working group. The working group could consist of research organizations, utilities, regulators, and leading researchers in the field of *Cryptosporidium* and source water contamination. The knowledge base and varying perspectives of workgroup participants would help identify areas most in need of continued research, while also providing utilities, such as PWD, with a better understanding of how they may interpret and utilize existing research results.

In addition to forming a working group, PWD believes it would be beneficial to create a literature database that captures and organizes the results from both ongoing and completed research studies. A research database could be extremely useful in assessing existing projects, gaps in research, and also to serve as a tool for utilities to evaluate what research is applicable to their watershed and what research is strictly site-specific.

This is a project that PWD could initiate, with eventual support and project management coming from the *Cryptosporidium* working group.

7.8 Resource Requirements and Commitments

In order to determine PWD's resource requirements and commitments for the Queen Lane watershed control plan program, the budgets for ongoing and future initiatives outlined in Section 7.5 above were assessed. The budget values for each initiative are either based on contract numbers or on staff full-time equivalent (FTE) calculations. Table 7-11 below provides the final budget numbers for each initiative. The budget currently allocates $50,000 toward expanding research efforts. Approximately $1.7 million of the annual budget for the watershed control plan program are accounted for in ongoing initiatives. These initiatives are already financed and require no additional funding under the watershed control plan program.

Table 7-11 Annual Budget for the Watershed Control Plan Program

Wastewater Discharge/Compliance	
Project Name	**Project cost/year**
In-City	
Continue to support Lehigh's Cryptosporidium source tracking study	$218,000.00
Continue to regularly review and update Philadelphia's Act 537 Plan	$23,000.00
Implement initiatives outlined in the annual Combined Sewer Management and Stormwater Management Plans	$100,000.00
Maximize usage for the Early Warning System while maintaining the system's ongoing O&M needs	$360,000.00
Develop a Source Water Assessment update for the Schuylkill River	$23,000.00
SubTotal:	**$724,000.00**
Watershed-Wide	
Continue to support efforts of the SAN Pathogens/Compliance Workgroup's annual workplans	$60,000.00
Support SAN efforts to identify and abate wildcat sewers throughout the Schuylkill River watershed	--
Support PA DEP efforts to develop an effluent monitoring plan for Cryptosporidium at major WWTPs in the Schuylkill River watershed	--
Support incorporation of Cryptosporidium monitoring into NPDES permits	--
Through SAN, ensure high priority areas requiring regulatory enforcement action are identified and addressed	--
SubTotal:	**$60,000.00**

Agricultural Land Use & Runoff	
Project Name	**Project cost/year**
In-City	
Develop maintenance plans for PWD's in-city agricultural BMPs	$11,500.00
Coordinate with National Lands Trust to install agricultural BMPs at Erdenheim Farm	$23,000.00
Re-assess land use in the Schuylkill River watershed	$11,500.00
SubTotal:	**$46,000.00**
Watershed-Wide	
Continue to actively participate in the SAN Agricultural Workgroup and support initiatives outlined in the annual workplans	$34,500.00
Coordinate with SAN to develop maintenance and monitoring plans for BMPs installed as result of parcel prioritization process	--
Identify priority projects and available funding sources	--
Assess status of CAFO NPDES permits in the Schuylkill River watershed	--
Explore opportunities to partner with academic institutions and organizations on Cryptosporidium-related research	$11,500.00
Promote drinking water protection in existing funding programs	$3,000.00
SubTotal:	**$49,000.00**
Animal Vectors	
Project Name	**Project cost/year**
In-City	
Maintain plantings at the site of the Belmont Meadow Extension/Intake project; continue to monitor goose activity	$5,800.00
Continue education/outreach efforts, including working with Fairmount Park to expand existing programs or create new programs that focus on the relationship between geese and drinking water	$3,000.00
Complete implementation of the USDA waterfowl management program at Belmont, Queen Lane and Baxter WTPs	$50,000.00
Complete implementation of the USDA waterfowl management program at PWD's three WWTPs	$25,000.00
SubTotal:	**$83,800.00**
Watershed-Wide	
Continue to support Lehigh's source tracking research (accounted for above)	--

Raise awareness as to threat animal vectors pose to our drinking water supplies, in particular, by supporting Lehigh's efforts to publish scientific journal articles	$5,800.00
SubTotal:	**$5,800.00**
Education/Outreach	
Project Name	**Project cost/year**
In-City	
Remain an active participant in watershed partnerships and begin integrating drinking water issues into the scope of work for the Wissahickon watershed partnership	$70,000.00
Continue to submit a comprehensive annual water quality report that emphasizes critical source water issues	$23,000.00
Continue to convene the Water Quality Council (WQC) to address water quality issues on a holistic basis	$1,400.00
Continue to work with Fairmount Park to improve the environmental quality of the City's parks and streams	$600,000.00
Continue to maintain the FWWIC and promote source water protection through the center's exhibits and programs	$115,000.00
Continue to operate and maintain Philly RiverCast and promote the web-based recreational warning system	$19,000.00
Implement in-city source water programs - East Falls and Manayunk neighborhoods	$23,000.00
SubTotal:	**$851,400.00**
Watershed-Wide	
Continue to participate in SAN workgroups and support initiatives outlined in each group's workplan	$17,000.00
Continue to collaborate with the Partnership for the Delaware Estuary on various education and outreach initiatives, including the publication of guidance materials, and organization of public programs and meetings surrounding water quality concerns	$25,000.00
Continue to support the Schuylkill River Restoration Fund to achieve implementation of priority projects	$100,000.00
SubTotal:	**$142,000.00**
Research	
Support ongoing research needs that focus on high priority sources of *Cryptosporidium*, specifically agriculture land use/runoff and WWTP effluent	$50,000.00
SubTotal:	**$50,000.00**
TOTAL:	**$2,012,000.00**

7.9 Schedule for plan implementation

The watershed control program implementation plan is based on an approximately five-year timeline. PWD's goal is to implement all initiatives by 2015, or when the second round of LT2 monitoring is due and the first sanitary survey will be submitted to the state. The status of each initiative will be reported on in the plan's status reports, which PWD will submit to the PADEP on an annual basis.

The projects outlined in the watershed control plan will be implemented according to the schedule below in Table 7-12. Should any changes to the proposed project implementation schedule occur, PWD will report each change and the subsequent reasons for altering the schedule in the annual status report submitted to the PADEP.

Table 7-12 LT2 Watershed Control Plan Implementation Schedule

Wastewater Discharge/Compliance	Data Collection & Evaluation		Planning & Design		Implementation/ Completion	
Project Name	**Start**	**End**	**Start**	**End**	**Start**	**End**
In-City						
Continue to support Lehigh's *Cryptosporidium* source tracking study	ongoing					
Continue to regularly review and update Philadelphia's Act 537 Plan	ongoing					
Implement initiatives outlined in the annual Combined Sewer Management and Stormwater Management Plans	ongoing					
Maximize usage for the Early Warning System while maintaining the system's ongoing O&M needs	ongoing					
Develop a Source Water Assessment update for the Schuylkill River	Summer 2009	Winter 2015	N/A	N/A	Spring 2015	Spring 2016
Watershed-Wide						
Continue to support efforts of the SAN Pathogens/Compliance Workgroup's annual workplans	ongoing					
Support SAN efforts to identify and abate wildcat sewers throughout the Schuylkill River watershed	ongoing					
Support PA DEP efforts to develop an effluent monitoring plan for Cryptosporidium at major WWTPs in the Schuylkill River watershed	ongoing					
Support incorporation of Cryptosporidium monitoring into NPDES permits	ongoing					
Ensure high priority areas requiring regulatory enforcement action are identified and addressed	ongoing					

Agricultural Land Use & Runoff	Data Collection & Evaluation		Planning & Design		Implementation/ Completion	
Project Name	**Start**	**End**	**Start**	**End**	**Start**	**End**
In-City						
Develop maintenance plans for PWD's in-city agricultural BMPs	Winter 2012	Winter 2013	Spring 2013	Spring 2014	Summer 2014	Summer 2015
Coordinate with National Lands Trust to install agricultural BMPs at Erdenheim Farm	Summer 2012	Summer 2013	Fall 2013	Fall 2014	Spring 2015	Spring 2016
Re-assess land use in the Schuylkill River watershed	Fall 2012	Fall 2013	N/A	N/A	Winter 2014	Winter 2015
Watershed-Wide						
Continue to actively participate in the SAN Agricultural Workgroup and support initiatives outlined in the annual workplans	ongoing					
Coordinate with SAN to develop maintenance and monitoring plans for BMPs installed as result of parcel prioritization process	ongoing					
Identify priority projects and available funding sources	ongoing					
Assess status of CAFO NPDES permits in the Schuylkill River watershed	ongoing					
Explore opportunities to partner with academic institutions and organizations on Cryptosporidium-related research	ongoing					
Promote drinking water protection in existing funding programs	ongoing					
Animal Vectors	**Data Collection & Evaluation**		**Planning & Design**		**Implementation/ Completion**	
Project Name	**Start**	**End**	**Start**	**End**	**Start**	**End**
In-City						
Maintain plantings at the site of the Belmont Meadow Extension/Intake project; continue to monitor goose activity	ongoing					
Continue education/outreach efforts, including working with Fairmount Park to expand existing programs or create new programs that focus on the relationship between geese and drinking water	ongoing					
Implement goose control measures on Fairmount Park Properties, including Peter's Island	N/A	N/A	N/A	N/A	FY 2012	ongoing as needed

Continue implementing a waterfowl management program at Belmont	N/A	N/A	N/A	N/A	Spring 2003	ongoing as needed
Complete implementation of the USDA waterfowl management programs at Queen Lane and Baxter WTPs	N/A	N/A	N/A	N/A	Spring 2011	ongoing as needed
Complete implementation of the USDA waterfowl management program at PWD's three WWTPs	N/A	N/A	N/A	N/A	Spring 2011	ongoing as needed
Watershed-Wide						
Continue to support Lehigh's source tracking research	ongoing					
Raise awareness as to threat animal vectors pose to our drinking water supplies, in particular, by supporting Lehigh's efforts to publish scientific journal articles	ongoing					
Education/Outreach	**Data Collection & Evaluation**		**Planning & Design**		**Implementation/ Completion**	
Project Name	**Start**	**End**	**Start**	**End**	**Start**	**End**
In-City						
Remain an active participant in watershed partnerships and begin integrating drinking water issues into the scope of work for the Wissahickon watershed partnership	ongoing					
Continue to submit a comprehensive annual water quality report that emphasizes critical source water issues	ongoing					
Continue to convene the Water Quality Council (WQC) to address water quality issues on a holistic basis	ongoing					
Continue to work with Fairmount Park to improve the environmental quality of the City's parks and streams	ongoing					
Continue to maintain the FWWIC and promote source water protection through the center's exhibits and programs	ongoing					
Continue to operate and maintain Philly RiverCast and promote the web-based recreational warning system	ongoing					

Implement in-city source water programs - East Falls and Manayunk neighborhoods	Winter 2011	Summer 2012	Fall 2012	Winter 2014	Spring 2014	Spring 2015
Watershed-Wide						
Continue to participate in the SAN workgroups and support initiatives outlined in each group's workplan	ongoing					
Continue to collaborate with the Partnership for the Delaware Estuary on various education and outreach initiatives, including the publication of guidance materials, and organization of public programs and meetings surrounding water quality concerns	ongoing					
Continue to support the Schuylkill River Restoration Fund to achieve implementation of priority projects	ongoing					

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Section 8 Future Action with Regard to State Regulations

In order to maintain the 0.5-log credit for the Watershed Control Plan, PWD will comply with all State-mandated regulations throughout the plan implementation process. The following three action items are required once the Watershed Control Plan is approved:

1) submit an annual watershed control program status report to the State;
2) undergo a watershed sanitary survey every three years for community systems; and,
3) make the watershed control plan, annual status reports, and watershed sanitary survey reports available to the public upon request.

This section outlines the State's watershed control plan regulations and PWD's corresponding future actions.

8.1 Submit an annual watershed control program status report to the State

The focus of the annual status report will be to describe the system's implementation of the approved plan and assess the adequacy of the plan to meet its goals. Implementation of the watershed control plan will involve two main components: maintaining the ongoing initiatives identified in the Section 7 Project Assessments for both the City and entire watershed, and moving forward with implementation of the proposed/future initiatives, also outlined in Section 7. Both aspects of implementation will be assessed in the watershed program status report that PWD will submit to the State on an annual basis. The status of each initiative will be assessed, and evaluations made as to the perceived benefits and overall effectiveness or ineffectiveness for all implemented initiatives. The progress made with implementing future initiatives will be compared to the original "schedule for plan implementation" outlined in Section 7. Upon assessing both current/ongoing initiatives and proposed initiatives, PWD will address any shortcomings in plan implementation, including those previously identified by the State or as a result of the watershed survey conducted as part of the implementation process (US EPA 2006). If shortcomings do exist in the plan implementation process, the status report will explain how PWD plans to address these shortcomings.

In addition, the regulations state that the annual status report must include a description of any significant changes that have occurred in the watershed since the last watershed sanitary survey. PWD will submit a watershed sanitary survey to the State every three years, in accordance with the State's regulatory requirements, and will provide information on any significant watershed changes, should they arise, in the annual status reports that are submitted following each watershed sanitary survey.
PWD will also immediately inform the State if significant changes to the approved watershed control plan are deemed necessary, prior to making any such change. If any changes in the watershed control plan reduce the level of source water protection

originally outlined in the plan, PWD will identify actions that will be taken to mitigate the effect of these changes.

8.2 Develop watershed sanitary survey every 3 years

As part of the plan implementation process, PWD will submit a watershed sanitary survey every three years. The State requires that the survey be conducted according to State guidelines and by persons the State approves. Specific criteria for the sanitary survey are as follows:

1) The watershed sanitary survey must meet the following criteria: encompass the region identified in the State-approved watershed control plan as the area of influence; assess the implementation of actions to reduce source water *Cryptosporidium* levels; and identify any significant new sources of *Cryptosporidium*.
2) If the State determines that significant changes may have occurred in the watershed since the previous watershed sanitary survey, systems must undergo another watershed sanitary survey by a date the State requires, which may be earlier than the regular date.

In accordance with the zone delineations in the Source Water Assessment, PWD has identified Zones A, B, and C, or the entire Schuylkill River watershed, as the area of influence for *Cryptosporidium* contamination at Queen Lane. Potential sources of *Cryptosporidium* located in Zones A and B are considered highest priority. Nonetheless, PWD will work to evaluate the status of potential sources within all three zones.

To assess the implementation of actions to reduce source water *Cryptosporidium* levels, PWD will evaluate the status of ongoing and future initiatives through the annual watershed control plan status report. As stated above, each initiative will be evaluated in terms of its implementation progress and the initiative's observed benefits and overall effectiveness at supporting PWD's source water protection goals.

PWD's Schuylkill River Source Water Assessment (SWA) will serve as the baseline for subsequent sanitary surveys that are completed during the watershed control plan implementation process. Within the SWA, and outlined in Section 5 of this plan, PWD identifies the highest priority point and non-point sources for *Cryptosporidium* contamination at Queen Lane. Updating the original ranking of priority dischargers in the Schuylkill River watershed, Zones A and B, required the following steps: identifying those dischargers that no longer exist or have changes in name or ownership; compiling information regarding updates or improvements made to existing high-priority dischargers; and identifying recently proposed or constructed permitted facilities within the watershed. Section 5 outlines the results of this update. PWD will continue to track the status of these sources for each sanitary survey following approval of the watershed control plan. New facilities that are identified through the status updates will be assessed in terms of their potential impact at the intake, taking into account such factors as time of travel from source to intake, the geographical location (Zone A, B, or C), and the frequency and/or potential for release.

In an effort to improve the accuracy and comprehensiveness of the status updates, PWD will expand its evaluation of wastewater-related changes in the watershed by working with the Schuylkill Action Network (SAN) to identify new sources and persistent areas of concern in regard to pathogen contamination. There are multiple approaches to tracking the progress of wastewater conveyance and treatment system improvements; tracking that is needed to reduce the contaminative risk associated with malfunctioning or hydraulically overloaded systems. Tracking approaches may include working with the State to identify areas of concern through the coordination of 25 PA Code Chapter 94 and Act 537 enforcement. Systematic tracking of these changes will help identify the presence of new priority sources in addition to those identified in the original Source Water Assessment analysis.

PWD will also continue to evaluate the threat posed by non-point sources, specifically, runoff from agricultural land. Section 5 aims to establish a link between pasture/livestock numbers and the prevalence of agricultural activities in each county in the watershed. The results broadly indicate that agricultural activity is either remaining relatively constant or decreasing throughout the watershed. Ideally, PWD would like to update the land use assessment results described in the Source Water Assessment to gain a better understanding of high-priority sub-watersheds with regard to agricultural activities. The Source Water Assessment identified land use categories for each sub-watershed using the 1992 USGS National Land Cover Dataset (NLCD), and updated information from the 2000 Census data for residential and commercial areas. Since direct comparison of the 1992 NLCD and the 2001 National Land Cover Database is not encouraged by the USGS, PWD was not able to directly compare changes in land use between the two datasets. Future efforts to re-assess land use on a sub-watershed scale would use the more recent 2001 National Land Cover Database, updated with 2010 Census data, when it becomes available. A 2011 NLCD is anticipated, but could take several years to publish. When the necessary data becomes available, PWD will re-assess land use to update both this plan and the Source Water Assessment.

In addition to updating and recording changes in point and non-point sources, PWD will request the sanitary surveys from other water utilities throughout the Schuylkill River watershed. Information from these surveys will be used to better direct enforcement efforts through SAN, and compliment the above-described watershed-wide status updates.

8.3 Make the watershed control plan, annual status reports, and watershed sanitary survey reports available to the public upon request

The State mandates that all reports must be in a plain language style and include criteria by which to evaluate the success of the program in achieving plan goals. The State may approve systems to withhold from the public portions of the annual status report, watershed control plan, and watershed sanitary survey based on water supply security considerations.

PWD will provide contact information on the Office of Watersheds website, www.phillywatersheds.org, should members of the public wish to review the watershed control plan and/or the subsequent annual status reports and watershed sanitary surveys. In addition, PWD will include on their Office of Watersheds website a brief overview of how PWD is achieving LT2 compliance, including a summary of action items addressed in the watershed control plan.

Pending approval of the Watershed Control Plan, the following dates should be noted for continued compliance under the LT2 regulation.

