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Cobbs Creek Integrated Watershed Management Plan

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Cobbs Creek Integrated Watershed Management Plan

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Cobbs Creek Integrated Watershed Management Plan

Darby-Cobbs Watershed Partnership Mission Statement

"To improve the environmental health and safe enjoyment of the Darby-Cobbs watershed by sharing resources through cooperation of the residents and other stakeholders in the watershed. The goals of the initiative are to protect, enhance, and restore the beneficial uses of the Darby-Cobbs waterways and riparian areas. Watershed management seeks to mitigate the adverse physical, biological, and chemical impacts of land uses as surface and groundwater are transported throughout the watershed to the waterways."

Executive Summary

Foreword

This plan presents a logical and affordable pathway to restore and protect the beneficial and designated uses of the waters of the Cobbs Creek basin. Based on extensive physical, chemical and biological assessments, the plan explores the nature, causes, severity and opportunities for control of water quality impairments in the Cobbs Creek watershed. The primary intent of the planning process, as articulated by the stakeholders, is to improve the environmental health and safe enjoyment of the Cobbs watershed by sharing resources and through cooperation among residents and other stakeholders in the watershed. The goals of the initiative are to protect, enhance, and restore the beneficial uses of the Cobbs waterways and its riparian areas. The plan recommends appropriate remedial measures for the Cobbs Creek basin, provides a financial commitment to initiate the implementation of the plan, and seeks to provide the impetus for stakeholders of the Darby basin to follow suit.

The Darby-Cobbs Watershed Partnership worked with the Philadelphia Water Department to complete a comprehensive, multi-year watershed assessment covering the Darby, Cobbs, and Tinicum sub-basins (see Figure E-1). Results of the watershed-wide assessment suggests that at some times during dry weather periods, bacteria contamination of the Cobbs's waters prevents the achievement of water quality standards that would support swimming or other forms of primary contact recreation in the creek. Also, stream aesthetics, accessibility and safety are compromised due to illegal litter and dumping, trash from stormwater discharges, and bank deterioration along the stream corridors. Existing aquatic and riparian habitat, degraded by urban runoff, limit the diversity of fish and benthic life and prevent the development of healthy living resources conditions necessary to support recreational activities such as fishing. Wet weather water quality is limited by bacteria discharged from combined and separate storm sewers. High rates of urban runoff cause flood flows that erode the stream banks and bottoms and expose and compromise utility infrastructure.

The good news is that measurable progress can be made towards restoring the legislated designated beneficial uses of the stream. To this end, this plan provides an investment strategy for achieving definable levels of environmental return in the Cobbs Creek basin. It is estimated that significant progress towards improving the areas of environmental concern discussed above can be made for an investment of less than $100 per household per year over a 20-year horizon. The plan proposes that the other municipalities in the Cobbs basin make similar financial commitments to implementation that will ensure the restoration and preservation of the waters that flow from and through their communities, shaping their quality of life along the way. A significant portion of this funding is directed towards work that reflects the widely recognized national need to renew our water resources infrastructure. These efforts basically are things that should be done anyway. It is proposed that a combination of Federal, state, local government, and private funding be brought to bear to implement this plan. The Philadelphia Water Department expended over $1 million in the development of the plan, and will commit $2 million per year or more towards implementing its recommendations over the next 20 years. The plan proposes that the other municipalities in the Cobbs basin make similar financial commitments to implementation that will ensure the restoration and preservation of the waters that flow from and through their communities.