Table 8-1 Important Dates for LT2 Watershed Control Plan (WCP) Compliance

Action Item	Due Date
WCP Due to State	April 2011
State Approval of WCP Due	April 2012
First Annual Report Due to State	April 2013*
First Sanitary Survey Due to State	April 2015
Second Round of Crypto Sampling Due	April 2015

*Need to confirm due date if state approves plan earlier than April 2012

8.4 Concluding Statement

PWD's ultimate goal is to lower *Cryptosporidium* concentrations at Queen Lane during the second round of LT2 monitoring. It is very likely that there is no single action item that will guarantee lower *Cryptosporidium* concentrations at the intake; therefore, a comprehensive implementation approach is necessary. PWD's comprehensive approach, as indicated by the in-city and watershed-wide action items outlined in Section 7.5, includes strategies to address wastewater discharges and compliance, agriculture land use and runoff, animal vectors, and continued and expanded education and outreach. For the watershed control plan approach to be successful, PWD will need to rely on the collaboration and cooperation of watershed partnerships. In addition, certain initiatives, such as the incorporation of *Cryptosporidium* monitoring results into monthly DMRs, will require support from state and federal regulatory authorities. Watershed-wide cooperation is needed not only in terms of planning support, but in regard to funding support as well. PWD feels that certain funding programs, such as the USDA/NRCS water quality improvement programs, can more directly support source water projects located above drinking water intakes in the watershed. Although it is a challenge to coordinate source water protection efforts for pathogen contamination on such a large scale, doing so will not only make this watershed control program a success, but will reduce the risks associated with pathogen contamination throughout a large portion of the Schuylkill River watershed.

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Philadelphia Water Department

The ARAMARK Tower
1101 Market Street

Philadelphia, Pennsylvania 19107-2994

August 20, 2012

Mark Johnson
Southeast Regional Program Manager, Safe Drinking Water
Pennsylvania Department of Environmental Protection
2 East Main Street
Norristown, PA 19401

Re: Response to PADEP's Letter Dated March 30, 2012 Regarding the Philadelphia Water Department's Watershed Control Program Plan for the Queen Lane Intake

Dear Mr. Johnson,

The Philadelphia Water Department (PWD) respectfully submits the following responses to the Pennsylvania Department of Environmental Protection's (PADEP's) letter dated March 30, 2012 regarding the Queen Lane Intake Watershed Control Program Plan (WCP) for Long Term 2 Enhanced Surface Water Treatment Rule (LT2) compliance. The proceeding responses address each of PADEP's original comments, which are italicized below. It should be noted that specific sections of the original WCP dated March 2011 are superseded by a revised set of sections attached to this letter in Appendix A. The sections that are to be superseded are clearly indicated and should be considered complete replacements of the original corresponding WCP sections.

Section 109.1204(b)(2)(ii): *Identification of both potential and actual sources of Cryptosporidium contamination and an assessment of the relative impact of these sources on the system's source water quality.*

1. *Clear cross-reference to your 2006 Source Water Protection Plan when used to satisfy this requirement and including modifications or updates to the information regarding Cryptosporidium.*

   The original WCP contains references and updates to pertinent information and data from the Source Water Assessment (SWA) as well as the Source Water Protection Plan (SWPP) for the Queen Lane intake. Since one focus of the WCP is to update the priority sources of *Cryptosporidium* identified in the

2002 SWA, the SWA is more frequently referenced than the SWPP in the original WCP.

The SWPP is cited in the following sections of the original WCP:

- Section 4: Delineation of Area of Influence, page 14;
- Section 5.2: Qualitative Assessment of the Relative Impact of Contamination Sources on Water Quality at the Queen Lane Intake, page 39;
- Section 6.2: Analysis of the Relative Effectiveness of Control Measures in Reducing Cryptosporidium Loadings to Source Water, page 45;
- Section 6.3: Analysis of the Feasibility of Control Measures, page 48; and,
- Section 7: Statement of Goals and Specific Actions, page 50.

2. *A map of sewage treatment plant sources with information on treatment, discharge quantities, and long-term crypto related issues.*

Please refer to Appendix B for a map of wastewater treatment plants (WWTPs) in the Schuylkill River watershed. The map indicates treatment level where data is available, as well as permitted discharge quantities.

In regards to long-term *Cryptosporidium*-related issues, PWD's primary means of identifying WWTP-related issues is through Early Warning System (EWS) notifications. However, the EWS does not provide a fully accurate representation of WWTPs in the watershed that regularly experience sewerage-related issues and may represent a vulnerability to the watershed. Only certain plants are diligent with reporting overflows or other treatment issues to the EWS, so not all sewerage-related events are captured through the system. In addition, *Cryptosporidium* monitoring is not required through NPDES permits. Therefore, there are no comprehensive datasets available to evalute which plants may pose a risk.

One plant that has seen significant issues in the recent past is Reading WWTP. The last event reported to the EWS (on September 21st, 2011) regarding Reading's WWTP cites that an 8-10 MGD raw sewage bypass occurred at the 6th and Canal Pump Station so that two emergency repairs could be made to a 42" force main. Additional events at Reading's WWTP

were reported to the EWS in the weeks preceeding the event on September 21st. Due to Reading's considerable size (permitted flow is 28.5 MGD) and the extent to which they have experienced sewerage-related infrastructure issues in the recent past, it may be appropriate to identify Reading WWTP as a potential vulnerabiltiy for pathogen contamination until sufficient upgrades are completed at the plant.

3. *A land use map showing the locations of agriculture pasture and manure spreading sources.*

   Please refer to Appendix C for a land use map of the Schuylkill River watershed. Future efforts to re-assess land use on a sub-watershed scale would use the more recent 2001 National Land Use Database, updated with 2010 Census data, when it becomes available. A 2011 National Land Cover Dataset (NLCD) is anticipated, but could take several years to publish. As part of PWD's proposed Source Water Protection Program initiatives, PWD plans to update land use characteristics, including pasture and agriculture-related land uses, for the Schuylkill River watershed when the appropriate data becomes available. Please refer to page 125 of the WCP for further explanation regarding the creation of an updated land use map.

4. *A map showing the locations of concentrated animal operations and large lamb or calf population sources.*

   Please refer to Appendix D for a map of concentrated animal feeding operations (CAFOs) in the Schuylkill River watershed. According to the CAFO data, which PWD obtained from PADEP, there are a total of 24 CAFOs in the Schuylkill River watershed. Information on the number and types of animal units present at each farm is also included on the map.

5. *A map of waters impaired by fecal microbial and pathogen contaminant sources for any designated use.*

   Please refer to Appendix E for three maps displaying impaired streams in the Schuylkill River watershed. The first map illustrates impaired streams for various sources of impairment. The second map illustrates impaired streams from agricultural land use, while the third map illustrates impaired streams from pathogen contamination, specifically. All maps were created using data from the Pennsylvania Department of Environmental Protection 2010 Pennsylvania Integrated Water Quality Monitoring and Assessment Report. Watersheds that contain streams impaired by pathogens include the

Tulpehocken Creek, Maiden Creek, French Creek, Perkiomen Creek, and Wissahickon Creek watersheds.

6. *The results of* Cryptosporidium *compliance sampling conducted by other water systems in the Schuylkill River watershed is available and has not been considered in identifying sources or analysis.*

   The results from LT2 *Cryptosporidium* compliance sampling became available to PWD *following* submittal of the WCP in March of 2011. For this reason, the LT2 data from other drinking water treatment plants throughout the Schuylkill River watershed were not utilized in the original WCP. It should also be noted that PWD submitted a grandfathered *Cryptosporidium* dataset from 2001-2003 for LT2 compliance. Therefore, not all LT2 drinking water system data is from the same monitoring period. Regardless of the results from other drinking water systems, PWD would still identify the same priority sources and WCP initiatives for the Schuylkill River Watershed and Queen Lane intake.

   Upon obtaining the LT2 sampling data from other drinking water systems in the state, PWD has concluded that the variabaility in *Cryptosporidium* concentrations, the accuracy issues associated with the analytical method, and the monitoring timeframe for the first round of LT2 sampling at the Queen Lane intake render the results incomparable and of little use when evaluating PWD's WCP. To support this conclusion, it should be noted that the matrix spike recovery for the Queen Lane intake during the LT2 monitoring period (2001-2003) was 43.5%. For monitoring that has occurred since 2003 at the Queen Lane intake, the average percent recovery has increased to 59.6%. To PWD's knowledge, no other plants in the Schuylkill River watershed were placed in Bin 2 or higher as a result of the first round of LT2 sampling. Therefore, despite the presence of priority *Cryptospoiridum* sources such as agricultural land use in the Schuylkill watershed, the LT2 monitoring results and bin classifications do not provide adequate evidence as to whether other intakes or locations in the watershed are "impacted" or "non-impacted" . PWD believes that a presumptive approach that utilizes data from scientific studies is the best method to identify sources and areas of vulnerabiltiy related to pathogen contamation.

Section 109.1204(b)(2)(iii): *An analysis of the effectiveness and feasibility of control measures that could reduce Cryptosporidium loading from sources of contamination to the system's source water.*

Section 109.1204(b)(2)(iv): *A statement of goals and* ***specific actions the system will take*** *to reduce source water Cryptosporidium levels. The plan must explain how the actions are expected to contribute to specific goals, identify watershed partners and their roles, identify resource requirements and commitments, and include a schedule for plan implementation with deadlines for completing specific actions identified in the plan.*

7. *A list of specific watershed partners and their roles. Copies of written agreements with third parties where those parties are expected to implement a specific action (for example: county government, municipal government, federal agencies, private land owners, organizations).*

   Specific watershed partners and their roles are broken down for each project that is currently implemented as part of PWD's Source Water Protection Program. Please refer to Table 7-2: In-City Project Assessment (page 51) and Table 7-3: Watershed-wide Project Assessment (page 67). For future action items that PWD will strive to implement as part of the department's ongoing source water protection efforts, specific partners are identified where possible.

   It is infeasible to gather written agreements with *all* potential future partners at this stage in the WCP process. However, PWD has included letters of support from partners that will be instrumental in the implementation of initiatives specific to this WCP. The letters of support are attached in Appendix F, and include communications with the following individuals - organizations:

   - Lyn O'Hare – Workgroup Lead, Schuylkill Action Network (SAN) Agricultural Workgroup
   - Larry Loyd – Senior Ecologist, Berks County Conservancy (BCC)
   - Dan Grieg – District Excecutive, Berks County Conservation District (BCCD)
   - Jen Adkins – Executive Director, Partnership for the Delaware Estuary
   - Tom Davidock – SAN Coordinator, Partnership for the Delaware Estuary
   - Kurt Zwikl, Executive Director, Schuylkill River National State and Hertiage Area

   In addition to the above letters of support, PWD has attached the following documentation for projects and partnerships relevant to the WCP in Appendix G:

- Contract with Lehigh University for *Cryptosporidium* related research
- Documentation of Philadelphia Water Department Schuylkill River Restoration Fund (SRRF) Contributions for the 2012 funding year
- USDA Waterfowl Management Program Contract

8. *A schedule for plan implementation with deadlines for completing specific actions identified in the plan.* ***Specific information concerning actions and dates relating to sewage treatment plants.***
9. *A more clear and more specific summary comparison between the high impact sources and the specific actions PWD will take.*

PWD would like to address comments #8 and #10 (listed above as # 8 and #9) from the PADEP's March 30th 2012 letter by submitting a revised portion of the WCP. The revised WCP begins at Section 7.4, "Recommendations for Future Actions and their Contributions to Specific Goals," and ends with the final section, Section 9, "Future Action with Regard to State Regulations." Through this revised portion of the WCP, PWD aims to identify WCP-specific initiatives that will physically remove *Cryptosporidium* oocysts from Philadelphia's source waters. In the revised sections, PWD differentiates between Source Water Protection Program initiatives which PWD will *strive* to continue implementing and/or initiate throughout the 5-year WCP implementation period, and those initiatives that are specific to this WCP which PWD *commits* to implementing. To clarify which initiatives constitute the revised WCP, PWD created and/or revised the sections listed below. It should also be noted that significant revisions were made to Section 7.5: "Quantitative assessment of the relative impact of contamination sources and source water protection initiatives on water quality at the Queen Lane intake."

- Section 7.4.2: Watershed Control Program Plan Initiatives
- Section 7.7.2: Watershed Control Program Plan Initiatives: Resource Requirements and Commitments
- Section 7.8: Schedule for Plan Implementation

In the original WCP, PWD identified the following high impact sources of *Cryptosporidium* at the Queen Lane intake: agricultural land use/runoff, WWTP effluent, and contamination from animal vectors. The revised WCP sections identify specific WCP initiatives to address each of the high impact

sources of pathogen contamination. For example, PWD identifies the type and number of agricultural BMPs that will be implemented over the 5-year WCP implementation period. Some project specifics, such as which agricultural BMPs will be implemented at what farms, are contingent upon multiple factors such as resource availability and farmer cooperation. PWD believes that project specifics, including progress updates, can be reported on through the annual WCP status reports. As outlined above, funding details for the revised set of WCP initiatives are provided in Section 7.7, and a schedule for implementation is provided in Section 7.8.

In regard to your comment requesting "Specific information concerning actions and dates relating to sewage treatment plants," it is not feasible for PWD to provide specific information relating to actions and dates for sewage treatment plant upgrades, expansions, and other related projects in the initial WCP. A primary source of information on WWTP projects in the watershed are news releases. This information is gathered on a sporadic basis, as it becomes available. PWD's intent, as stated on page 88 of the original WCP, is to work with the SAN Pathogens/Compliance Workgroup to track WWTP upgrades and new facilities and community sewer improvement projects. The workgroup will compile quarterly reports of all major upgrades and expansions in the Schuylkill River watershed. As deemed appropriate, PWD will include these reports in the annual LT2 WCP status reports to the PA DEP.

10. *Section 7: Statement of Goals and Specific Actions contains items completed before the compliance sampling time period that will not further reduce crypto levels beyond the reduction already achieved. Additionally, this section contains in-city actions that do not affect the area of the Schuylkill River around the intake or upstream (for example: Philadelphia combined sewer overflows or sanitary sewage planning).*

PWD submitted a grandfathered *Cryptosporidium* dataset from 2001-2003 for LT2 compliance. A majority of the projects and initiatives that fall under PWD's Source Water Protection Program were implemented following the monitoring period for LT2. If any projects and initiatives were in place prior to 2001, the long-term positive impacts of these source water protection measures on water quality should not be negated.

In regard to PADEP's comment that select in-city actions do not directly affect the Queen Lane intake, such as PWD's sanitary sewage planning initiatives, PWD would like to clarify that these initiatives are not a focus of the WCP, but instead serve to demonstrate the sewerage-related control

measures that PWD already has in place. PWD's comprehensive in-city CSO and Stormwater Management Programs aim to ensure proper functioning of the City's sewer infrastructure and promote the overarching goal of source water protection. In addition, it should be noted that some in-city projects included in the CSO and Stormwater Management Programs, such as the 2006 Monoshone Assessment, do influence water quality at the Queen Lane intake. PWD has not revised the in-city initiatives section, Section 7.2.1., in the original WCP. However, through the new set of WCP initiatives presented in Section 7.4.2, PWD hopes to clearly convey which projects PWD will focus on to reduce *Cryptosporidium* concentrations at the Queen Lane intake.

Thank you for the opportunity to respond to your comments regarding our Watershed Control Program Plan. We look forward to hearing from you.

Sincerely,

Howard Neukrug
Water Commissioner, City of Philadelphia Water Department

cc: Chris Crockett
John Muldowney
David Katz
Christine Marjoram
Kelly Anderson
Julia Rockwell
Susan Weaver
Joseph Feola
John Fabian
Kevin Smith

APPENDIX A: Revised LT2 Watershed Control Program Plan Sections

Table of Contents

7.4 Recommendations for future actions and their contributions to specific goals

By assessing the comprehensive list of Source Water Protection Program (SWPP) projects and initiatives that contribute to reducing the risk of pathogen contamination in Philadelphia's source waters, PWD is able to evaluate areas of vulnerability that still exist. Listed in Table 7-8 below is a general evaluation of priority sources and whether or not they are adequately being addressed based on the in-city and watershed-wide project assessments.

Table 7-8 General Vulnerability Assessment of Priority *Cryptosporidium* Sources

Priority Cryptosporidium Sources	Currently Being Addressed	
	In-City	In Watershed
Treated WWTP Effluent	N/A	No*
Raw Sewage Discharges	Yes	Yes (Reg.)**
CSOs	N/A	Yes (Reg.)
Defective Laterals	Yes	Yes (Reg.)
Wildcat Sewers	N/A	Yes (Reg.)
SSOs	Yes	Yes (Reg.)
Infrastructure Inspection/Main.	Yes	Yes (Reg.)
Agricultural Runoff	Yes	Yes
Animal Vectors (specifically geese)	Yes	No

*When a priority source is listed as "No," not being addressed, there may exist select sites where the issue is currently being addressed, however, on a larger scale the source still represents a considerable vulnerability.
**"Yes (Reg.)" indicates a source that is generally addressed through regulatory requirements and permit issuances. WWTP effluent is not considered "regulated" since *Cryptosporidium* monitoring is currently not a NPDES permit requirement.

Throughout the watershed, vulnerabilities still exist in the areas of treated WWTP effluent and animal vectors. Issues related to raw sewage discharges may represent a vulnerability, but are not under PWD's jurisdiction to address outside the City of Philadelphia. Agricultural runoff is being addressed both in-city and in the Schuylkill River watershed, however, PWD encourages expanding these efforts to further minimize the threat of oocyst contamination at the intake.

Section 7.4.1 below outlines ongoing and proposed initiatives from PWD's SWPP that are relevant to this Watershed Control Program Plan (WCP). Section 7.4.2 outlines the control measures that are specific to this WCP, and which PWD plans to implement over a 5-year period.

7.4.1 Source Water Protection Program Initiatives

The SWPP initiatives relevant to this WCP are presented below by priority source category for both Philadelphia and the entire watershed, with ongoing initiatives in each category presented first, followed by future/proposed initiatives.

7.4.1.1 Wastewater Discharge/Compliance

Treated effluent is a consistent source of *Cryptosporidium* contamination that is largely outside of PWD's role and jurisdictional rights to address. The following initiatives, which are either led or supported by PWD, aim to reduce the risk of *Cryptosporidium* contamination from treated WWTP effluent while minimizing the occurrence of raw sewage discharges.

Ongoing Initiatives:

In-City

- Continue to regularly review and update Philadelphia's Act 537 Plan. The plan was last updated on February 27th, 2009.

- Continue to implement the initiatives outlined in the annual Combined Sewer Management and Stormwater Management Plans in order to fulfill the City's Stormwater and CSO permits. Ongoing initiatives include monitoring as part of the Defective Lateral Detection and Abatement Program and completion of the Main and Shurs Elimination project.

- Continue to maximize usage for the Early Warning System while maintaining the system's ongoing operations and maintenance needs.

Watershed-wide

- Continue to support Lehigh's *Cryptosporidium* source tracking study by providing support in terms of sampling, elution, and project management and oversight.

- Continue to support efforts of the SAN Pathogens/Compliance Workgroup. The following strategies for the 2010 SAN Pathogens/Compliance Workplan are as follows: 1) Improve discharger/water supplier communication of events and use of the Delaware Valley Early Warning System and PAWARN, 2) identify priority wastewater discharges/issues in the watershed and formulate action plans to address them, 3) provide support (financial, information, expertise, collaborative problem-solving) for partners/communities to implement projects that reduce priority discharges, and 4) provide a forum for partner and agency communication and coordination around discharge issues and the formulation of creative new ideas and approaches for solving related problems (SAN 2010a).

- Continue to support SAN in its efforts to identify and abate wildcat sewers throughout the Schuylkill River watershed.

Proposed Initiatives:

In-City

- Develop a Source Water Assessment update for the Schuylkill River by revisiting priorities established in the 2002 assessment and updating water quality analyses with recent data.

Watershed-Wide

- Support/help develop an effluent monitoring plan for *Cryptosporidium* at major WWTPs in the Schuylkill River watershed. In conjunction with this effort, should *Cryptosporidium* monitoring be considered for incorporation into NPDES permits, PWD will support such an effort. However, in regard to *Cryptosporidium* monitoring, it is very important to PWD that the EPA promulgate an analytical method that takes into account critical factors such as recovery rates and sample variability. Track the progress of these initiatives by continuing to attend SAN Pathogens/Compliance workgroup meetings.

- Through continued participation in the SAN Pathogens/Compliance workgroup, help ensure that high-priority areas requiring regulatory enforcement action are identified and addressed. Areas of concern may be identified using the following measures to track wastewater-related changes in the watershed.

    - Identify high-priority municipalities in need of updated Act 537 Plans in the Schuylkill River watershed. Municipalities with outdated plans located in Zones A and B of the area of influence are especially relevant.
    - Continue to align sewage facilities planning, or Act 537, enforcement with the wasteload management reports filed under Chapter 94.
    - In addition to the above two measures, track WWTP upgrades, new facilities and community sewer improvement projects (such as the sewering of new areas) by reviewing Part II Permits.
    - Track projects funded under government loan programs, such as PennVest.

- Coordinate with SAN to provide wet weather and high flow management education to WWTP operators in a workshop format. Include overview of information that should be included in I & I abatement and high-flow maintenance plans.

- Support future research initiatives surrounding the impact of WWTP effluent on *Cryptosporidium* surface water concentrations by partnering with research organizations and/or academic institutions. Possible research initiatives are outlined in further detail in Section 7.7 below.

7.4.1.2 Agricultural Land Use & Runoff

Within the City of Philadelphia, PWD has addressed agricultural runoff through the projects listed in the in-city assessment. The expanse of agricultural land within the city is obviously minimal, so future agricultural BMP efforts should be focused elsewhere in the watershed. The following SWPP initiatives aim to reduce the impact of agricultural activities on water quality in the Schuylkill River. Please refer to Section 7.4.2 for a list of specific agricultural BMPs that PWD plans to help implement as part of the WCP program.

Ongoing Initiatives

In-City

- BMPs have been implemented at all agricultural sites within the City.

Watershed-Wide

- Continue to be an active participant in the SAN Agricultural Workgroup and support future efforts. The following strategies for the 2010 SAN Agricultural Workplan are as follows: 1) support implementation of projects that demonstrate best management practices and/or creative solutions for agriculture in priority areas (with funding, information, expertise, collaborative problems, solving, etc.), 2) provide a forum for partner and agency communication and coordination around agricultural impacts and issues and the formulation of creative new ideas and approaches for solving related problems, 3) promote agricultural best management practice successes and understanding of agricultural water quality issues and solutions to target audiences in the watershed through an educational/outreach program, and 4) monitor the impacts of agricultural BMP installations on stream water quality.

Proposed Initiatives

In-City

- Develop a maintenance plan for PWD's in-city agricultural BMPs, which include Northwestern Stables, Belmont Stables, Courtesy Stables, Monestary Stables and the WB Saul High School project.

- The National Lands Trust (NLT) is currently performing stream restoration on a tract of land on Erdenheim Farm, located in the Wissahickon watershed. The land is currently not being used for grazing, but may be used for this purpose in the future. PWD will

consider future coordination with the NLT to install additional agricultural BMPs at the farm.

- As part of the Source Water Assessment update process, PWD plans to re-assess land use in the Schuylkill River watershed. To complete this update, the 2001 National Land Use Database will be used, along with more current information from the 2010 Census.

Watershed-Wide

- Coordinate with SAN to develop a maintenance and monitoring plan for the agricultural BMPs installed as a result of the parcel prioritization process. The maintenance plan may be centered on regular visual assessments to identify any problems or repair needs.

- PWD will explore the possibility of partnering with academic institutions on *Cryptosporidium*-related research. Relevant research may include monitoring to assess the efficacy of different agricultural BMPs at removing pathogens from runoff. PWD will also identify priority research needs that may be fulfilled in collaboration with Lehigh University. Potential future research initiatives are outlined in Section 7.7 below.

- Through involvement in the SAN Agriculture Workgroup, PWD will continue to work with partners and state and federal officials to identify priority projects and available funding sources. For funding programs that already exist within the watershed, such as the USDA/NRCS conservation programs outlined in the 2008 Farm Bill, PWD will help promote drinking water protection, and *Cryptosporidium* contamination reduction, as a high-priority water quality improvement goal that requires adequate funding.

- Through the SAN Agriculture Workgroup, PWD will work with partners to identify CAFOs located in the Schuylkill River watershed and assess the status of their NPDES permits.

- Starting in 2012, PWD has committed Schuylkill River Restoration Fund dollars to be directed toward priority agricultural BMPs addressing pathogen-contaminated stormwater runoff from livestock operations. These projects will be selected on an annual basis through the established project selection processes. PWD's commitment through the Schuylkill River Restoration Fund will address priority stormwater and pathogen concerns while promoting the importance of watershed partnerships.

7.4.1.3 Animal Vectors

Wild animals throughout the watershed can serve as mechanical vectors of *Cryptosporidium,* transferring viable oocysts from original hosts to Philadelphia's source

waters. Geese in particular were identified as vectors during the Lehigh-led source tracking studies. The following SWPP initiatives aim to reduce the impacts of geese near PWD's intakes and expand the implementation of animal vector control measures throughout the watershed.

Ongoing Initiatives

In-City

- Maintain plantings at the site of the Belmont Meadow Extension/Intake project. Continue to monitor goose activity around the Belmont intake.

- Continue education/outreach efforts concerning the threat of animal vectors and the role they play in the cycle of pathogen contamination. These efforts may include working with Fairmount Park to expand existing programs, such as the dog waste program, and developing new programs that focus on the relationship between geese and drinking water quality.

Watershed-Wide

- Continue to support Lehigh's source tracking research to further identify and understand the animals that serve as mechanical vectors of *Cryptosporidium* in the watershed.

Proposed Initiatives

In-City

- Identify and implement appropriate goose control measures at Fairmount Park properties, including Peter's Island, and incorporate educational signage in these areas.

- Complete implementation of the USDA waterfowl management program at the Queen Lane, Belmont and Baxter Water Treatment Plants along with PWD's three WWTPs.

Watershed-Wide

- As part of the Source Water Protection Program's education and outreach efforts, raise awareness of the threat animal vectors pose to our drinking water supplies. These efforts may focus on supporting Lehigh's efforts to publish scientific journal articles.

7.4.1.4 Education/Outreach

Education and outreach initiatives are a critical component of PWD's SWPP since point source discharges and land uses throughout the entire Schuylkill River watershed are capable of impacting water quality conditions at Queen Lane. Many education and outreach initiatives are implemented through PWD's watershed partnerships, which are maintained by various programs within PWD. Therefore, a primary PWD goal is to

maintain its watershed partnerships and continue to promote the importance of source water protection. PWD is committed to seeking opportunities that will expand partnership development and strengthen source water protection in the Schuylkill River watershed.

Ongoing Initiatives

In-City

- Remain an active participant in the watershed partnerships and begin integrating drinking water issues into the scope of work for the Wissahickon Watershed Partnership.

- Continue to submit a comprehensive annual water quality report that emphasizes critical source water issues and, in particular, educates customers as to the research initiatives and implementation strategies PWD is using to reduce the risk of *Cryptosporidium* contamination.

- Continue to convene the Water Quality Council (WQC) to address water quality issues on a holistic basis. Utilize the committee as a forum for providing feedback to strengthen the Watershed Control Plan.

- Continue to work with Fairmount Park to improve the environmental quality of the City's parks and streams through land management practices and BMP implementation.

- Continue to maintain the FWWIC and promote source water protection through the center's various exhibits and learning programs.

- Continue to operate Philly RiverCast and promote the web-based recreational warning system.

Watershed-Wide

- Continue to be an active member of the SAN Pathogens/Compliance and Agricultural workgroups and support initiatives outlined in the 2010 workplans.

- Continue to collaborate with the Partnership for the Delaware Estuary on various education and outreach initiatives, including the publication of guidance materials and organization of public programs and meetings surrounding water quality concerns.

- Continue to support the Schuylkill Restoration Fund to achieve implementation of best management practices at high-priority sites in the watershed.

Proposed Initiatives

In-City

Implement in-city source water programs in the East Falls, Roxborough, and Manayunk neighborhoods along the Schuylkill River. These programs will involve the implementation of stormwater management practices, storm drain labels and a dog waste control program. Through the programs, communities will become more involved in protecting their waterways as they develop a better understanding of the impacts of daily activities on their drinking water source.

7.4.2 Watershed Control Program Plan Initiatives

PWD's goal is to maintain and initiate the ongoing and proposed SWPP action items, respectively, identified in Section 7.4.1 above. The action items specific to this WCP consist of structural and non-nonstructural control measures that will physically reduce the loading of *Cryptosporidium* oocysts in the Schuylkill River watershed. The WCP control measures address primary vulnerabilities, specifically, WWTP effluent, agricultural land use/runoff, and animal vectors, that are not fully addressed through the ongoing or proposed SWPP initiatives. The WCP control measures consist of the following: quantifying the water quality implications of UV installation at the Upper Gwynedd and Fleetwood WWTPs; supporting the installation of manure storage units on at least 5 separate farms; supporting the installation of vegetated buffers on at least 5 farms; supporting the completion of at least 5 Comprehensive Nutrient Management Plans (CNMPs) at farms throughout the Schuylkill River watershed; implementing a riparian buffer to deter animal vectors at a select site; and, implementing a PWD waterfowl management program. Each WCP control measure is summarized in Table 7-9 below.

Table 7-9 Watershed Control Program Plan Initiatives

Project	Project Type - Priority Source Addressed	Project Lead/Partners
UV Installation - Upper Gwynedd WWTP	Structural - WWTP Effluent	N/A
UV Installation - Fleetwood WWTP	Structural - WWTP Effluent	N/A
Farm - Manure Storage Unit #1	Structural - Ag Land Use/Runoff	SAN Ag Workgroup Partners/PWD
Farm - Manure Storage Unit #2		
Farm - Manure Storage Unit #3		
Farm - Manure Storage Unit #4		
Farm - Manure Storage Unit #5		
Farm - Vegetated Buffers #1		
Farm - Vegetated Buffers #2		
Farm - Vegetated Buffers #3		
Farm - Vegetated Buffers #4		
Farm - Vegetated Buffers #5		
Nutrient Management Plans - 5 Farms	Non-Structural - Ag Land Use/Runoff	NRCS/SAN Ag Workgroup Partners/PWD
Riparian Buffer Plantings - 1 Site	Structural – Animal Vectors	PWD/SAN Partners
Waterfowl Management Program	Non-Structural - Animal Vectors	PWD/USDA

As stated above, the WCP control measures directly address pathogen contamination from WWTP effluent, agricultural runoff, and animal vectors; three of the primary sources of vulnerability for *Cryptosporidium* contamination in the Schuylkill River watershed and at the Queen Lane intake. Descriptions of PWD's involvement in the implementation of each WCP initiative are provided below.

7.4.2.1 UV Installation at Fleetwood and Upper Gwynedd WWTPs

Although PWD is not directly involved in the installation of UV at the Upper Gwynedd and Fleetwood WWTPs, these and related WWTP upgrade projects should be recognized for their potential to reduce pathogen contamination in the watershed. PWD will continue to track the progress of the Upper Gwynedd and Fleetwood WWTP UV projects, and other significant WWTP upgrade projects, through involvement in the SAN Pathogens and Compliance Workgroup.

7.4.2.2 Agricultural BMPs and Comprehensive Nutrient Management Plans

PWD will directly support the implementation of agricultural BMPs, specifically, manure storage units and vegetated buffers, at a total of 10 separate farms in the Schuylkill River watershed. PWD's primary role will involve funding of the various agricultural projects through annual contributions to the Schuylkill River Restoration (SRRF) fund. Details on PWD's funding goals and commitments are provided in Section 7.7. Actual BMP implementation will be led by PWD's various partners, specifically,

partners involved in the SAN Agricultural Workgroup. Workgroup partners include the Berks County Conservancy (BCC), the Berks County Conservation District (BCCD), and the National Resources Conservation Service (NRCS).

Manure management issues at farms are often addressed through the Comprehensive Nutrient Management Plan (CNMP) process led by NRCS. The NRCS and SAN consider the completion of CNMPs at farms a criteria for funding eligibility in the Schuylkill River watershed. According to the NRCS, CNMPs are "conservation plans unique to livestock operations. These plans document practices and strategies adopted by livestock operations to address natural resource concerns related to soil erosion, livestock manure and disposal of organic by-products" (www.pa.nrcs.usda.gov). PWD's role in supporting the implementation of agricultural BMPs will help ensure that there are adequate resources available to complete additional CNMPs. In tandem with the agricultural BMP implementation goals described above, PWD plans to help support the completion of at least an additional 5 CNMPs at farms in the Schuylkill River watershed.

7.4.2.3 Animal Vector Projects

The general vulnerability assessment presented earlier in Section 7.4 also identified animal vectors as a risk throughout the watershed. To address animal vectors, PWD commits to completing and continuing implementation of a USDA Waterfowl Management Program at PWD's 3 drinking water treatment plans and 3 wastewater treatment plants, and also at additional Fairmount Park Properties, including Peter's Island. Geese on Peter's Island pose a particular threat to the Belmont drinking water intake, as the island is located only 0.20 miles upstream from the intake. The Waterfowl Management Program with USDA includes visual, audible and chemical deterrents, habitat modifications, exclusion measures, and non-lethal waterfowl management techniques. For more information on PWD's contract with the USDA, please refer to Section 7.2.1.3, page 59.

In addition to implementing a Waterfowl Management Program, PWD commits to helping implement a riparian buffer planting at a site (to-be-determined) located in the Schuylkill River watershed. PWD will work in collaboration with SAN partners to identify a geese-impacted site that has the potential to impact water quality at the Queen Lane intake.

7.4.3 Urban & Residential Runoff

Although urban and residential runoff is not as significant a source of *Cryptosporidium* as agriculture runoff and WWTP effluent in the Schuylkill River watershed, Philadelphia is addressing urban runoff through the City's 2009 Long Term Control Plan Update (PWD 2009a). On September 1st, 2009, PWD submitted the Green City, Clean Waters plan to the PADEP and EPA to detail how PWD will invest approximately $2 billion over the next 25 years to reduce CSOs substantially. To ensure this public investment not only results in clean and beautiful waterways, but also provides tangible, additional benefits to our citizens, PWD is dedicating a large portion of this plan to a green stormwater infrastructure approach.

PWD's definition of green stormwater infrastructure includes a range of soil-water-plant systems that intercept stormwater, infiltrate a portion of it into the ground, evaporate a portion of it into the air and, in some cases, release a portion of it slowly back into the sewer system. As a result, less stormwater enters the combined sewer system, ultimately reducing CSOs and the risk of pathogen contamination associated with these overflows. Integrating green stormwater infrastructure into a highly developed area like Philadelphia requires a decentralized and creative approach to planning and design.

Various tools can be implemented to accomplish this, including stormwater planters, rain gardens and green roofs. Implementing innovative green stormwater infrastructure throughout our City can maximize economic, social and environmental benefits for Philadelphia. The following benefits have been associated with green infrastructure implementation in the City:

- Reduced CSOs; approx. 5-8 billion gallons of CSOs avoided per year
- Enhanced groundwater recharge
- Additional habitat and recreation space
- Increased carbon sequestration
- Improved air quality
- Reduced energy and fuel demand
- Mitigation of urban heat island effect
- Higher property values

PWD encourages the use of innovative stormwater management in upstream communities to achieve similar benefits. Philadelphia is implementing green infrastructure on a relatively large scale, but even small-scale green infrastructure projects can have positive water quality impacts. PWD will continue its outreach efforts to educate communities on the innovative designs that can be used to address stormwater management.

Stormwater BMPs are not within the scope of this watershed control plan program. Therefore, the effectiveness of green infrastructure at reducing *Cryptosporidium* surface water contamination is not evaluated in this plan. Urban stormwater BMPs are usually not installed with the primary intention to capture pathogens in runoff. However, the benefits achieved in terms of nutrient and sediment reduction may produce ancillary benefits related to pathogen removal. The 2006 Pennsylvania Stormwater Best Management Practices Manual indicates that vegetated filter strips have a TSS removal efficiency of approximately 30%. Riparian buffer restoration can achieve a pollutant removal efficiency of approximately 65% (PADEP 2006). Turbidity can serve as an indicator of TSS, and the relationship between *Cryptosporidium* and turbidity is made explicit in the EPA LT2 regulations. Therefore, it is reasonable to conclude that the removal of sediment through the implementation of stormwater BMPs that infiltrate runoff may also reduce pathogen levels, including *Cryptosporidium*, in runoff.