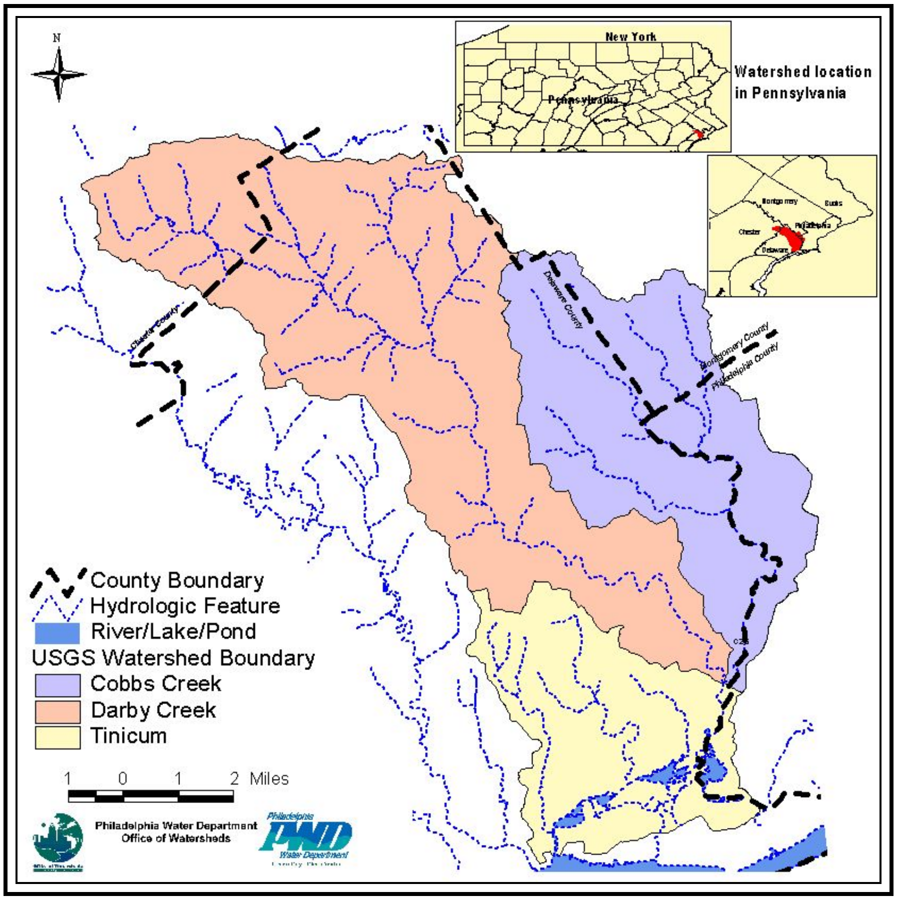


Figure E-1: Darby-Cobbs Watershed. This plan summarizes the results of watershed assessment activities in the Darby, Cobbs, and Tinicum basins. Detailed planning, alternatives analysis, and recommendations are provided for the Cobbs basin. The plan recommends appropriate measures for the Cobbs Creek basin and seeks to provide an example for stakeholders in the Darby and Tinicum basins to follow.

Introduction

Stewardship of a river must be built around the needs of the community. It will grow by making visible the critical way the health of the watershed is integral to basic quality of life issues. Once the seeds of stewardship have been planted, members of the community can be recruited to take action in protecting their watershed. In 1999, The Philadelphia Water Department (PWD) acted as the municipal sponsor of the Darby-Cobbs Watershed Partnership, an exciting and groundbreaking effort to connect residents, businesses and government as neighbors and stewards of the watershed. Since then, the Partnership has been active in developing a vision for the watershed and guiding and supporting subsequent planning activities within both the Darby and Cobbs sub-watersheds.

PWD, with the support of the Darby-Cobbs Watershed Partnership, has just completed a multi-year watershed planning effort to restore the Cobbs Creek Watershed to one that can boast fishable, swimmable and enjoyable streams. The planning process and implementation recommendations are contained in the recently completed Cobbs Creek Integrated Watershed Management Plan (CCIWMP). This executive summary presents the major findings of the CCIWMP.

Background

The Darby-Cobbs Watershed Partnership first worked with PWD to complete a comprehensive, multi-year watershed assessment covering the Darby, Cobbs, and Tinicum drainage basins (see Figure E-1). The assessment provides a snapshot of current conditions in the watershed, and lays the groundwork for the development of more detailed plans to improve conditions in each of the sub-basins within the Darby-Cobbs watershed. With portions of the Cobbs Creek watershed served by combined sewers, and with significant interest from the Partnership in improving water quality and riparian habitat conditions, PWD then took the next step by leading the development of the CCIWMP. During the stakeholder process, the Pennsylvania Environmental Council drafted a resolution for the partnership to establish common ground for municipal coordination required for the plan to be successful. The resolution and its signatories are reprinted below.

Partnership Resolution

Whereas, the Darby Creek watershed and its tributaries, the largest of which is the Cobbs Creek, constitute an important natural resource by providing aquatic and terrestrial habitat, an important cultural and historical resource with many key sites throughout the watershed, an important recreational resource providing fishing opportunities, and parkland for exploration and relaxation; and

Whereas, the Darby Creek and its tributaries have been degraded by development and historical absence of municipal stormwater management controls contributing to damaging floods, extensive erosion and low flows in times of drought; and

Whereas, the Pennsylvania Department of Environmental Protection has determined through its biological assessment process that the water quality of certain segments of the Darby Creek and its tributaries have become impaired; and

Whereas, various studies are underway to guide conservation and improvement of the Darby Creek including a Rivers Conservation Management Plan (under the auspices of the Darby Creek Valley Association), a Stormwater Management Plan prepared pursuant to the Stormwater Management Act of 1978; and

Whereas, cooperative action taken in coordination with municipalities and citizens located both up and downstream in the watershed is the key to enhancing the value of the Darby Creek for all its residents; and

Whereas, the Darby-Cobbs Watershed Partnership was created to serve that purpose and provides a structure for watershed-based planning and action to conserve and to improve the environmental health and safe enjoyment of the watershed; and

Whereas, the Darby-Cobbs Watershed Partnership will work to eliminate the impairment of the stream segments and restore the watershed to its unimpaired state for uses so designated by the Department of Environmental Protection.