7.5 Quantitative assessment of the relative impact of contamination sources and source water protection initiatives on water quality at the Queen Lane intake

The WCP initiatives outlined in Section 7.4.2 above were identified for this plan because they have the potential to reduce the total *Cryptosporidium* watershed load. In order to quantitatively assess the impact of PWD projects and their potential to reduce the total *Cryptosporidium* load in the Schuylkill River watershed, a series of calculations were performed to: 1) provide an estimated range for the total watershed load that is comprised of contributions from the priority sources outlined earlier in this plan and 2) provide an estimated range for the potential reductions in watershed load achieved through the implementation of PWD projects.

Upon determining an estimated range for the total watershed load, a first attempt was made to establish a target reduction by comparing the observed average concentration of 0.076 oocysts/L at the Queen Lane intake during the LT2 monitoring period (2001-2003) to a desired Bin 1 concentration of 0.074 oocysts/L.

It should be emphasized that the calculations described below serve as a preliminary step in developing a quantitative method to assess *Cryptosporidium* loads from priority sources in the Schuylkill River watershed. The method outlined below is based on assumptions and values found in published scientific literature. Due to a lack of data and information available to support quantitative assessments of *Cryptosporidium* sources, the accuracy of this method cannot be determined, and the results should not be used to make any absolute conclusions. The uncertainties associated with quantifying *Cryptosporidium* loads and the impact of priority projects only highlight the need for continued and expanded research.

The following summary provides a description of the quantitative approach used to determine both the watershed loads and the project impact estimates. An explanation is also provided regarding the development of target reductions for the estimated range in total watershed loads.

7.5.1 *Cryptosporidium* Watershed Loads

A range for the total watershed load was calculated based on the potential contribution from high-priority *Cryptosporidium* sources in the Schuylkill River watershed. Using a range, or minimum and maximum estimates, for the proceeding calculations was considered appropriate since significant variations exist in the results, depending on which calculation method is used. The watershed load is comprised of loading estimates for agricultural land use/runoff, WWTP effluent and stormwater runoff. Through the use of two different calculation methods, minimum and maximum watershed loads were established for the impact of agricultural land use and WWTP effluent. Only one method was used to calculate the impact of urban stormwater runoff, thereby resulting in a constant watershed load instead of a range. Brief descriptions of the calculation method(s) used for each source are outlined below.

7.5.1.1 Agricultural Land Use/Runoff Loading Calculations

To produce minimum and maximum estimates, two different calculation methods were used to determine the contribution from agricultural land use/runoff to the total oocyst watershed load. The first method is similar to the approach used in the Source Water Assessment (SWA), in which a land use analysis, runoff volumes, and a *Cryptosporidium* event mean concentration (EMC) are used to calculate a total *Cryptosporidium* watershed load. The second method utilizes estimated infected livestock populations for the entire Schuylkill River watershed, as well as oocyst shedding rates for each category of livestock (C. Crockett, personal communication, December 2010).

The two methods result in significantly different estimates for the impact of agricultural land. The SWA, or runoff, method results in a watershed load that is 2 orders of magnitude lower than the watershed load calculated using the animal population method. Therefore, the watershed load that results from the runoff method was designated as the minimum loading estimate, and the watershed load that results from the animal population method was designated as the maximum loading estimate. The results from the two sets of calculations are displayed in Table 7-10 below.

Table 7-10 Annual *Cryptosporidium* Oocyst Load Attributable to Agricultural Land Use

Watershed Load Source	Min Estimate (oocysts/yr)	Max Estimate (oocysts/yr)
Agricultural Land Use	6.65E+12	7.75E+14

7.5.1.2 WWTP Effluent Loading Calculations

To calculate a range for the impact of WWTP effluent on the total oocyst watershed load, minimum and maximum values for oocysts/Liter in secondary effluent were used. The secondary effluent concentrations are based on pooled values from various sources of literature, and are documented in Crockett's 2007 paper titled *The Role of Wastewater Treatment in Protecting Water Supplies against Emerging Pathogens*. The oocyst concentrations were each multiplied by the average daily flow rate, in MLD, of each of the 72 WWTPs in the Schuylkill River Watershed to determine a total daily load. For the plants that have tertiary treatment systems, an additional 1 log, or 90% removal, was assumed for effluent oocyst concentrations. The results from these calculations are displayed in Table 7-11 below.

Table 7-11 Annual *Cryptosporidium* Oocyst Watershed Load Attributable to WWTP Effluent

Watershed Load Source	Min Estimate (oocysts/yr)	Max Estimate (oocysts/yr)
WWTP Effluent	5.09E+09	6.51E+14

The large range in watershed loads is attributable to the significant range in secondary effluent oocyst concentrations used in the calculations (Crockett 2007).

7.5.1.3 Urban/Developed Stormwater Runoff Loading Calculations

To calculate an estimate for the annual oocyst watershed load from urban stormwater runoff, the approach from the SWA was used. The SWA, or runoff, method utilizes a land use analysis, runoff volume, and a *Cryptosporidium* EMC for urban/developed land. Land use categories and EMCs that encompass urban/developed lands were

selected from the 2005 Schuylkill River Source Water Assessment. Only one method was considered feasible for these calculations, so the minimum and maximum estimates are equivalent. The result for the urban stormwater runoff calculations are displayed in Table 7-12 below.

Table 7-12 Annual *Cryptosporidium* Watershed Load Attributable to Urban Stormwater Runoff

Watershed Load Source	Estimate (oocysts/yr)
Urban Stormwater Runoff	1.14E+12

7.5.1.4 Total *Cryptosporidium* Watershed Load Results

Minimum and maximum estimates for the total annual watershed load were calculated by summing the minimum and maximum results for loading from agricultural land use, WWTP effluent and urban stormwater runoff, respectively. A summary of the oocyst loading calculations for the Schuylkill River watershed is provided in Table 7-13 below.

Table 7-13 Annual *Cryptosporidium* Watershed Loading Estimates

Watershed Load	Min Estimate (oocysts/yr)	Max Estimate (oocysts/yr)
WWTP Effluent	5.09E+09	6.51E+14
Agricultural Land Use	6.65E+12	7.75E+14
Stormwater Runoff	1.14E+12	1.14E+12
TOTAL LOAD	**7.80E+12**	**1.43E+15**

7.5.2 Target Reduction

Using the estimated minimum and maximum *Cryptosporidium* total watershed loads, a range of target reductions was calculated. There is no way to guarantee that achieving a target reduction will subsequently lower the oocyst concentration at the intake. However, a benchmark reduction still helps define a quantitative target for reducing the watershed load, and also provides a means to evaluate the impact of source water protection initiatives.

To calculate a benchmark reduction, the ratio of 0.074 oocysts/L, or a maximum Bin 1 concentration, to 0.076 oocysts/L, or the observed concentration at the intake, was used. Based on the ratio of 0.074/0.076, a target reduction of 2.7% was calculated. Multiplying the total watershed loads by 2.7% yields the minimum and maximum target reductions listed in Table 7-14 below.

Table 7-14 Target Reduction Estimates for the Range in Total *Cryptosporidium* Watershed Loads

Watershed Load	Min Estimate (oocysts/yr)	Max Estimate (oocysts/yr)
TOTAL LOAD	**7.80E+12**	**1.43E+15**
TARGET REDUCTION (2.7% of total load)	**2.11E+11**	**3.85E+13**

7.5.3 Project Impact Estimates

As projects are implemented under the LT2 watershed control plan program, their impact can be assessed using the same presumptive approaches used to estimate the total watershed load. The impact, or potential for reducing the total watershed load, can then be compared to the range in target reductions that is established above. PWD calculated minimum and maximum estimates for the potential impact of select control measures. The control measures included in this analysis are: UV installation at 2 plants in the Schuylkill River watershed, the installation of manure storage units on at least 5 separate farms, and the installation of vegetated buffers on at least 5 separate farms. The minimum and maximum impact estimates for each control measures were established using the same calculation methods as in the watershed load estimates described above. The impact estimates for each individual control measure were then compared to the range of target reductions for the total oocyst watershed load. The calculation methods for each group of control measures are presented below.

7.5.3.1 UV Installation at WWTPs

PWD has confirmed that since the first round of LT2 monitoring, UV machines are installed or will be installed at the Upper Gwynedd and Fleetwood WWTPs, respectively. The following news releases pertain to the installation of UV treatment at the Upper Gwynedd and Fleetwood WWTPs. The status of these projects should be periodically checked throughout the WCP implementation period. News releases pertaining to the UV installation projects are listed below.

- *Upper Gwynedd is improving creek health, saving cash with UV system*
  Published: 3/11/11 in the Lansdale Reporter

- *Activation of UV disinfection system at Upper Gwynedd treatment plant delayed*
  Published: 11/17/11 in the Lansdale Reporter

- *Municipal authority set to switch to UV disinfection system*
  Published: 2/22/2012 in the Reading Eagle

The UV disinfection dose for wastewater and reuse applications has traditionally ranged from 40-100mJ/cm^2, with up to 4 log inactivation achieved at a dose of 40 mJ/cm^2 (CH2MHill 2009). In order to calculate the impact of UV installation at the Upper Gwynedd and Fleetwood WWTPs, a conservative 3 log removal/inactivation in *Cryptosporidium* oocyst concentrations was applied to the average flows at both plants. A range for the impact of UV installation at the two WWTPs was calculated using both the minimum and maximum values for oocysts/Liter in secondary effluent. The minimum potential removal/inactivation and maximum potential removal/inactivation estimates were then compared to the minimum and maximum target reductions, respectively. The results of these calculations are displayed below in Table 7-15.

Table 7-15 Estimates for the Impact of UV at Upper Gwynedd & Fleetwood WWTPs

STRUCTURAL CONTROL MEASURE	Min Potential Inactivation (oocysts/yr)	Max Potential Inactivation (oocysts/yr)	Min Reduction as % of Min Target Reduction	Max Reduction as % of Max Target Reduction
UV Installation - Upper Gwynedd	1.41E+08	1.80E+13	0.07%	46.8%
UV Installation - Fleetwood	2.61E+07	3.34E+12	0.01%	8.7%
TOTALS	**1.67E+08**	**2.14E+13**	**0.08%**	**55.5%**

The large range in the potential impact of UV installation on the watershed load is attributable to the significant range in secondary effluent oocyst concentrations, as noted earlier. It should be emphasized that although UV disinfection inactivates *Cryptosporidium* oocysts, it does not physically remove oocysts in WWTP effluent. Therefore, although public health risks are substantially reduced through oocyst inactivation, non-viable oocysts or empty oocyst shells will not be differentiated from viable and infectious oocysts under the current EPA monitoring methods used at drinking water treatment plant intakes.

7.5.3.2 Implementation of Agricultural BMPs

The same two methods used to calculate the potential impact of agricultural land use on the total oocyst watershed load were used to establish a range of project impact estimates. Each of the two methods was applied to two different agricultural BMPs: manure storage units and vegetated buffers. For manure storage units, it was assumed that all contaminated manure and/or runoff (100%) is prevented from reaching surface water. The assumption of 100% removal is appropriate since although data is not available to establish a percent removal, the impact of storage units is known to be significant. For vegetated buffers, an average 2 log (99%) oocyst removal from contaminated manure and/or runoff was assumed. The vegetated buffer removal rate is based on a 2002 article titled *Transport of* Cryptosporidium parvum *Oocysts through Vegetated Buffer Strips and Estimated Filtration Efficiency*. According to the study, "Log_{10} reductions for spiked *C. parvum* oocysts ranged from 1.0 to 3.1 per meter of vegetated buffer…" for buffers with specific design characteristics. The study further concludes that the results indicate "...a vegetated buffer strip comprised of similar soils at a slope of ≤ 20% and a length of ≥ 3m should function to remove ≥ 99.9% of *C. parvum* oocysts from agricultural runoff generated during events involving mild to moderate precipitation" (Atwill et al 2002).

For all agricultural BMP calculations, a "standard" farm with several set parameters was assumed. The characteristics of the standard farm are as follows:

- 120 acre dairy farm
- 80 cows (includes heifers) and 10 calves

All standard farm characteristics were confirmed as appropriate for the Schuylkill River watershed with Larry Lloyd from the Berks County Conservancy (BCC) and Nick Ramsey from the National Resources Conservation Service (NRCS). The animal

population estimates were also confirmed using the USDA's definition of a small farm, which is said to contain between 25 and 70 animal units of any type.

Minimum and maximum estimates for the impact of manure storage units and vegetated buffers were calculated using the standard farm parameters. For the minimum estimates, the stormwater runoff method was utilized for each standard farm. For the maximum estimates, the animal population method was used for each standard farm. The results from these calculations are displayed in Table 7-16 below.

Table 7-16 Estimates for the Impact of Manure Storage Units and Vegetated Buffers

Structural Control Measure	Estimated Min Reduction/Farm (oocysts/yr)	Estimated Max Reduction/Farm (oocysts/yr)	Min Reduction as % of Min Target Reduction	Max Reduction as % of Max Target Reduction
Manure Storage Unit*	2.20E+09	2.41E+12	1.04%	6.3%
Vegetated Buffer**	2.18E+09	2.38E+12	1.03%	6.19%
TOTALS (5 Farms – Manure Storage Units)	**1.10E+10**	**1.20E+13**	**5.22%**	**31.26%**
TOTALS (5 Farms – Vegetated Buffers)	**1.09E+10**	**1.19E+13**	**5.17%**	**30.95%**

*Assumes 100% removal by manure storage units
**Assumes 2 log (99%) removal by vegetated buffers

For each standard farm, the reduction achieved by a manure storage unit can range from approximately 1% to 6% of the min and max target reductions in the total watershed load, respectively. For a standard farm with vegetated buffers, the reduction achieved by the buffer can also range from approximately 1% to 6% of the min and max target reductions in the total watershed load, respectively. Assuming that manure storage units and vegetated buffers are installed at 5 separate farms each (10 farms total), the results indicate that a cumulative maximum reduction of over 60% of the max target reduction can be achieved.

7.5.3.3 Total Loading Impacts from the Selected Control Measures

As a final step, the cumulative impact of all control measures on the minimum and maximum total watershed loads was calculated. Comparisons were only made within the minimum and maximum estimates for each set of values (i.e., only minimum loading estimates were compared to the minimum target reduction in total watershed load and vice versa).

By summing the potential impacts of UV installation at two WWTPs and agricultural BMP implementation at 10 separate farms, the range of estimates for cumulative impact displayed in Table 7-17 below was calculated.

Table 7-17 Potential Cumulative Impacts of the Selected Control Measures

Cumulative Min Potential Reduction as % of Min Target Reduction	Cumulative Max Potential Reduction as % of Max Target Reduction
10.5%	>100%*

*Actual percentage comes to approximately 118% of the max target reduction

7.5.4 Conclusions Regarding the Quantitative Approach

Several conclusions can be drawn from the quantitative approaches developed for the LT2 Watershed Control Plan.

1) Estimating the impact of different sources of *Cryptosporidium* is only possible using a presumptive approach that relies heavily on values found in published scientific literature. The accuracy of this approach is unclear and most likely results in an overestimate of the number of *Cryptosporidium* oocysts that reach surface waters within the Schuylkill River watershed.
2) It is clear from the wide range of percentages displayed in Table 7-16 above that the extent to which the selected WCP control measures will reduce the oocyst watershed load is highly variable. However, the calculations do indicate at least a 10% contribution to the target reduction in total watershed load. It can be concluded that the selected control measures for WCP implementation will have a positive impact, but their precise impact is indeterminable through quantitative analysis alone.
3) The Schuylkill River watershed is a large area to consider as the area of influence. While sources of *Cryptosporidium* throughout the entire watershed should be taken into account, the factors that affect the impact of contamination sources and the delivery ratio, or the percent of oocysts that travel from source to surface waters, are amplified many times over such a large area.
4) During the second round of LT2 monitoring, improvements in the analytical methods used to detect *Cryptosporidium* may affect the observed surface water concentrations at the intake. Therefore, the oocyst concentration at the intake during the second round of monitoring may reflect the improved analytical method, and not the impact or success of source water protection initiatives. Since the 1st and 2nd rounds of monitoring are not suitable for comparison due to changes in the recovery rates, evaluation of program success should focus on tracking the implementation of the WCP initiatives outlined earlier in this plan. Any quantitative approach used to measure program success should focus on updating relevant calculations and modeling results as changes to priority point and non-point sources are identified and additional research is performed.
5) Moving forward, expanding data collection and research opportunities will be necessary to develop a better understanding of the sources of *Cryptosporidium* and the effectiveness of source water protection initiatives. PWD proposes several research initiatives for increasing the understanding of agriculture and WWTP effluent sources of *Cryptosporidium*. These initiatives are listed below in Section 7.6

7.6 Future research initiatives

The quantitative approaches used to calculate *Cryptosporidium* loads in the Schuylkill River watershed clearly indicate that more research is needed to not only improve the accuracy of future quantitative assessments, but also to increase PWD's understanding

of the impact of specific *Cryptosporidium* sources on surface water concentrations at the Queen Lane intake.

It has been established that agricultural runoff and WWTP effluent both have a direct impact on source water concentrations of *Cryptosporidium*. PWD proposes several research initiatives that aim to improve the understanding of *Cryptosporidium* surface water contamination as it relates to agriculture sources and WWTP effluent. The proposed research initiatives and the mechanisms through which research and monitoring can be performed are described below.

7.6.1 Agriculture Related Research

Section 6, Analysis of Control Measures, describes projects elsewhere in the nation that attempt to quantify the oocyst removal capabilities of agriculture BMPs. The presumptive approach described above relies heavily on values from literature to provide quantitative estimates for the prevalence of infection in livestock populations and oocyst shedding rates. Although existing data are helpful in developing a general understanding of the impact of agriculture sources and the effectiveness of select control measures, many of these results are site-specific and not necessarily directly applicable to farms in the Schuylkill River watershed.

In order to increase the understanding of agriculture impacts in the Schuylkill River watershed, PWD proposes localized, long-term research efforts that focus on farms that have the potential to contribute to surface water contamination at the Queen Lane intake. Future focused research efforts may include the following components that are listed below.

- Increased monitoring at farm BMP sites in the Schuylkill River watershed.
- Increased monitoring upstream and downstream of farms in the Schuylkill River watershed.
- Assessing, in greater depth, agriculture sources of contamination in the subwatersheds listed in the Source Water Assessment's prioritization of *Cryptosporidium* sources.
- Evaluating farms within the Schuylkill River watershed and developing site-specific farm management practices that will reduce the risk of *Cryptosporidium* surface water contamination. Management practices could include containment and manure management of potentially infected calf populations.

Through research efforts similar to those listed above, PWD and its watershed partners may be able to gain a better understanding of the water quality impacts of specific agriculture sources as well as the most effective practices available to reduce these impacts within the Schuylkill River watershed.

7.6.2 WWTP Related Research

Treated WWTP effluent is generally a concern when it comes to protecting drinking water supplies; *Cryptosporidium* being one aspect of this concern. Using a presumptive approach based on results from pooled literature sources, PWD was able to estimate a range of *Cryptosporidium* loads attributable to WWTP effluent in the Schuylkill River

watershed. Moving forward, monitoring downstream of WWTPs in the Schuylkill River watershed will increase PWD's understanding of the relationship between treated effluent and *Cryptosporidium* surface water concentrations.

In collaboration with Lehigh University, PWD has already begun to explore possible research areas involving the impact of WWTP effluent. Lehigh is currently evaluating the efficacy of biofilms in capturing the presence of oocysts in surface waters. One proposed research area involves using biofilm samplers to capture the impact of WWTP effluent by installing samplers both upstream and downstream of WWTPs. In addition to focusing on the impact of WWTPs, this study also explores the use of biofilms as a significantly cheaper monitoring alternative to *Cryptosporidium* filters. Identifying new and less costly *Cryptosporidium* monitoring methods is an important area of research that, if expanded upon, could potentially increase the feasibility of collecting and analyzing *Cryptosporidium* monitoring data over larger areas of study and for longer periods of time.

7.6.3 Additional Research Opportunities and the Mechanisms through which Research can be Performed

PWD's partnerships with water research organizations and academic institutions create an opportunity to further *Cryptosporidium*-related research in the watershed. Organizations such as the Water Research Foundation (WaterRF) and the American Water Resources Association (AWRA) could be instrumental in leading *Cryptosporidium* research studies. PWD, as an active member of these organizations, can help identify priority research areas and support project planning efforts. In addition, PWD could expand its opportunities to partner with academic institutions as priority projects are identified.

In order to identify the highest priority research needs relating to *Cryptosporidium* and the threat it poses to our nation's drinking water supplies, PWD proposes the creation of a forum or working group. The working group could consist of research organizations, utilities, regulators, and leading researchers in the field of *Cryptosporidium* and source water contamination. The knowledge base and varying perspectives of workgroup participants would help identify areas most in need of continued research, while also providing utilities, such as PWD, with a better understanding of how they may interpret and utilize existing research results.

In addition to forming a working group, PWD believes it would be beneficial to create a literature database that captures and organizes the results from both ongoing and completed research studies. A research database could be extremely useful in assessing existing projects, gaps in research, and also to serve as a tool for utilities to evaluate what research is applicable to their watershed and what research is strictly site-specific.

7.7 Resource goals and commitments

7.7.1 Source Water Protection Program Initiatives: Resource Goals

Budgets for the ongoing and future initiatives described in Section 7.4.1above were assessed. The numbers presented in Table 7-18 below represent PWD resources allocated to SWPP initiatives that *may* contribute to pathogen contamination reduction in the Schuylkill River watershed. The budget values for each initiative are either based on contract numbers or on staff full-time equivalent (FTE) calculations. Funding details for the specific projects that PWD plans to help implement for this WCP are provided in Section 7.8.2 below.

Table 7-18 PWD Source Water Protection Program Initiatives & Estimated Budget

Wastewater Discharge/Compliance	
Project Name	**Project cost/year**
In-City	
Continue to regularly review and update Philadelphia's Act 537 Plan	$23,000.00
Continue to implement initiatives outlined in the annual Combined Sewer Management and Stormwater Management Plans	$100,000.00
Maximize usage for the Early Warning System while maintaining the system's ongoing O&M needs	$360,000.00
Develop a Source Water Assessment update for the Schuylkill River	$23,000.00
Subtotal:	**$506,000.00**
Watershed--Wide	
Continue to support Lehigh's *Cryptosporidium* source tracking and biofilm sampling studies in Philadelphia's source waters	$218,000.00
Continue to support efforts of the SAN Pathogens/Compliance Workgroup's annual workplans	$60,000.00
Support SAN efforts to identify and abate wildcat sewers throughout the Schuylkill River watershed	--
Support PADEP efforts to develop an effluent monitoring plan for *Cryptosporidium* at major WWTPs in the Schuylkill River watershed	--
Through SAN, help ensure high priority areas requiring regulatory enforcement action are identified and addressed	--
Coordinate with SAN to provide wet weather and high flow management education to WWTP operators in a workshop format	--
Subtotal:	**$278,000.00**

Agricultural Land Use & Runoff	
Project Name	**Project cost/year**
In-City	
Develop maintenance plans for PWD's in-city agricultural BMPs	$11,500.00
Consider coordinating with National Lands Trust to install agricultural BMPs at Erdenheim Farm	$23,000.00
Re-assess land use in the Schuylkill River watershed	$11,500.00
Subtotal:	**$46,000.00**
Watershed--Wide	
Continue to actively participate in the SAN Agricultural Workgroup and support initiatives outlined in the annual workplans	$34,500.00
Coordinate with SAN to develop maintenance and monitoring plans for BMPs installed as a result of the parcel prioritization process	--
Identify priority projects and available funding sources	--
Assess status of CAFO NPDES permits in the Schuylkill River watershed	--
Subtotal:	**$34,500.00**

Animal Vectors	
Project Name	**Project cost/year**
In-City	
Maintain plantings at the site of the Belmont Meadow Extension/Intake project; continue to monitor goose activity	$5,800.00
Continue education/outreach efforts, including working with Fairmount Park to expand existing programs or create new programs that focus on the relationship between geese and drinking water	$3,000.00
Complete implementation of the USDA waterfowl management programs at Queen Lane and Baxter WTPs, as well as PWD's 3 WWTPs	$80,000.00
Identify and implement appropriate goose control measures at Fairmount Park properties, including Peter's Island	$80,000.00
Subtotal:	**$168,800.00**

Watershed--Wide	
Continue to support Lehigh's source tracking research (accounted for above)	--
Raise awareness as to threat animal vectors pose to our drinking water supplies, in particular, by supporting Lehigh's efforts to publish scientific journal articles	$5,800.00
Subtotal:	**$5,800.00**
Education/Outreach	
Project Name	**Project cost/year**
In-City	
Remain an active participant in watershed partnerships and begin integrating drinking water issues into the scope of work for the Wissahickon watershed partnership	$70,000.00
Continue to submit comprehensive source water protection components and updates to the annual water quality report that emphasizes critical source water issues	$23,000.00
Continue to convene the Water Quality Council (WQC) to address water quality issues on a holistic basis	$1,400.00
Continue to work with Fairmount Park to improve the environmental quality of the City's parks and streams	$600,000.00
Continue to maintain the FWWIC and promote source water protection through the center's exhibits and programs	$115,000.00
Continue to operate and maintain Philly RiverCast and promote the web-based recreational warning system	$19,000.00
Implement in-city source water programs - East Falls and Manayunk neighborhoods	$23,000.00
Subtotal:	**$851,400.00**
Watershed--Wide	
Continue to participate in the SAN workgroups and support initiatives outlined in each group's annual workplan	$17,000.00
Continue to collaborate with the Partnership for the Delaware Estuary on various education and outreach initiatives, including the publication of guidance materials, and organization of public programs and meetings surrounding water quality concerns	$25,000.00
Continue to support the Schuylkill River Restoration Fund to achieve implementation of priority projects	$100,000.00
Subtotal:	**$142,000.00**
Research	
Support ongoing research needs that focus on high priority sources of *Cryptosporidium*, specifically agricultural land use/runoff and WWTP effluent	$50,000.00
Subtotal:	**$50,000.00**
TOTAL:	**$2,082,500.00**

7.7.2 Watershed Control Program Plan Initiatives: Resource Requirements and Commitments

The WCP initiatives focus on reducing the *Cryptosporidium* watershed load through the implementation of structural and non-structural BMPs. BMPs that directly address high priority sources of *Cryptosporidium* are likely to have an impact on the surface water concentrations of *Cryptosporidium* in the watershed. PWD will either fund or directly contribute funding to the following projects: agricultural BMPs (manure storage units and vegetated buffers), Comprehensive Nutrient Management Plans, riparian plantings, and the waterfowl management program.

7.8 Schedule for plan implementation

This WCP implementation plan is based on a five-year timeline, commencing with WCP approval. Therefore, if the plan is approved during 2012, PWD's goal will be to implement the WCP projects outlined in Section 7.4.2 by 2017. The 2017 deadline is two years following submittal of the 2nd round of LT2 monitoring and the first sanitary survey to the State. Following approval of the plan, the status of each WCP project will be reported on in the plan's status reports, which PWD will submit to the PADEP on an annual basis.

In regard to the SWPP initiatives listed in Table 7-18 above, PWD's goal is to maintain or initiate the projects throughout the 5-year WCP implementation timeline. If any major status updates regarding these initiatives do occur, such as notable successes or the discontinuation of an activity or project, PWD will report on these changes during the WCP annual status reports. However, the WCP implementation program will strictly focus on the control measures, outlined in Section 7.4.2, which aim to physically reduce the loading of *Cryptosporidium* oocysts in the Schuylkill River watershed.

The status of each WCP control measure or project will form the basis of each annual status report submitted to the State. Should any changes to the proposed project implementation schedule occur, PWD will report each change and the subsequent reasons for altering the schedule in the annual status report submitted to PADEP. A schedule for the implementation of each WCP control measure is provided in Table 7-19 below.

Table 7-19 LT2 Watershed Control Plan Implementation Schedule

Project	Implementation Timeframe		
	Project Initiation	Construction Started	Project/Construction Complete
Farm - Manure Storage Unit #1	2012	2012	2013
Farm - Manure Storage Unit #2	2013	2013	2014
Farm - Manure Storage Unit #3	2014	2014	2015
Farm - Manure Storage Unit #4	2015	2015	2016
Farm - Manure Storage Unit #5	2016	2016	2017
Farm - Vegetated Buffers #1	2012	2012	2013
Farm - Vegetated Buffers #2	2013	2013	2014
Farm - Vegetated Buffers #3	2014	2014	2015
Farm - Vegetated Buffers #4	2015	2015	2016
Farm - Vegetated Buffers #5	2016	2016	2017
Riparian Buffer Plantings - 1 Site	2014	2014	2014
Waterfowl Management Program	2011	N/A	2017
Nutrient Management Plans - 5 Farms	2012 - 2017	N/A	2017

As outlined in Table 7-19 above, PWD plans to support the implementation of agricultural BMPs at two farms each year over 5 years. By 2014, PWD will also initiate a riparian buffer planting project with SAN partners. Implementing the USDA Waterfowl Management Program and completing 5 Comprehensive Nutrient Management Plans will occur throughout the 5-year WCP implementation period.

PWD is not responsible for funding the UV installation projects at Upper Gwynedd and Fleetwood WWTPs. However, as stated earlier, PWD will track the progress of these projects in collaboration with the SAN Pathogens Workgroup.

Section 8 Other Accomplishments in the Schuylkill River Watershed

8.1 Enforcement

PWD's commitment to reducing the risk of pathogen contamination in the watershed, and supporting its partners in this effort, is clearly evident through the extensive list of projects above. Enforcement efforts on the part of municipal, county, state and federal regulators are also a critical component of PWD's goal to ensure a safe drinking water source for the City of Philadelphia.

At the end of 2009, the SAN Pathogens and Compliance Workgroup compiled a list of state highlights and accomplishments for the year. These accomplishments demonstrate the workgroup is fulfilling its mission to address pathogen contributions in the watershed through the following action items: improving reporting of sewage overflows; promoting self-assessment by local municipalities of sewer collection system capacity, maintenance, operation and management; and ensuring compliance with combined system regulation/requirements, targeted inspections, compliance assistance, and appropriate enforcement (SAN 2009). Table 8-1 below details the 2009 SAN Pathogens and Compliance Workgroup highlights.

Table 8-1 SAN Pathogens & Compliance Workgroup Highlights, 2009

Project Location	Description
Schuylkill Valley Sewer Authority (Schuylkill County)	As of June 2009, approximately 95% of the households in the following areas have been connected to public sewage treatment, eliminating partially treated and/or untreated wastewater discharges into the headwaters of the Schuylkill: Brockton, Mary-D, Tuscarora, Schuylkill Twp, Cumbola, Kaska, Silver Creek, Blythe Twp, Middleport, and New Philadelphia
Lansford Borough (Schuylkill County)	A $2.9 million project to separate stormwater from sanitary sewage lines is nearly complete. The project will results in a 40% reduction of stormwater into the WWTP shared with neighboring Summit Hill and Coaldale, thereby eliminating sewage overflows into Panther Creek. The state has imposed a moratorium on development in all three communities due to sewage overflows.
West Penn and Walker Township (Schuylkill County)	Work continues on updating the Act 537 Plan for West Penn and Walker Township to address malfunctioning on-lot sewage disposal systems and wildcat sewers in the areas of Reynolds and Clamtown, which impact the Little Schuylkill River. West Penn is under a mandate from EPA to correct illegal wildcat sewer systems that were identified in South Tamaqua and were found to be discharging directly into the Little Schuylkill River.
Lynn Township WWTP Expansion (Lehigh County)	PADEP has approved the municipality's Act 537 Plan to expand its overloaded WWTP. The expansion will double the capacity to 160,000 GPD. The plant serves approximately 450 customers, including the village of New Tripoli, properties along Route 309 and the Northwestern Lehigh School District's main campus; effluent is discharged into Ontelaunee Creek.
Sewage Plans for Maxatawny Township (Berks County)	After a decade of planning, Maxatawny Twp has submitted plans to PADEP for a $9.5 million STP. The facility would serve about 250 homes and businesses that have malfunctioning on-lot sewage disposal systems. The plant will be located on land owned by the Borough of Kutztown and is designed to handle 140,000 GPD. The Twp Municipal Authority received a $4.5 million H2O PA Grant in July and the balance will likely be funded through a loan.

City of Reading (Berks County)	Reading will miss the federal government's November 2012 deadline to open a new STP on Fritz's Island, and may face possible fines. The sewer plant is being built under a consent decree imposed on Reading in 2004. The City must also repair the conveyance system to the plant. The city is proposing to replace the existing force main with a $70 million 10-ft diameter tunnel. The existing main cracked open in January 2008, releasing an estimated 20 million gallons of raw sewage into the Schuylkill River.
Robeson and Union Townships Sewer Line Study (Berks County)	Robeson and Union township municipal authorities continue to study options for conveying sewage from the Geigertown area to the Birdsboro WWTP. The municipalities are under a PADEP mandate to provide public sewer service to 113 homes in Geigertown, where many on-lot systems have failed.
PADEP v. David Weiszer (Berks County)	Water Management Program staff in both the SE and SC Regional Offices worked jointly on an enforcement case involving unpermitted discharges of industrial waste from a poultry processor in Exeter Twp. The case specifically dealt with significant amounts of chicken waste that were being discharged directly into an unnamed tributary of the Schuylkill River. In January, PADEP filed a complaint for civil penalties under the Clean Streams Law in the amount of $176,000. On August 28th, the PADEP served defendant with a Request for Admissions and the defendant failed to respond. On November 2nd, the PADEP filed a Motion for Summary Judgment with the Board based upon the legal premise that all PADEP's Admissions are now deemed admitted by the Defendant, and no dispute of material fact exists as to the Defendant's liability for violations of the Clean Streams Law.
West Pikeland Twp (Chester County)	In the process of updating their Act 537, a special area of interest was identified in the lower end of the twp where public sewage is needed for approximately 80 homes that have malfunctioning OLDS. Recently the twp released a copy of a summary of sewage needs data compiled from a survey sent to residents. Earlier this year, twp officials estimated a new public sewage system for a portion of the twp would cost about $4.5 million. After reviewing the results of the survey and considering alternatives, the costs may be halved.

PADEP terminates East Norriton Order (Montgomery County)	PADEP has agreed to terminate a February 2007 consent order requiring the twp to reduce inflow and infiltration of sewer lines after it received the twp's 2009 Corrective Action Plan. Chronic I & I problems had caused major sewage overflows at the Germantown Pike sewage pump station into a tributary of Stoney Creek. In 2007, the twp required 251 homeowners to replace their sewer laterals.
Sewage issues close New Hanover campground (Montgomery County)	In February, eviction notices were sent to residents of the Hickory Park Campground. At the center of the dispute was a failing septic system. Over the several previous months, the system had been cited by the Montgomery County Health Department for violating health standards and by the PADEP for sending untreated sewage into Swamp Creek. The site was purchased by the twp to be utilized as a public park.
Perkiomen Creek Bacteria Sampling	The workgroup continues a partnership with the USGS and PWD to collect and analyze bacteria (fecal coliform and *E. coli*) at WQN Station 116 on the Perkiomen Creek. Quarterly sampling has been conducted for 5 years and the workgroup plans to evaluate the data in the upcoming year. Through the PADEP-SERO samples were also collected in 2008 for recreational use determination for this stretch of the Perkiomen; final results indicate the study area does NOT meet standards for recreational use.
Promotion of DelVal EWS and PAWARN	The workgroup continues to promote the DelVal EWS to WWTP operators throughout the Delaware watershed. The PADEP-SERO distributes an informational letter and the NERO encourages listing the System on the downstream notification call list. The workgroup also provides utilities information on PA's Water/Wastewater Agency Response Network (PAWARN).
Source Water Protection Plans	Although not a task of the workgroup, PADEP continues to work with public water suppliers in the watershed to develop and implement source water protection plans. Plans (surface water sources) were recently approved for Blythe Twp Municipal Authority (Silver Creek, Moss Glenn and Crystal Reservoir), Schuylkill County Municipal Authority (Kauffman, Indian Run and Mt. Laurel Reservoirs, Wolfe Creek, Eisenhuth and Pine Run), Minersville Municipal Authority (Dyer Run) and Schuylkill Haven Borough Water Authority (Silver Creek Reservoir/Tumbling Run); initial discussions were held with Boyertown Municipal Authority.