Therefore, it is resolved that the «Governing_Body» does hereby declare support for the Darby-Cobbs Watershed Partnership and act freely to join as a Watershed Partner,

Furthermore, the «Governing_Body» does resolve to appoint a liaison who will participate in the Partnerships' conservation planning and action programs and will regularly (at the discretion of this body) provide reports on the Partnerships' activities.

Resolution Signatories

Counties: Chester, Delaware, Philadelphia

Municipalities: Colwyn Borough, East Lansdowne Borough, Folcroft Borough, Lansdowne Borough, Marple Township, Newtown Township, Radnor Township, Ridley Township, Sharon Hill Borough, Tinicum Township, Upper Darby Township, Lower Merion Township, Springfield Township, City of Philadelphia

With the addition of this plan, the watershed communities now have a blueprint for restoring this urban stream into a community asset, while making significant progress toward improving water quality during both dry and wet weather.

The primary intent of the plan, as articulated by the stakeholders, is to mitigate wet weather impacts caused by urban stormwater runoff and combined sewer overflow (CSO), identify ways to improve water quality, aesthetics, and recreational opportunities in dry weather; and restore living resources in the stream and along the stream corridor. PWD placed a high priority on the development of the CCIWMP because it represents one of the three major components of the City of Philadelphia's CSO Long Term Control Plan (LTCP) strategy. This component entails a substantial commitment by the City to watershed planning to identify long term improvements throughout its watersheds, including any additional CSO controls that will result in an improvement to water quality and, ultimately, the attainment of water quality standards.

PWD was not alone in this planning effort. Significant support from other agencies helped to fund various pieces of the plan in order to better integrate the planning effort with other regulatory programs. The USEPA provided funding under a Section 104(b)(3) Water Quality Cooperative Agreement, money that helped PWD to develop the modeling framework that underlies much of the analysis in the plan. USEPA also provided Wetland Program Grant money to help assess existing wetlands within Cobbs Creek and provide basic data for developing wetland restoration projects. PADEP provided funding, through a Growing Greener Grant, to partially fund stream assessment and restoration along a stretch of Cobbs Creek near Marshall Road. Through Act 167 money, PADEP also funded PWD modeling and analysis to support stormwater planning. Finally, initial planning efforts and the development of planning goals, embodied in a Rivers Conservation Plan, were funded by PA-DCNR.

At the outset, there was insufficient physical, chemical, and biological information on the nature and causes of water quality impairments, sources of pollution, and appropriate remedial measures for the Cobbs Creek. The lack of information made it impossible to determine what needed to be done for additional CSO control or control of other wet weather sources throughout the watershed. Lack of sufficient information is not unique to Cobbs Creek. In fact recognition of this deficiency, especially with respect to the effects of wet weather discharges and receiving water dynamics, has increased nationwide and led to a broader recognition of the need for watershed-based planning and management to properly define water quality standards and goals.

The USEPA Long Term Control Planning Guidance suggests that the sources of watershed pollution and impairment, in addition to CSOs, are varied and include other point source discharges; discharges from storm drains; overland runoff; habitat destruction; land use activities, such as agriculture and construction; erosion; and septic systems and landfills. The Guidance notes that the major advantage in using a watershed-based approach to develop a LTCP is that it allows the site-specific determination of the relative impacts of CSOs and non-CSO sources of pollution on water quality.

Plan Goals

Considerable stakeholder input towards developing watershed goals was sought from the beginning of this planning effort. Stakeholder input was primarily organized through the Partnership, which reached consensus on a set of planning goals and objectives. In addition, the plan sought to integrate goals derived from other relevant regulatory programs and plans to more fully achieve the ideal of integrated water resource planning. The resulting integrated planning goals, and their relation to the major regulatory programs, are summarized in Table E-1.

Table E-1 Regulatory Support for Stakeholder Goals for the Cobbs Creek Watershed

Goal Description	Act 167 Stormwater	Act 537 Sewage Facilities	TMDL Program	NPDES Stormwater	CSO Program	RCP
Streamflow and Living Resources. Reduce the impact of urbanized flow on the living resources to meet designated uses	x					x
Stream Habitat and Aquatic Life. Improve stream habitat and indices of aquatic integrity.			x	x	x	x
Stream Channels and Banks. Reduce streambank and stream channel deposition and scour to protect and restore the natural functions of aquatic habitat and ecosystems, streambanks, and stream channels.	x					x
Flooding. Decrease flooding.	x					x
Water Quality. Improve dry and wet weather stream quality.		x	x	x	x	x
Pollutant Loads. Decrease pollutant loads to surface waters.		x	x	x	x	x
Stream Corridors. Protect and restore stream corridors, buffers, floodplains, and natural habitats including wetlands.						x
Quality of Life. Enhance community environmental quality of life.	x	x	x	x	x	x
Stewardship. Foster community stewardship.				x	x	x
Coordination. Improve inter-municipal, inter-county, state-local, and stakeholder cooperation and coordination on a watershed basis.	x		x	x	x	x

Planning Approach

Once the Partnership had established the goals and objectives for the CCIWMP, a planning approach was designed to achieve the desired results through a cooperative effort between Philadelphia and the other watershed municipalities. The approach has four major elements:

- Data collection, organization and analysis
- Systems description
- Problem identification and development of plan objectives
- Strategies, policies and approaches

Figure E-2 summarizes the primary steps of the planning process. The right column shows the sections of the plan relevant to each step in the planning process.