Wastewater Operation Certification Program	Montgomery County Community College and Reading Area Community College both offered a 180-hour certification program designed to help license new operators in the field of wastewater operation. The curriculum was developed by PADEP (Jennifer Fields). Upon completion of the program, enrollees are eligible to take the PADEP certification exam for their operator license. The SAN Pathogens & Compliance workgroup is working on modifying one of the course modules into an approved continuing education credit wet-weather/high-flow workshop for operators within the Schuylkill watershed.

Source: Joe Hebelka, PADEP, 2010

Enforcement efforts to reduce the risk of *Cryptosporidium* contamination extend beyond the accomplishments achieved through SAN initiatives. For example, Pennsylvania's conservation districts work in partnership with state and federal agencies to implement effective, locally led conservation programs. Conservation districts play a multi-faceted role in the watershed, from assisting county and municipal governments in land reviews and stormwater management plans to conducting educational programs related to soil and water conservation (PACD 2010). Within the Schuylkill River watershed, conservation district representatives participate in key partnerships, including SAN and the Wissahickon Watershed Partnership, to aid in project implementation, education and outreach.

On a municipal level, effective management of publicly owned treatment works (POTWs) upstream of the Queen Lane intake has contributed to the success of source water protection efforts in the Schuylkill River. POTWs must manage all aspects of their treatment system and processes in order to meet NPDES permit requirements. Developing pretreatment standards and implementing wet weather management procedures are just two examples of POTW management practices.

State and federal-level enforcement play a critical role in ensuring the adequacy of wastewater collection systems and treatment plants. Many wastewater-related issues are not within Philadelphia's jurisdiction to address; therefore, the State's efforts to oversee permit compliance at upstream communities are crucial to protecting water quality conditions, including *Cryptosporidium* levels, at Philadelphia's downstream intakes. The elimination/reduction of combined sewer overflows (CSOs) upstream of the intake is one such example. The implementation and enforcement of Long Term Control Plans (LTCPs) is critical to managing and reducing or eliminating combined sewer overflows. The Source Water Assessment identifies 11 upstream CSOs that represent sources of contamination at the Queen Lane intake. Two of these CSO communities, Bridgeport and Norristown, are located in Zone B and represent high-priority sources; the remaining CSOs are located farther upstream, in the Schuylkill County area. Norristown's LTCP was approved in March 2002, with the plan of eliminating CSOs through system separation. The sewer separation plan was completed in August 2007, which helped to decrease wet weather flows and eliminate one CSO area. Infiltration and inflow still need to be addressed to eliminate the remaining CSO area and treatment plant overloading (CDM 2009). Bridgeport's LTCP was approved in May 2004, with plans to address CSOs through presumptive measures and a partial separation of the system.

Additional issues requiring State-level enforcement are wet weather management and infrastructure maintenance. The state's efforts under the Act 537 program and 25 PA Code Chapter 94 address many sewerage-related issues that pose a threat to water quality in the watershed. The major provisions under the Act 537 program, or sewage facilities program, serve to correct existing sewage disposal problems and prevent future problems from occurring at both large, municipally owned sewage treatment plants and individual onlot sewage disposal systems (OLDS). The Act requires proper planning of all types of sewage facilities, permitting of individual and community OLDS, as well as uniform standards for designing OLDS (PADEP 2008).

Chapter 94, Wasteload Management, encompasses both collection system capacity and plant capacity issues (PA Code 2011). The goal of Chapter 94 compliance is to reduce wastewater volume and pollutant mass loadings through the application of pollution prevention practices to avoid hydraulic, organic and industrial wastewater overloads at sewerage facilities. The chapter specifically states the following objectives:

- Prevent the occurrence of overloaded sewerage facilities.
- Limit additional extensions and connections to an overloaded sewer system or a sewer system tributary to an overloaded plan.
- Improve opportunities to prevent or reduce the volume and toxicity of industrial wastes generated and discharged to sewerage facilities and where prevention and reduction opportunities have been maximized, and to recycle and reuse municipal and industrial wastewaters and sludges.

PADEP reviews Chapter 94 reports annually to track treatment plants and sewer collection systems that regularly experience hydraulic overloads. The causes behind frequent hydraulic overloads, such as SSOs due to infiltration/inflow, are assessed and actions taken to resolve these issues. PWD strongly values these enforcement efforts and plans to continue its work with government agencies, utilities and other organizations to continue to identify and address sources of pathogen contamination to aid in the enforcement process.

8.2 Policy Changes

In addition to Pennsylvania's enforcement actions, the state has developed policy changes that further address source water protection issues. An example of recent policy development includes the revisions made to Title 25 Pa. Code Chapter 102: Erosion and Sediment Control and Stormwater Management. According to the State, Chapter 102 serves to protect surface waters of the Commonwealth through the utilization of Best Management Practices (BMPs) that minimize accelerated erosion and sedimentation during earth disturbance activities, and manage post construction stormwater runoff after earth disturbance activities. A final-form rulemaking amended the existing regulation to achieve several objectives including: the incorporation of NPDES permit requirements for stormwater discharge from construction activities, long-term operations and maintenance requirements for post construction management stormwater BMPs, revisions to the agricultural planning and implementation requirements, updated erosion and sediment control requirements, and provisions for riparian buffers and riparian forest buffers (CWA 2010).

The revisions particularly relevant to this watershed control plan include those changes made to the agricultural section (Section 102.4 (a)). The regulations now call for an E&S plan to be developed for animal heavy use areas, in addition to the original requirement for agricultural plowing and tilling. The E&S plan must identify appropriate BMPs to minimize erosion and sedimentation. The new regulations under Chapter 102 may help reduce the impact of agricultural and livestock activity on water quality, including pathogen concentrations.

Another notable policy change is the 2008 EPA-issued rule on requirements for CAFOs that are applying for a NPDES permit (US EPA 2008). The final rule includes two main revisions. The first revision pertains to CAFO permitting, and asserts that only those CAFOs that discharge or propose to discharge must apply for permits. The revision requires a case-by-case evaluation of the CAFO's design, construction, operation and maintenance to determine whether the CAFO will discharge from its production site or land application area. The second revision adds a new requirement for permitted CAFOs. CAFOs that require permitting must now submit a Nutrient Management Plan (NMP) at the time of permit application, and the NMP must be incorporated into the CAFO's NPDES permit conditions. In addition, following review of the NMPs by the permitting authorities, the public must be provided with the opportunity for public review and comment (US EPA 2008).

Section 9 Future Action with Regard to State Regulations

In order to maintain the 0.5-log credit for the Watershed Control Plan, PWD will comply with all State-mandated regulations throughout the plan implementation process. The following three action items are required once the Watershed Control Plan is approved:

1) submit an annual watershed control program status report to the State;
2) undergo a watershed sanitary survey every three years for community systems; and,
3) make the watershed control plan, annual status reports, and watershed sanitary survey reports available to the public upon request.

This section outlines the State's watershed control plan regulations and PWD's corresponding future actions.

9.1 Submit an annual watershed control program status report to the State

The focus of the annual status report will be to describe the system's implementation of the approved WCP initiatives and assess the adequacy of the plan to meet its goals. Implementation of the watershed control plan will involve two main components: maintaining and initiating the SWPP projects identified in Section 7.4.1, and implementing the proposed WCP initiatives, outlined in Section 7.4.2. . In the WCP annual status reports, PWD will focus on providing updates related to the WCP initiatives outlined in Section 7.4.2. In addition, should there be any major status updates regarding the SWPP initiatives, such as notable successes or the discontinuation of an activity or project, PWD will report on these changes during the WCP annual status reports. The status of each WCP initiative will be assessed, and evaluations made as to the perceived benefits and overall effectiveness or ineffectiveness for all implemented initiatives. The progress made with implementing WCP initiatives will be compared to the original "schedule for plan implementation" outlined in Section 7.9. PWD will address any shortcomings in plan implementation, including those previously identified by the State or as a result of the watershed survey conducted as part of the implementation process (US EPA 2006). If shortcomings do exist in the plan implementation process, the status report will explain how PWD plans to address these shortcomings.

In addition, the regulations state that the annual status report must include a description of any significant changes that have occurred in the watershed since the last watershed sanitary survey. PWD will submit a watershed sanitary survey to the State every three years, in accordance with the State's regulatory requirements, and will provide information on any significant watershed changes, should they arise, in the annual status reports that are submitted following each watershed sanitary survey.
PWD will also immediately inform the State if significant changes to the approved WCP are deemed necessary, prior to making any such change. If any changes in the WCP reduce the level of source water protection originally outlined in the plan, PWD will identify actions that will be taken to mitigate the effect of these changes.

9.2 Develop watershed sanitary survey every 3 years

As part of the plan implementation process, PWD will submit a watershed sanitary survey every three years. The State requires that the survey be conducted according to State guidelines and by persons the State approves. Specific criteria for the sanitary survey are as follows:

1) The watershed sanitary survey must meet the following criteria: encompass the region identified in the State-approved watershed control plan as the area of influence; assess the implementation of actions to reduce source water *Cryptosporidium* levels; and identify any significant new sources of *Cryptosporidium*.
2) If the State determines that significant changes may have occurred in the watershed since the previous watershed sanitary survey, systems must undergo another watershed sanitary survey by a date the State requires, which may be earlier than the regular date.

In accordance with the zone delineations in the Source Water Assessment, PWD has identified Zones A, B, and C, or the entire Schuylkill River watershed, as the area of influence for *Cryptosporidium* contamination at Queen Lane. Potential sources of *Cryptosporidium* located in Zones A and B are considered highest priority. Nonetheless, PWD will work to evaluate the status of potential sources within all three zones.

To assess the implementation of actions to reduce source water *Cryptosporidium* levels, PWD will evaluate the status of the WCP initiatives through the annual watershed control plan status report. As stated above, each initiative will be evaluated in terms of its implementation progress and the initiative's observed benefits and overall effectiveness at supporting PWD's source water protection goals.

PWD's Schuylkill River Source Water Assessment (SWA) will serve as the baseline for subsequent sanitary surveys that are completed during the watershed control plan implementation process. Within the SWA, and outlined in Section 5 of this plan, PWD identifies the highest priority point and non-point sources for *Cryptosporidium* contamination at Queen Lane. Updating the original ranking of priority dischargers in the Schuylkill River watershed, Zones A and B, required the following steps: identifying those dischargers that no longer exist or have changes in name or ownership; compiling information regarding updates or improvements made to existing high-priority dischargers; and identifying recently proposed or constructed permitted facilities within the watershed. Section 5 outlines the results of this update. PWD will continue to track the status of these sources for each sanitary survey following approval of the watershed control plan. New facilities that are identified through the status updates will be assessed in terms of their potential impact at the intake, taking into account such factors as time of travel from source to intake, the geographical location (Zone A, B, or C), and the frequency and/or potential for release.

In an effort to improve the accuracy and comprehensiveness of the status updates, PWD will expand its evaluation of wastewater-related changes in the watershed by working

with the Schuylkill Action Network (SAN) to identify new sources and persistent areas of concern in regard to pathogen contamination. There are multiple approaches to tracking the progress of wastewater conveyance and treatment system improvements; tracking that is needed to reduce the contaminative risk associated with malfunctioning or hydraulically overloaded systems. Tracking approaches may include working with the State to identify areas of concern through the coordination of 25 PA Code Chapter 94 and Act 537 enforcement. Systematic tracking of these changes will help identify the presence of new priority sources in addition to those identified in the original Source Water Assessment analysis.

PWD will also continue to evaluate the threat posed by non-point sources, specifically, runoff from agricultural land. Section 5 aims to establish a link between pasture/livestock numbers and the prevalence of agricultural activities in each county in the watershed. The results broadly indicate that agricultural activity is either remaining relatively constant or decreasing throughout the watershed. Ideally, PWD would like to update the land use assessment results described in the Source Water Assessment to gain a better understanding of high-priority sub-watersheds with regard to agricultural activities. The Source Water Assessment identified land use categories for each sub-watershed using the 1992 USGS National Land Cover Dataset (NLCD), and updated information from the 2000 Census data for residential and commercial areas. Since direct comparison of the 1992 NLCD and the 2001 National Land Cover Database is not encouraged by the USGS, PWD was not able to directly compare changes in land use between the two datasets. Future efforts to re-assess land use on a sub-watershed scale would use the more recent 2001 National Land Cover Database, updated with 2010 Census data, when it becomes available. A 2011 NLCD is anticipated, but could take several years to publish. When the necessary data becomes available, PWD will re-assess land use to update both this plan and the Source Water Assessment.

In addition to updating and recording changes in point and non-point sources, PWD may request the sanitary surveys from other water utilities throughout the Schuylkill River watershed. Information from these surveys will be used to better direct enforcement efforts through SAN, and compliment the above-described watershed-wide status updates.

9.3 Make the watershed control plan, annual status reports, and watershed sanitary survey reports available to the public upon request

The State mandates that all reports must be in a plain language style and include criteria by which to evaluate the success of the program in achieving plan goals. The State may approve systems to withhold from the public portions of the annual status report, watershed control plan, and watershed sanitary survey based on water supply security considerations.

PWD will provide contact information on the PWD website, www.phillywatersheds.org, should members of the public wish to review the watershed control plan and/or the subsequent annual status reports and watershed sanitary surveys. In addition, PWD

will include on their PWD website a brief overview of how PWD is achieving LT2 compliance, including a summary of action items addressed in the watershed control plan.

Pending approval of the WCP, the following dates should be noted for continued compliance under the LT2 regulation.

Table 9-1 Important Dates for LT2 Watershed Control Plan (WCP) Compliance

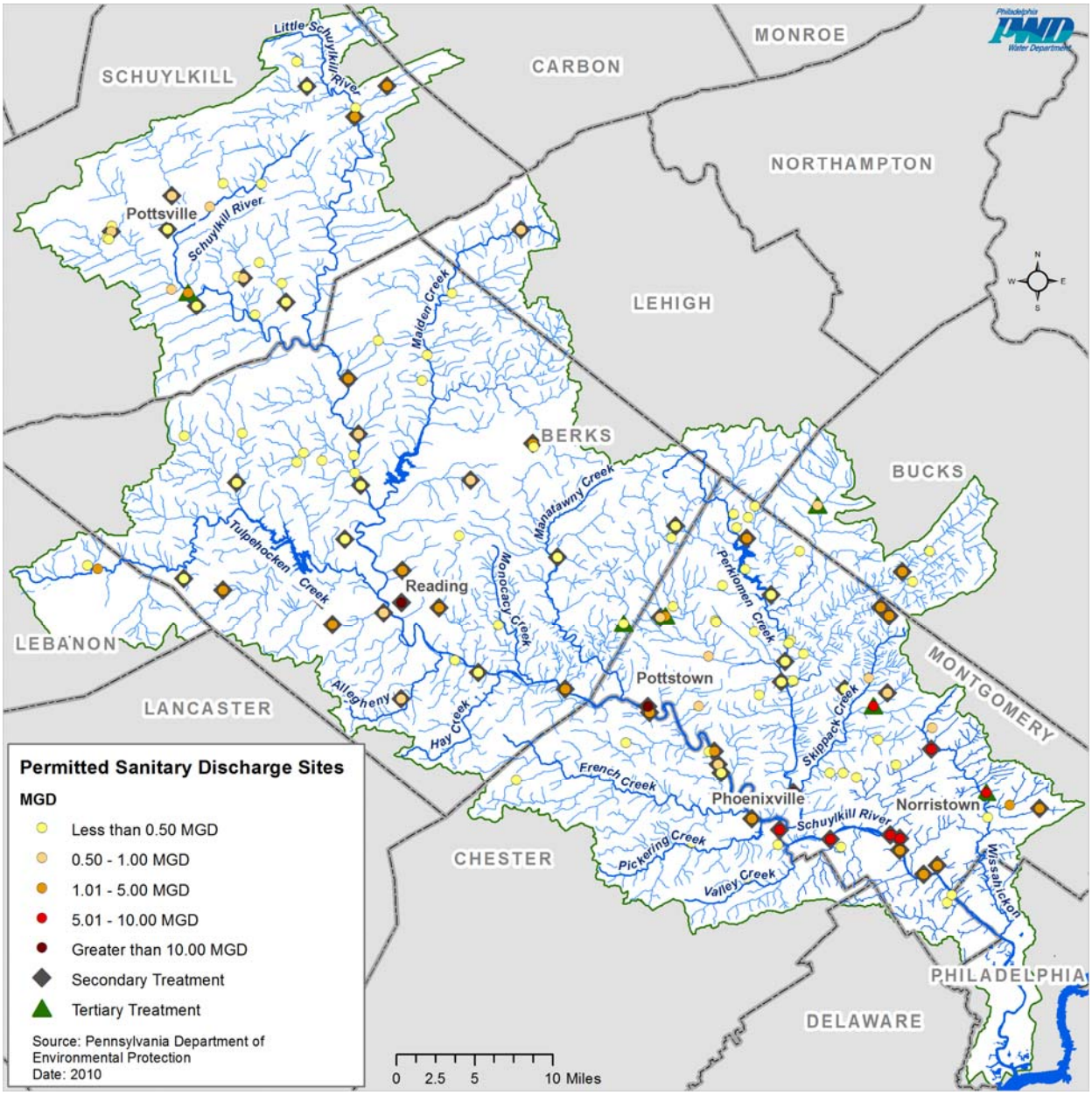
Action Item	Due Date
WCP Due to State	April 2011
State Approval of WCP Due	April 2012
First Annual Report Due to State	April 2013*
First Sanitary Survey Due to State	April 2015
Second Round of Crypto Sampling Due	April 2015

*Need to confirm due date if state approves plan earlier or later than April 2012