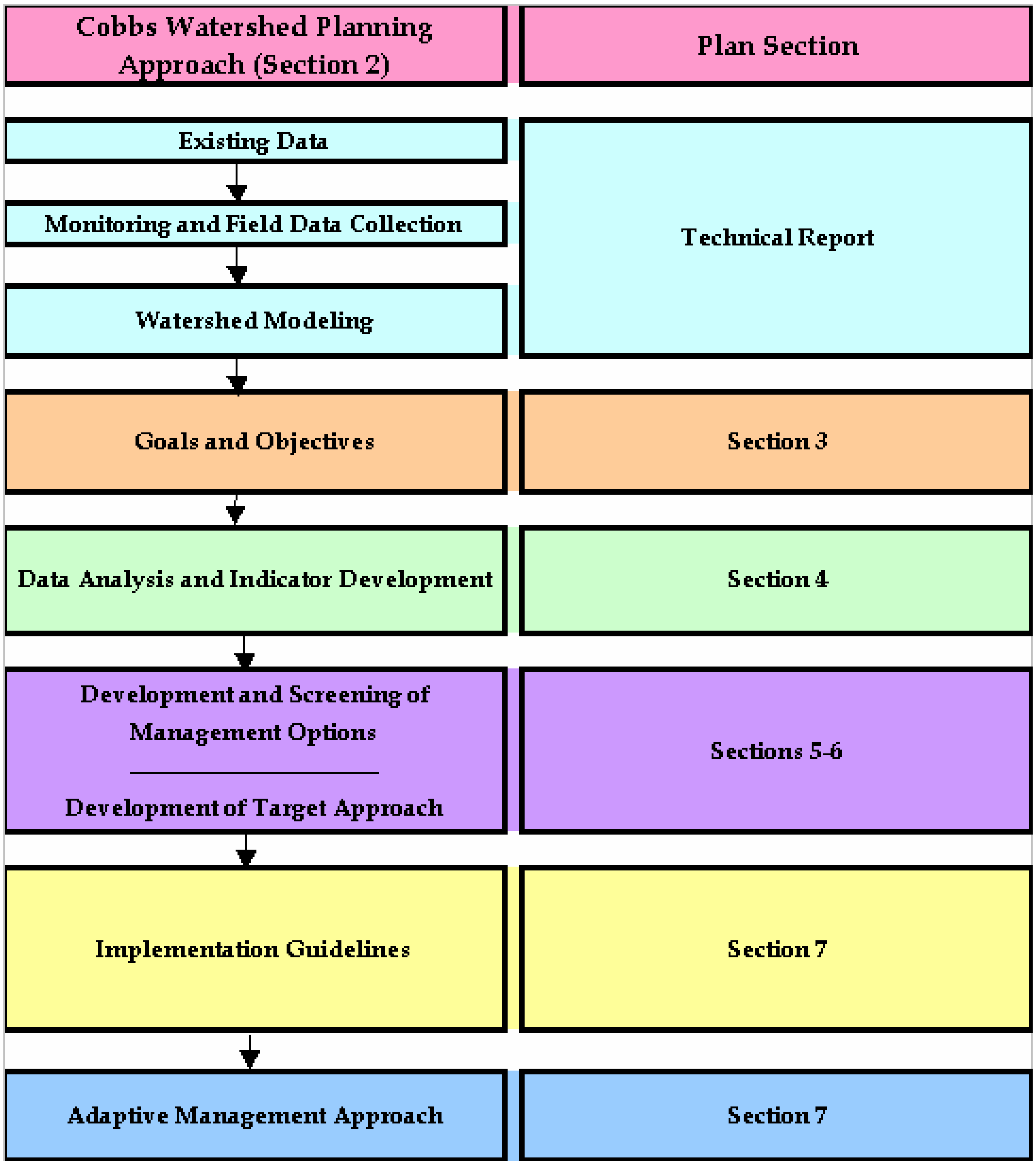


Figure E-2: Cobbs Planning Approach

Watershed Status and Problem Identification

An important aspect of the watershed management plan is a basic description of existing conditions within the watershed and streams. To accomplish this, a series of indicators were developed to represent the results of the data collection efforts and the data analysis and modeling. An indicator is a measurable quantity that characterizes the current state of at least one aspect of watershed health. The indicators were selected for their potential use both in assessing current conditions and assessing future progress in improving conditions.

Through the extensive field studies, modeling, and data analysis, the highest priority problems in the Cobbs Creek were identified, and the means for addressing the problems were developed. Given that the Cobbs Creek watershed is a highly urbanized watershed with both CSOs and significant stormwater flows, some of the highest priority problems included:

Dry Weather Water Quality and Aesthetics

- Water quality concerns including high fecal coliform during dry weather
- Dry weather sewage flows in separate sewered areas
- Trash-filled, unsightly streams that discourage residential use.
- Safety concerns along streams and stream corridors

Healthy Living Resources

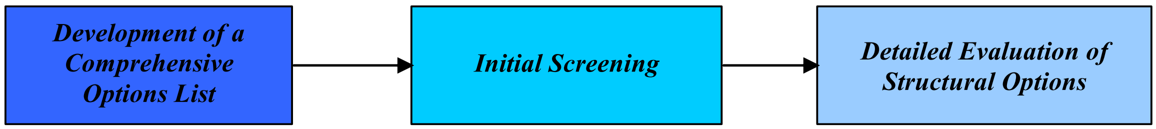
- Degraded aquatic and riparian habitats
- Limited diversity of fish and benthic life
- Periodic, localized occurrences of low dissolved oxygen primarily associated with plunge pools and areas of stagnant water behind dams
- Utility infrastructure threatened by bank and streambed erosion
- Limited public awareness and sense of stewardship for Cobbs Creek

Wet Weather Water Quality and Quantity

- Water quality concerns including high fecal coliform during wet weather, and nutrients and metals during wet weather flows
- CSO impacts on water quality and stream channels
- Little volume control and treatment of stormwater flows in separate sewered areas

Development and Screening of Management Options

Lists of management measures, called options, were developed to address the identified problems and to meet each of the goals and objectives established for the Cobbs Creek watershed. Only those options deemed feasible and practical for Cobbs Creek were considered in the final list of management options. Options were developed and evaluated in three steps:



Since the plan cannot prescribe actions to be undertaken by all the participants in the planning process, recommendations and guidelines for implementation were developed. Modeling and other analyses were used to develop six alternatives, each with a different approach and cost to achieve the goals and objectives. From an analysis of these six alternatives, the final recommendations were made.

Implementation Approach

In developing watershed management alternatives and discussing goals and objectives with stakeholders, it became clear that implementation could best be achieved by defining three distinct targets to meet the overall plan objectives. Two of the targets (A and B) were defined so that they could be fully met with a limited set of options that are fully implemented. For the third target (C), it was agreed to set interim objectives, recommend measures to achieve the interim objectives, implement those controls, and monitor and reassess the effectiveness of the plan in meeting the objectives.

TARGET A: Dry Weather Water Quality and Aesthetics

The first target is to meet water quality standards in the stream during dry weather flows. Target A was defined for Cobbs Creek with a focus on trash removal and litter prevention, and the elimination of sources of sewage discharge during dry weather.

TARGET B: Healthy Living Resources

Improvements to the number, health, and diversity of the benthic invertebrate and fish species in the Cobbs Creek will require investment in habitat improvement and measures to provide the opportunity for organisms to avoid high velocities during storms. Improving the ability of an urban stream to support viable habitat and fish populations must focus primarily on the elimination or remediation of the more obvious impacts of urbanization on the stream. These include loss of riparian habitat, eroding and undercut banks, scoured streambed or excessive silt deposits, channelized and armored stream sections, trash buildup, and invasive species.

TARGET C: Wet Weather Water Quality and Quantity

The third target is to restore water quality to meet fishable and swimmable criteria during wet weather and address flooding issues. Improving water quality and flow conditions during and immediately following storms is the most difficult target to meet in the urban environment. The only rational approach to achieve this target must include stepped implementation with interim targets for reducing wet weather pollutant loads and stormwater flows, along with monitoring for the efficacy of control measures.

Initial load reduction targets for parameters such as stormwater flow, metals, total suspended solids, and bacteria were set in conjunction with the stakeholders. Based on preliminary work by PWD, 20% reductions are a challenging but achievable interim target.

Implementation Guidelines

All measures or options were thoroughly screened and evaluated using a variety of approaches, including modeling, cost-effectiveness screening, and the use of a computerized multi-criteria evaluation tool. This resulted in the selection of only those options appropriate and deemed effective for the particular conditions found in the Cobbs Creek watershed. The implementation guidelines seek to present the options in such a way that each major stakeholder or responsible party understands what is expected. The guidelines are designed such that, if implementation follows the recommendations, all plan objectives associated with Targets A and B will be fully met, and the interim objectives for Target C will be met or exceeded.

In the plan, options are fully described, and the expected level of implementation is provided. Where possible, the locations where implementation is expected are also indicated. Implementation guidelines are presented in this executive summary in a series of tables. First, options are grouped by the party responsible for implementation. Second, options are grouped according to their applicability to the implementation targets. Finally, tables of planning level costs are provided.

Recommendations by Responsible Party

These summary tables present the recommended actions grouped according to the agency or organization primarily responsible for implementation. Tables E-2 through E-4 present the recommended actions for Philadelphia, Delaware, Montgomery, and Chester Counties; and PADEP.

Table E-2 Philadelphia Actions

Action	Where	When
Pet Waste, Litter, and Dumping Ordinances	Watershed-wide	Short-term
Public Education	Watershed-wide	Short-term
School-Based Education	All schools	Short-term
Public Participation and Volunteer Programs	Watershed-wide	Short-term
Inspection and Cleaning of Combined Sewers	Watershed-wide	Short-term
Combined Sewer Rehabilitation	Combined-Sewered Areas	Medium-term
Stream Cleanup and Maintenance	Cobbs Creek within or along City boundary	Short-term
Enhancing Stream Corridor Recreational and Cultural Resources	Along the stream corridor	Medium-term
Bed Stabilization and Habitat Restoration	Cobbs Creek 40%, West Indian Creek 44%	Short-term
Bank Stabilization and Habitat Restoration	Middle section of Cobbs Creek	Short-term
Channel Realignment and Relocation	Cobbs Creek, East and West Indian Creek	Short-term
Plunge Pool Removal	CSO and stormwater outfalls	Short-term
Improvement of Fish Passage	Woodland Avenue dam	Short-term
Wetland Creation	Riparian corridor	Short-term
Invasive Species Management	Riparian corridor	Short-term
Reforestation	Riparian corridor	Short-term
Requiring Better Site Design in Redevelopment	Watershed-wide	Short-term
Stormwater and Floodplain Management	Watershed-wide	Short-term
Post-Construction Stormwater Runoff Management	Municipalities required to do Phase II permit	Short-term
Sanitary Sewer Overflow Detection	Separate-Sewered Areas	Short-term
Sanitary Sewer Overflow Elimination: Structural Measures	Separate-Sewered Areas	Medium-term
CSO Control Program	Philadelphia combined sewer system	Short-term
Catch Basin and Storm Inlet Maintenance	All inlets	Short-term
Street Sweeping (Philadelphia Streets Department)	Streets and Parking Lots	Short-term
Responsible Landscaping on Public lands	Green space	Short-term
Responsible Bridge and Roadway Maintenance	Roadways and bridges	Short-term
Reducing Effective Impervious Cover through Better Site Design	Watershed-wide	Long-term
Increasing Urban Tree Canopy	Watershed-wide	Medium-term
Porous Pavement and Subsurface Storage	Parking lots watershed-wide	Long-term
Green Rooftops	Appropriate public buildings chosen by PWD	Medium-term
Capturing Roof Runoff in Rain Barrels or Cisterns	Homes where dry wells are not feasible	Medium-term
Maintaining/Retrofitting Existing Stormwater Structures	Watershed-wide	Short-term
Retrofitting Existing Sewer Inlets with Dry Wells	Inlets in combined-sewered areas	Long-term
Residential Dry Wells, Seepage Trenches, and Water Gardens	Homes and schools watershed-wide	Long-term
Bioretention Basins and Porous Media Filtration	Watershed-wide	Long-term
Treatment Wetlands: Onsite and Regional	Riparian corridor	Medium-term
Monitoring and Reporting	Watershed-wide	Ongoing