9.4 Concluding Statement

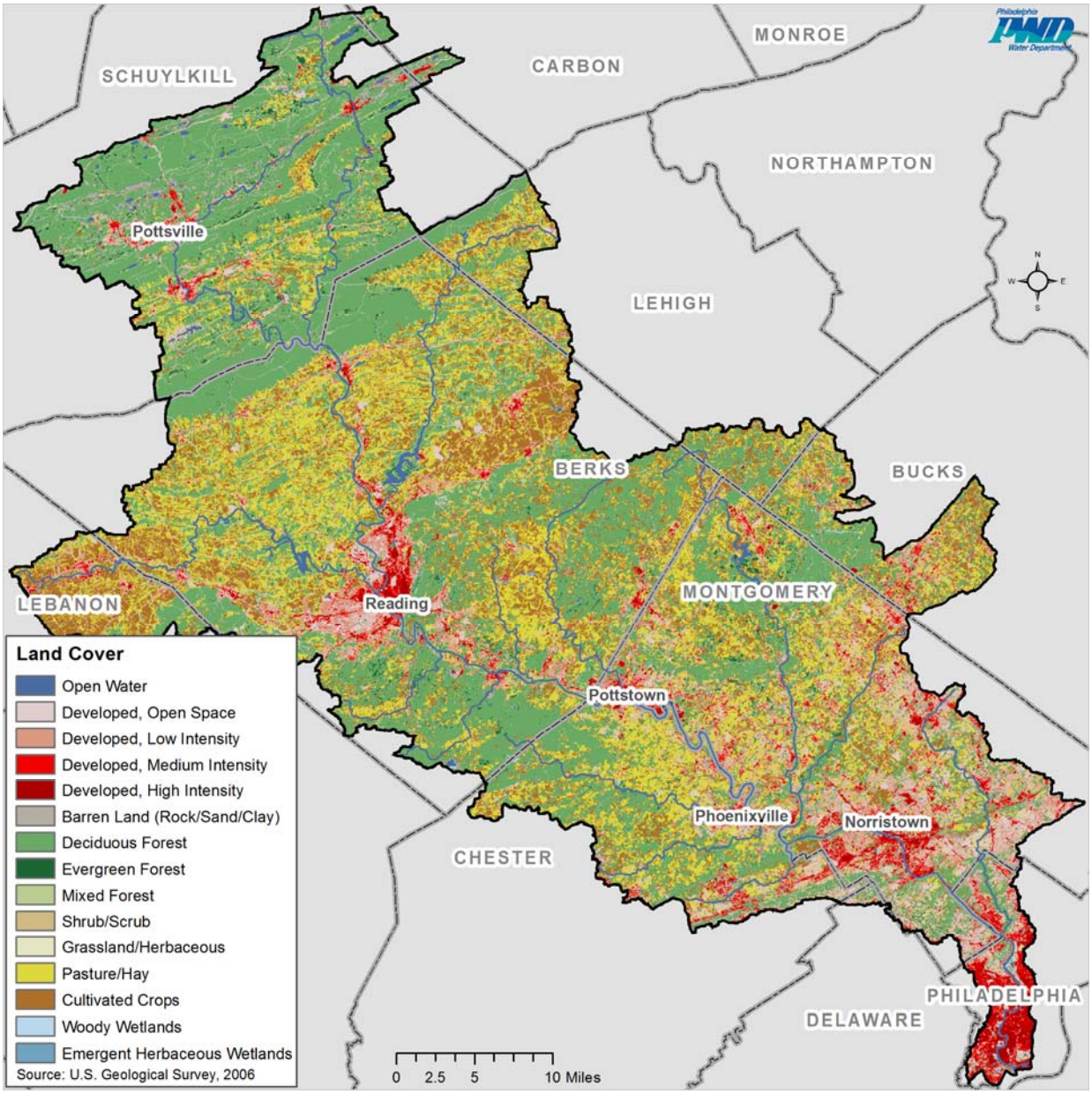
PWD's ultimate goal is to lower *Cryptosporidium* concentrations at Queen Lane during the second round of LT2 monitoring. It is very likely that there is no single action item that will guarantee lower *Cryptosporidium* concentrations at the intake; therefore, a comprehensive implementation approach is necessary. PWD's comprehensive approach, as indicated by the SWPP and WCP initiatives outlined in Section 7, includes strategies to address wastewater discharges and compliance, agriculture land use and runoff, animal vectors, and continued and expanded education and outreach. For the watershed control plan approach to be successful, PWD will need to rely on the collaboration and cooperation of watershed partnerships, particularly the SAN. Watershed-wide cooperation is needed not only in terms of planning support, but in regard to funding support as well. PWD is committing resources for priority projects addressing pathogen contaminated runoff through the Schuylkill River Restoration Fund. Although it is a challenge to coordinate source water protection efforts for pathogen contamination on such a large scale, doing so will not only make this watershed control program a success, but will reduce the risks associated with pathogen contamination throughout a large portion of the Schuylkill River watershed.

APPENDIX B: WWTPs in the Schuylkill River Watershed*



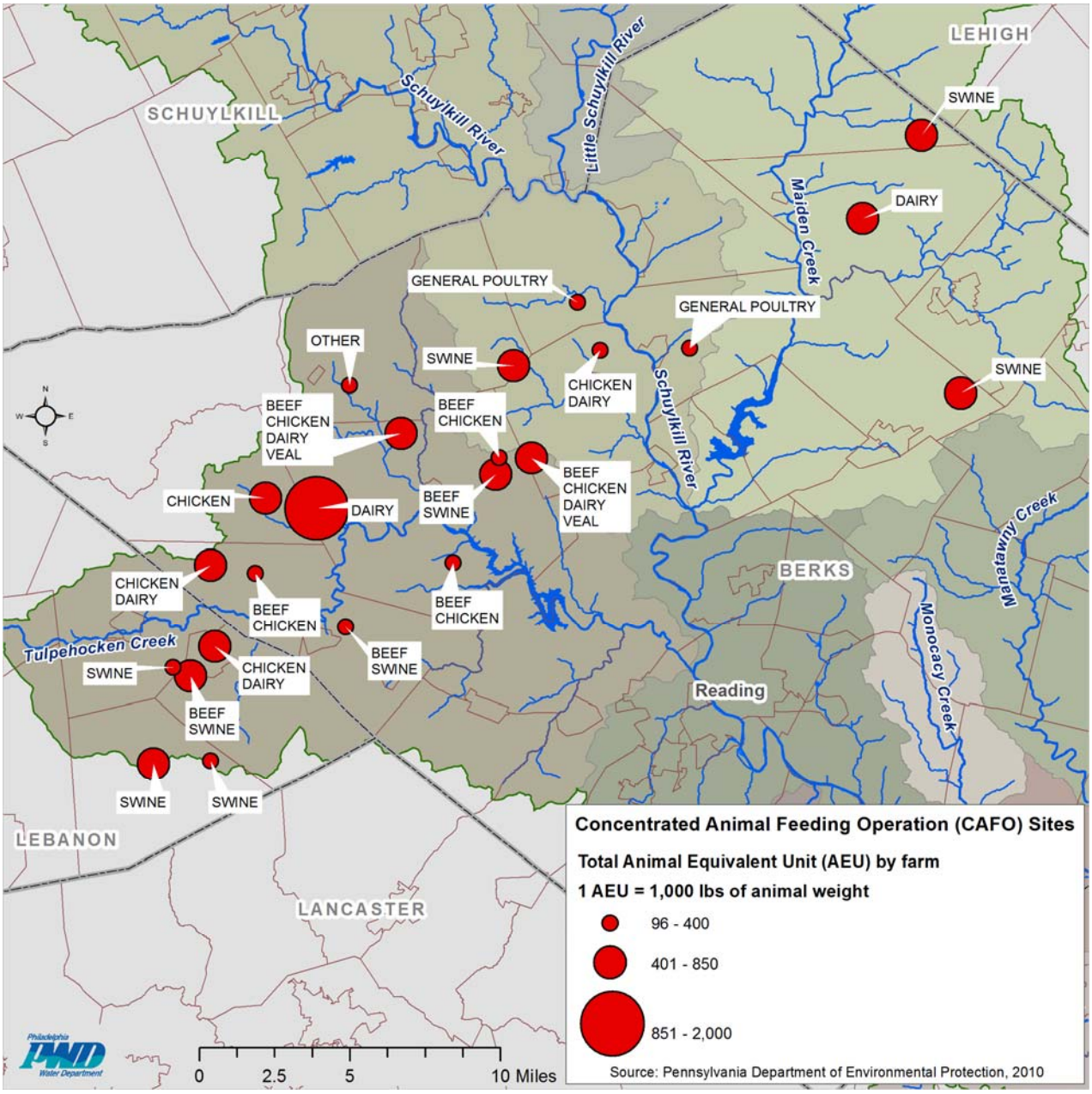
*please email Kelly Anderson, PWD Source Water Protection Manager, at Kelly.Anderson@phila.gov for an electronic copy

APPENDIX C: Schuylkill River Watershed Land Use *



*please email Kelly Anderson, PWD Source Water Protection Manager at Kelly.Anderson@phila.gov for an electronic copy

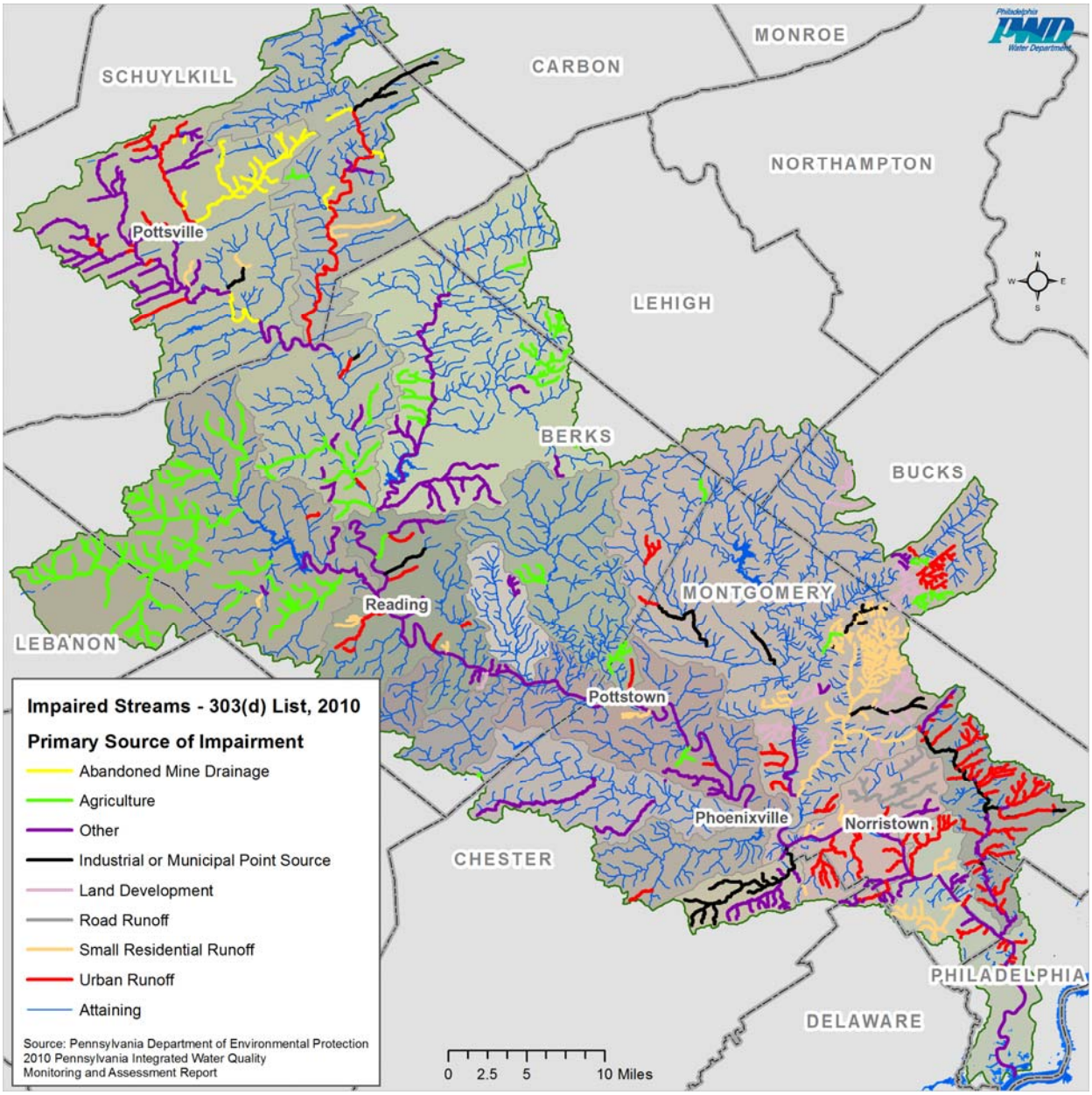
APPENDIX D: CAFOs in the Schuylkill River Watershed*



*please email Kelly Anderson, PWD Source Water Protection Manager at Kelly.Anderson@phila.gov for an electronic copy

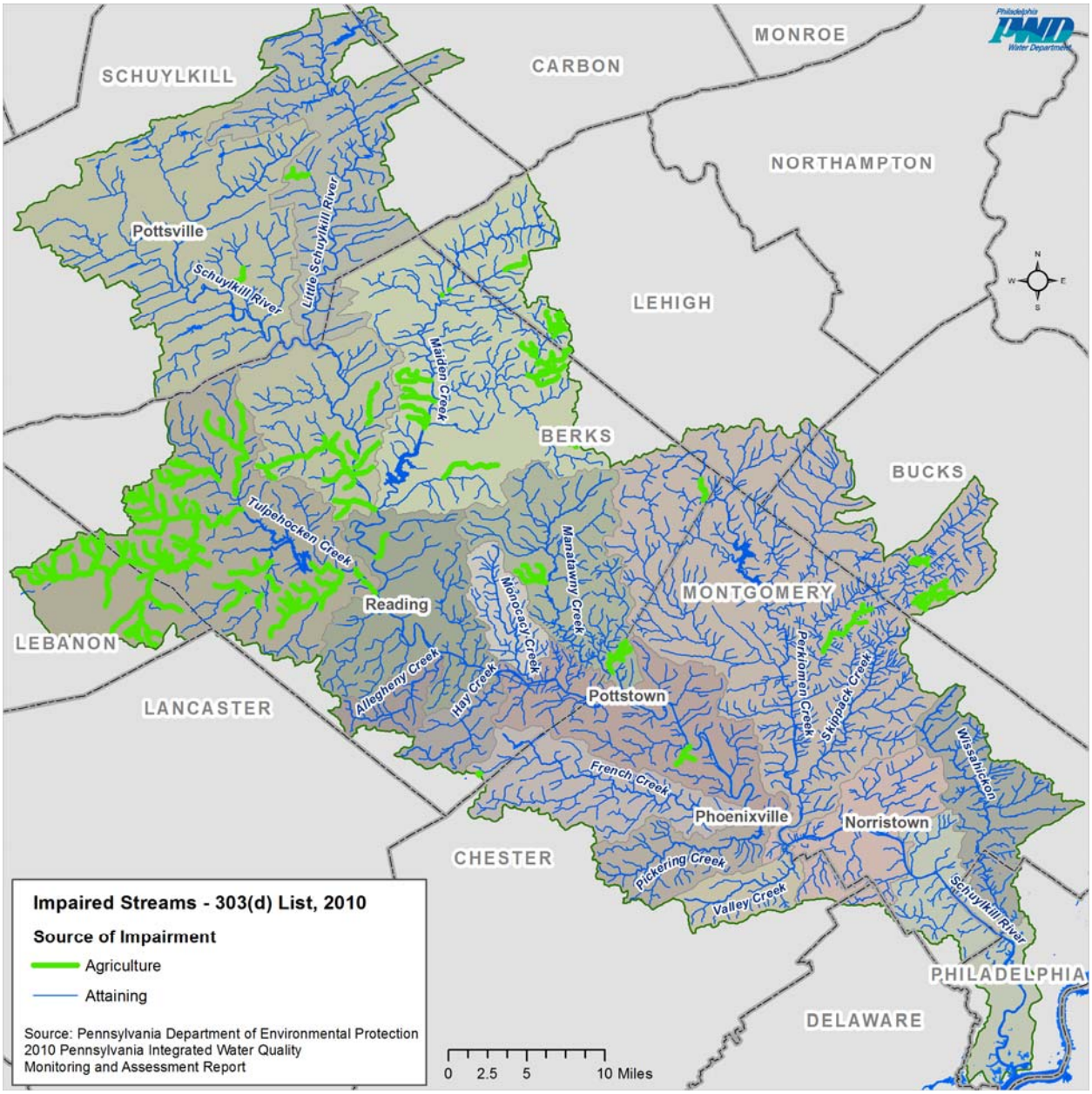
APPENDIX E: 303(d) List Impaired Stream Maps

Primary Sources of Impairment*



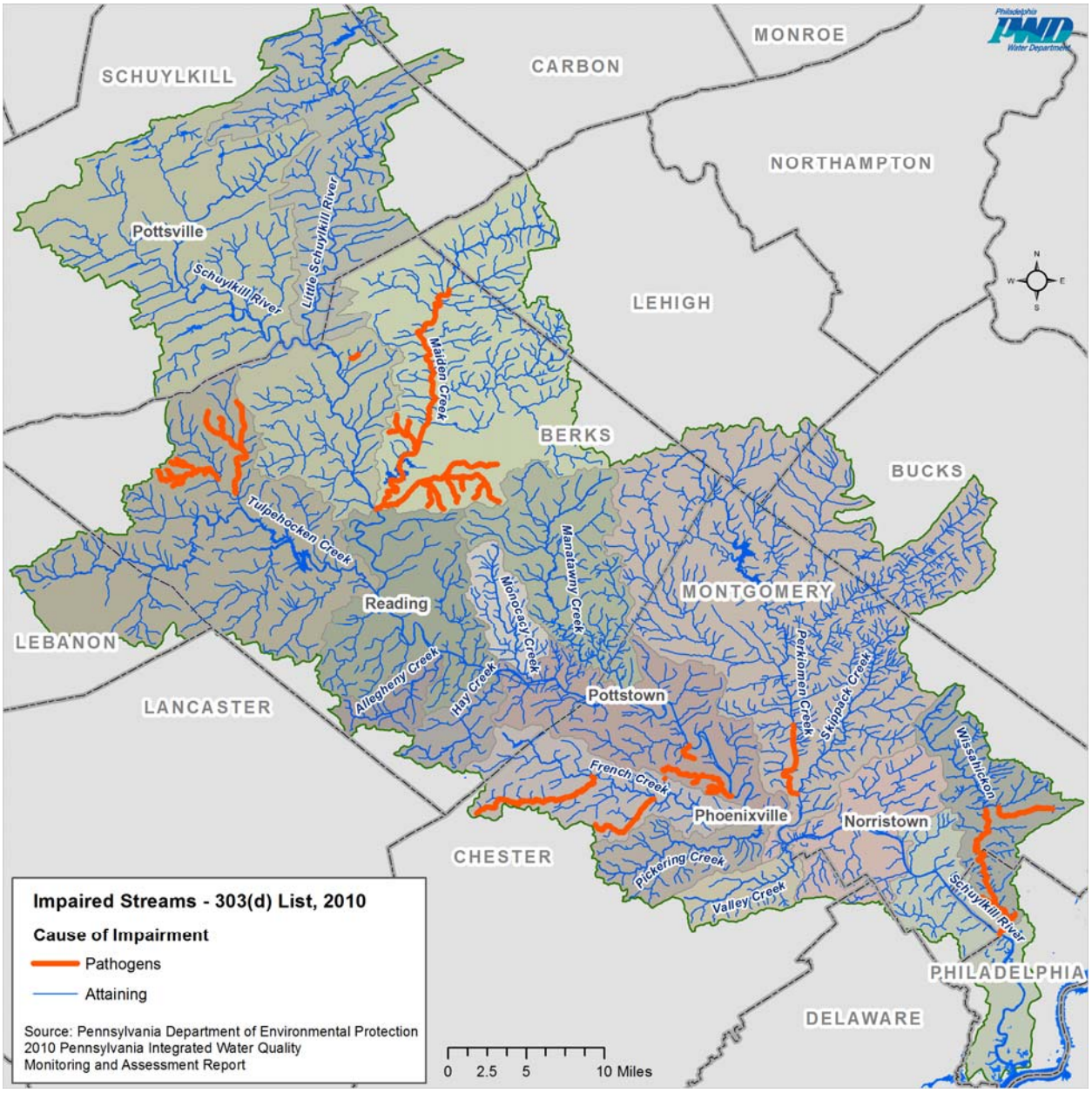
*please email Kelly Anderson, PWD Source Water Protection Manager at Kelly.Anderson@phila.gov for an electronic copy

Agricultural Impairment*



please email Kelly Anderson, PWD Source Water Protection Manager at Kelly.Anderson@phila.gov for an electronic copy

Pathogens Impairment*



*please email Kelly Anderson, PWD Source Water Protection Manager at Kelly.Anderson@phila.gov for an electronic copy

APPENDIX F: Letters of Support*

*please email Kelly Anderson, PWD Source Water Protection Manager at Kelly.Anderson@phila.gov for an electronic copy

June 22, 2012

Kelly Anderson
Philadelphia Water Department
Source Water Protection Program
1101 Market Street, 4th Floor

Dear Ms. Anderson,

On behalf of the Schuylkill Action Network (SAN), I would like to offer our support for the Philadelphia Water Department's efforts to develop and implement a Long Term Control Plan for the Schuylkill River (LT2). The SAN is committed to protecting and restoring the health of the Schuylkill River and has been working diligently over the past 9 years to engage stakeholders in activities that improve the watershed. The Philadelphia Water Department has been a critical partner in this effort and driving force behind many of our initiatives.

In 2002, the Philadelphia Water Department completed their extensive watershed analysis of the Schuylkill Watershed through Schuylkill River Source Water Assessment. One year later, the PWD finalized their protection plan for the watershed, and through key partnerships developed the SAN and initiated an aggressive implementation strategy, which started with a 1.5 Million dollar Targeted Watershed Initiative Grant for priority watershed projects.

Over the past 10 years, with the support of the PWD, the SAN has been able to address many water quality impairments originating from abandoned mine drainage, agriculture, stormwater runoff, and pathogens. Additionally, during this time, the SAN worked with the PWD to develop a comprehensive land protection land use model focusing on protecting the areas of greatest importance to drinking water. Along with implementing numerous education and outreach activities, the SAN has been able to see notable accomplishments demonstrated through active and engaged partnerships, financial investments in the watershed, and improvements in water quality.

Since the inception of the SAN, the PWD has played a critical role in working with our partner organizations to leverage funding for priority projects, securing well over 10 million dollars. Between 2010-2011, over 3.3 million dollars were secured for SAN priority projects. The PWD has played a primary role in this effort, providing significant financial support for the SAN operational expenses as well as providing more than $300,000 for projects through the Schuylkill River Restoration Fund.

The SAN fully supports the efforts of the PWD to move forward with the development and implementation of their Long Term Control plan for the watershed. We believe that this plan, and the continued support of the PWD, will lead to long-term improvements in water quality and the protection of the Schuylkill River as a source of drinking water for millions of watershed residents, within and upstream of the city of Philadelphia. We look forward to continuing our partnership with the PWD in the future.

Sincerely,

Tom Davidock
SAN Coordinator

Partnership for the Delaware Estuary, Inc.

June 26, 2012

Kelly Anderson
Philadelphia Water Department
Source Water Protection Program
1101 Market Street, 4th Floor
Philadelphia, PA 19107

Dear Ms. Anderson,

I am writing to you today to express support for the Philadelphia Water Department's efforts to develop and implement a Long Term Control Plan for the Schuylkill River (LT2). As the National Estuary Program responsible for implementing the Comprehensive Conservation Management Plan for the 6,000+ square mile Delaware Estuary study area, the Partnership for the Delaware Estuary (PDE) is charged to work with its partners on a wide variety of actions to sustain the Estuary's complex ecosystems. To this end, we have been partnering with the Philadelphia Water Department (PWD) to implement innovative projects to protect and enhance water quality in Delaware and Schuylkill Rivers for more than 15 years.

The Schuylkill watershed is the largest tributary to the Delaware Estuary, encompassing over 2,000 square miles and including more than 2,700 miles of streams and creeks. It is a priority for PDE not only because it plays a critical role in the ecological health of the estuary, but also because it provides drinking water for millions of people in our region. The PDE is working diligently with the PWD to enhance, restore, and protect this important waterway.

PDE has worked closely with the PWD to develop and manage the Schuylkill Action Network (SAN), an innovative source water protection program that serves as a national model for watershed protection. PWD has been an active partner in the SAN's efforts to address major sources of impairments from abandoned mine drainage, agriculture pollution, stormwater runoff, and pathogens. In 2004, PDE and PWD worked together to secure and administer a 1.5 Million dollar EPA Targeted Watershed Initiative grant for this purpose. The PWD also played a key role in developing the Schuylkill Watershed Priority Lands Strategy, a model that recognizes the Land-Water Connection and identifies the highest priority lands to protect. And the PWD has contributed financially to watershed efforts, providing over $300,000 to the Schuylkill River Restoration fund and providing partial support for PDE's Schuylkill Action Network coordinator position.

The PDE fully supports the efforts of the PWD to develop and implement the LT2 plan for the Schuylkill watershed. This plan, in combination with the support and leadership provided by the PWD, will greatly advance our efforts to implement the CCMP, enhance the Delaware Estuary and restore and protect the Schuylkill River. We look forward to working with the PWD through the implementation of this plan and other collaborative efforts in the Delaware Estuary.

Sincerely,

Jen Adkins
Executive Director

Partnership for the Delaware Estuary: *A National Estuary Program*
One Riverwalk Plaza, 110 South Poplar Street, Suite 202, Wilmington, DE 19801
1-800-445-4935 • Tel: 302-655-4990 • Fax: 302-655-4991 • Website: *www.DelawareEstuary.org*

We're saving a place for you...

25 North 11th Street, Reading, PA 19601
610-372-4992 tel · 610-372-2917 fax
email: info@berks-conservancy.org
web: www.berks-conservancy.org

June 12, 2012

Kelly Anderson
Phila. Water Department
Source Water Protection Program
1101 Market St., 4th Floor
Phila., Pa 19107

Re: Letter of Support

Dear Kelly,

Berks Conservancy is writing in support of the Philadelphia Water Department's Draft Watershed Control Plan, especially in regard to implementation of best management projects in the Schuylkill Watershed as the Philadelphia Water Department (PWD) Source Water Protection Program seeks approval from the Pennsylvania Department of Environmental Protection.

Berks Conservancy has been partnering with PWD for the last 10 years as part of the Schuylkill Action Network 's Ag Workgroup and Land Collaborative. PWD's commitment to the Schuylkill Watershed is unsurpassed among Schuylkill Watershed drinking water suppliers. PWD's contribution to the Schuylkill River Restoration Fund is a motive force for the implementation of best management practices in the Schuylkill River Basin. The mechanism for successful collaboration in the Schuylkill Watershed lives in the Schuylkill Action Network, the Schuylkill River Restoration Fund, and the cooperation of the many existing drinking water suppliers through their Source Water Protection Plans in the Schuylkill Watershed. These sustainable watershed partnerships will continue to work to implement priority best management practices projects aimed at addressing pathogens and excess nutrients in the Schuylkill River Watershed .

Berks Conservancy is ready, willing, and able to continue its partnership with PWD for addressing drinking water quality in the Schuylkill River Watershed

Sincerely,

Larry Lloyd, Ecologist

BERKS COUNTY
CONSERVATION DISTRICT

Conserving Natural Resources for Our Future

June 27, 2012

Ms. Kelly Anderson
Philadelphia Water Department
Source Water Protection Program
1101 Market Street, 4th Floor
Philadelphia, PA 19107

RE: Support Letter for the **Watershed Control Plan Project**

Dear Ms. Anderson:

The Berks County Conservation District (BCCD) would like to offer our strong support for the Philadelphia Water Department's Watershed Control Plan.

The Philadelphia Water Department (PWD) is an active partner in the *Schuylkill Action Network*, and has committed to partnerships with many other organizations to promote source water protection within the entire Schuylkill River Watershed. PWD has provided many opportunities for watershed improvement through their ongoing contributions to the Schuylkill River Restoration Fund (SRRF), which has supplied our workgroup partners with funding for the installation of agricultural best management practices (BMP) for several years. These practices, or BMPs, have been proven to reduce pathogens from agricultural run-off by decreasing the amount of nutrients escaping from local farms into surrounding creeks and streams. In addition, many of the BMPs have been installed on farms located in Berks County.

The Berks County Conservation District's continued collaboration with the Philadelphia Water Department would help achieve the BCCD's goal of reducing both agricultural and stormwater pollutants into priority watersheds, such as the Maiden Creek and Saucony Creek areas of the Schuylkill River Watershed.

Please add our support to your Watershed Control Plan, and direct any questions about the Berks County Conservation District's support to my attention at 610/372-4657 extension 201.

Sincerely,

Dan Greig

cc: Kathryn O'Brien, BCCD Watershed Specialist
Piper Sherburne, BCCD Chairperson

1238 County Welfare Road, Suite 200 • Leesport, PA 19533 • Tel (610) 372-4657 • Fax (610) 478-7058 • www.berkscd.com

SCHUYLKILL RIVER
NATIONAL & STATE HERITAGE AREA

140 College Drive

Pottstown, PA 19464

484-945-0200

Fax: 484-945-0204

E-mail: info@schuylkillriver.org

www.schuylkillriver.org

June 15, 2012

Kelly Anderson
Philadelphia Water Department
Source Water Protection Program
1101 Market Street, 4th Floor

Dear Kelly,

I am writing on behalf of the Schuylkill River National & State Heritage Area to express our appreciation for the work that the Philadelphia Water Department has been doing within the Schuylkill River watershed and to communicate our support for the Water Departments Watershed Control Plan.

We have been working with the Philadelphia Water Department for over a decade now on many regional projects and have found their partnership invaluable to the work of the Heritage Area.

In 2006, the Schuylkill River Restoration Fund was established by the Delaware River Basin Commission and Exelon Nuclear, to fund on the ground projects that would improve the quality and quantity of the Schuylkill River Watershed. To help in the selection of projects, the SRHA assembled an Advisory Committee made up of professionals in the conservation and water quality fields. Since its inception, the PWD has played a valuable and vital role on this committee.

In 2009, the PWD took their involvement a step further and for the last three years, has made financial contributions to this fund. Implementation projects within the City of Philadelphia have been successfully completed with both the financial help and professional consultation of Water Department staff.

In addition to their work on the Restoration Fund, we have partnered with the PWD on the regional work of the Schuylkill Action Network. The SRHA staff has been involved on several SAN committees and currently sits on the panel of the Planning Committee. The PWD's leadership and expertise have proven a tremendous asset to all of the ongoing work within the watershed.

Please note our support for the Watershed Control Plan. Please contact me with any questions.

Sincerely,

Kurt D. Zwikl
Executive Director

AGRICULTURAL WORKGROUP

June 12, 2012

Kelly Anderson
Philadelphia Water Department
Source Water Protection Program
1101Market Street, 4th Floor
Philadelphia, PA 19107

RE: Support Letter for the **Watershed Control Plan Project**

Dear Ms. Anderson:

The *Schuylkill Action Network*'s Agricultural Workgroupwould like to offer our strong support for the Philadelphia Water Department'sWatershed Control Plan.

The Philadelphia Water Department is an active partner in the *Schuylkill Action Network*, and has committed to partnerships with many other organizations to promote source water protection within the entire Schuylkill River Watershed. PWD has provided many opportunities for watershed improvement through their ongoing contributions to the Schuylkill River Restoration Fund (SRRF), which has supplied our workgroup partners with funding for the installation of agricultural best management practices for several years. These practices, or BMPs, have proven to reduce pathogens from agricultural runoff by decreasing the amount of nutrients escaping from local farms into surrounding creeks and streams.

The Agricultural Workgroup's continued collaboration with the Philadelphia Water Department would help achieve SAN's goal of reducing both agricultural and stormwater pollutants into the Maiden Creek and Saucony Creek areas of the Schuylkill River Watershed.

Please add our support to your Watershed Control Plan, and direct any questions about the Agricultural Workgroup support to my attention at 610.621.2000.

Sincerely,

Lyn O'Hare

Chair, Agricultural Workgroup

APPENDIX G: Supporting Projects & Partnerships*

*please email Kelly Anderson, PWD Source Water Protection Manager at Kelly.Anderson@phila.gov for an electronic copy

Philadelphia
Water Department

The ARAMARK Tower
1101 Market Street
Philadelphia, Pennsylvania 19107-2994

HOWARD M. NEUKRUG,P.E.
Commissioner

January 4, 2012

Lehigh University Supported Employee Assessment Services
526 Brodhead Avenue, 23 B
Bethlehem, Pa. 18015-3046

Attention: Mr. Thomas J. Meischeid, Director

Dear Mr. Meischeid:

Enclosed is a conformed copy of the following contract for the Project of Cryptosporidium Source Tracking In Philadelphia's Watershed for the Philadelphia Water Department.

Contract No.: 1220219
Encumbrance No.: MDXX12000323
Work Order No.: P- 1609
Encumbrance Amount: $100,000.00
Contract Amount: $100,000.00
Expiration Date for Contract: June 30, 2012

To facilitate payments on this contract, please send an original and two copies of all invoices and backup referencing the above Contract, Encumbrance, and Work Order Numbers along with a brief description of the work done during the billing period to:

Mrs. Alicia Robertson
Philadelphia Water Department
Finance Division
ARAMARK Tower, 5th Floor
1101 Market Street
Philadelphia, PA 19107-2994

For additional information regarding invoicing contact Mrs. Robertson at 215/685-6042.

Sincerely,

Betty L. Addison
Contract Conformance Manager

Enclosure

Cc: Arwilla Jones, Budget Officer, PWD
Gary Burlingame, PWD
Juanita Jones, PWD

Philadelphia
Water Department

The ARAMARK Tower
1101 Market Street
Philadelphia, Pennsylvania 19107-2994

HOWARD M. NEUKRUG,P.E.
Commissioner

October 26, 2011

USDA APHIS WS
PO Box 60827
Harrisburg, PA 17106-0827

Attention: Mr. Harris Glass, State Director

Dear Mr. Glass:

Enclosed is a conformed copy of the following amendment for Animal Control Services for the Philadelphia Water Department.

Contract No.: 1120410
Amendment No.: 1120410-01
Encumbrance No.: MDXX12000097-02 (Acct. Code 020 28 09 03 - $80,826.00)
Encumbrance No.: MDXX12000181-01 (Acct. Code 020 28 42 02 - $80,000.00)
Work Order No.: P- 1594
Encumbrance Amount: $160,826.00
Contract Amount: $241,652.00
Expiration Date for Contract: June 30, 2012

To facilitate payments on this amendment, please send an original and two copies of all invoices and backup referencing the above Amendment, Contract, Encumbrance, and Work Order Numbers along with a brief description of the work done during the billing period to:

Mrs. Alicia Robertson
Philadelphia Water Department
Finance Division
ARAMARK Tower, 5th Floor
1101 Market Street
Philadelphia, PA 19107-2994

For additional information regarding invoicing contact Mrs. Robertson at 215/685-6042.

Sincerely,

Betty L. Addison
Contract Conformance Manager

Enclosure

Cc: Arwilla Jones, Budget Officer, PWD
John Muldowney, PWD

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www.schuylkillriver.org

June 26, 2012

Kelly Anderson
Source Water Program Manager
Philadelphia Water Department
1101 Market Street, 4th Floor
Philadelphia, PA 19107

Dear Kelly:

Last week, another grant cycle of the Schuylkill River Restoration Fund was successfully completed. With the announcement of the Philadelphia Water Department's $100,000 contribution, the funds available for awards totaled over $300,000 for this year! We are extremely excited about our continued partnership together and the increased impact this will have on the watershed.

This year we received a total of ten Letters of Inquiry for the first stage of the grant process. Through a ranking system we chose to invite seven of those organizations to submit full proposals. The Advisory Committee, which was made up of members from PA DEP, PWD, Partnership for the Delaware Estuary, the Schuylkill Action Network, Exelon, EPA Region III, DRBC and SRHA, met to discuss the final applications and make a decision on which projects to fund. After hearing presentations from each of the applicants, the committee has chosen to pursue five of the seven projects that remain.

The committee is recommending that we fund two projects for the 2012 grant round from the Philadelphia Water Department funds. The following is the list of the organizations and projects proposed to be funded with Water Department monies. Final approval from Water Department officials on these projects is requested before we can proceed with contracting and project implementation.

- Berks County Conservancy, Havens Farm Agricultural Project - $42,000
- Wissahickon Sustainability Council, Cook-Wissahickon Native Meadow School Project, $27,065

Three additional projects will be funded through the Exelon Corp. funds and we are seeking final approval for those projects as well.

I am excited about these projects and feel that all of them can have significant impact on the watershed and our greater, regional community. As we continue to move forward we would like to make an official public announcement by the end of August. This would allow our award recipients to begin implementation on their projects in September.

Sincerely,

Kurt D. Zwikl
Executive Director