Table E-3 Delaware and Montgomery County Municipality Actions

Action	Where	When
On-Lot Disposal (Septic System) Management	All areas with septic systems	Short-term
Pet Waste, Litter, and Dumping Ordinances	Watershed-wide	Short-term
Public Education	All Cobbs Creek municipalities	Short-term
School-Based Education	All schools	Short-term
Public Participation and Volunteer Programs	All Cobbs Creek municipalities	Short-term
Capacity Management Operation and Maintenance	Separate-Sewered Areas	Short-term
Inspection and Cleaning of Sanitary Sewers	Separate and Combined Sewered Areas	Short-term
Sanitary Sewer Rehabilitation	Separate-Sewered Areas	Medium-term
Illicit Discharge, Detection, and Elimination (IDD&E)	All areas with a storm or combined sewer.	Short-term
Stream Cleanup and Maintenance	Cobbs Creek within or along City boundary	Short-term
Enhancing Stream Corridor Recreational and Cultural Resources	Along the stream corridor	Medium-term
Bed Stabilization and Habitat Restoration	Cobbs Creek 40%, West Indian Creek 44%	Short-term
Bank Stabilization and Habitat Restoration	Middle section of Cobbs Creek	Short-term
Channel Realignment and Relocation	Cobbs Creek, East and West Indian Creek	Short-term
Plunge Pool Removal	CSO and stormwater outfalls	Short-term
Improvement of Fish Passage	Woodland Avenue dam	Short-term
Wetland Creation	Riparian corridor	Short-term
Invasive Species Management	Riparian corridor	Short-term
Reforestation	Riparian corridor	Short-term
Requiring Better Site Design in Redevelopment	Watershed-wide	Short-term
Stormwater and Floodplain Management	Watershed-wide	Short-term
Post-Construction Stormwater Runoff Management	Municipalities required to do Phase II permit	Short-term
Sanitary Sewer Overflow Detection	All areas with separate sewers	Ongoing program
Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers	Separate-Sewered Areas	Medium-term
Catch Basin and Storm Inlet Maintenance	All inlets	Ongoing program
Street Sweeping	Streets and Parking Lots	Short-term
Responsible Landscaping on Public lands	Green space	Short-term
Responsible Bridge and Roadway Maintenance	Roadways and bridges	Short-term
Reducing Effective Impervious Cover through Better Site Design	Watershed-wide	Long-term
Increasing Urban Tree Canopy	Watershed-wide	Medium-term
Porous Pavement and Subsurface Storage	Parking lots watershed-wide	Long-term
Capturing Roof Runoff in Rain Barrels or Cisterns	Homes where dry wells are not feasible	Medium-term
Maintaining/Retrofitting Existing Stormwater Structures	Watershed-wide	Short-term
Residential Dry Wells, Seepage Trenches, and Water Gardens	Homes and schools watershed-wide	Long-term
Bioretention Basins and Porous Media Filtration	Watershed-wide	Long-term
Treatment Wetlands: Onsite and Regional	Riparian corridor	Medium-term
Monitoring and Reporting	Watershed-wide	Ongoing

Table E-4: PADEP Actions

Action	Where	When
Industrial Stormwater Pollution Prevention	Industrial sites	Short-term
Construction Stormwater Pollution Prevention	Construction sites	Short-term
Pollution Trading	To be determined	Long-term
Use Review and Attainability Analysis	To be determined	Short-term
Stewardship/Advocacy of Watershed Management Plan	Watershed-wide	Short-term
Watershed-Based Permitting	To be determined	Medium-term
Monitoring and Reporting	Watershed-wide	Ongoing

Recommendations by Implementation Target

Another way to summarize the recommendations is to list options by the target they are designed to address. This grouping by implementation target is shown below. If implementation occurs according to the guidelines in the plan, Targets A and B will be fully met, and implementation of options to meet Target C will results in a more than 20% reduction in wet weather flow volume and pollutant loading.

<u>Target A : Dry Weather Water Quality and Aesthetics</u>

Regulatory Approaches

AR1 On-Lot Disposal (Septic System) Management
AR2 Pet Waste, Litter, and Dumping Ordinances

Public Education and Volunteer Programs

AP1 Public Education
AP2 School-Based Education
AP3 Public Participation and Volunteer Programs

Municipal Measures

AM1 Capacity Management Operation and Maintenance (CMOM)
AM2 Inspection and Cleaning of Combined Sewers
AM3 Sanitary Sewer Rehabilitation
AM4 Combined Sewer Rehabilitation
AM5 Illicit Discharge, Detection, and Elimination (IDD&E)
AM6 Stream Cleanup and Maintenance

AO1 Enhancing Stream Corridor Recreational and Cultural Resources

AMR Monitoring and Reporting

Target B : Healthy Living Resources

Channel Stability and Aquatic Habitat Restoration

BM1 Bed Stabilization and Habitat Restoration
BM2 Bank Stabilization and Habitat Restoration
BM3 Channel Realignment and Relocation
BM4 Plunge Pool Removal
BM5 Improvement of Fish Passage

Lowland Restoration and Enhancement

BM6 Wetland Creation
BM7 Invasive Species Management

Upland Restoration and Enhancement

BM8 Biofiltration
BM9 Reforestation

BMR Monitoring and Reporting

Target C : Wet Weather Water Quality and Quantity

Regulatory Approaches

Zoning and Land Use Control

CR2 Requiring Better Site Design in Redevelopment

CR3 Stormwater and Floodplain Management
CR4 Industrial Stormwater Pollution Prevention
CR5 Construction Stormwater Pollution Prevention
CR6 Post-construction Stormwater Runoff Management
CR7 Pollution Trading
CR8 Use Review and Attainability Analysis
CR9 Watershed-Based Permitting

Municipal Measures

CM1 Sanitary Sewer Overflow Detection
CM2 Sanitary Sewer Overflow Elimination: Structural Measures
CM3 Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers
CM4 Combined Sewer Overflow (CSO) Control Program
- Nine Minimum Controls
- Long Term CSO Control Plan
- Watershed-Based Planning

CM5 Catch Basin and Storm Inlet Maintenance
CM6 Street Sweeping
CM7 Responsible Landscaping Practices on Public Lands
CM9 *R*esponsible Bridge and Roadway Maintenance

CMR Monitoring and Reporting

Stormwater Management

Source Control Measures

- *CS1* Reducing Effective Impervious Cover Through Better Site Design
- *CS2* Increasing Urban Tree Canopy
- *CS3* Porous Pavement and Subsurface Storage
- *CS4* Green Rooftops
- *CS5* Capturing Roof Runoff in Rain Barrels or Cisterns

Onsite and Regional Stormwater Control Facilities

- *CS6* Maintaining/Retrofitting Existing Stormwater Structures
- *CS8* Retrofit of Existing Sewer Inlets with Dry Wells
- *CS9* Residential Dry Wells, Seepage Trenches, and Water Gardens
- *CS12* Bioretention Basins and Porous Media Filtration
- *CS13* Treatment Wetlands: Onsite and Regional

Planning Level Cost Tables

Planning-level costs have been developed for the majority of the options being recommended. Because costs are highly dependent on site specific conditions as well as the extent that implementation occurs, costs are only approximate. These costs are useful, however, in providing order of magnitude funding needs, and also, as a comparison to potential costs associated with more traditional approaches to CSO control, such as large scale storage tanks designed to reach the 85% capture goal.

Planning level costs are provided for each of the options discussed under the three Targets. In many cases, the cost is left blank. This means that costs are not applicable because they are relatively small, or the option would be implemented by existing municipal staff and do not represent an additional cost.

The mix of structural BMPs and implementation percentages in this section are suggested as a feasible plan that will equal or exceed the 20% discharge reduction target. The exact mix of BMPs implemented in each area of the watershed will be determined by local municipalities or by a government or institutional body to be chosen at a later time.

Tables E-5 and E-6 provide costs for implementation to meet Targets A and B. Table E-7 provides costs for non-structural measures aimed at meeting Target C. Table E-8 provides cost estimates for structural measures designed to meet Target C (when combined with the measures in Table E-9). PWD costs are separated from outside agency costs (primarily municipalities) by apportioning costs based on ownership of facilities or simply by the relative areas of the watershed within and outside of Philadelphia City limits. Cost ranges are provided based on the costs associated with the various alternatives that were evaluated. Actual costs are expected to fall within the range, and will depend on the exact mix of options ultimately implemented.

"Cost per acre" values are provided in Table E-9 as a simple measure of the way costs are apportioned in the table.

The affordability of the costs associated with this plan was also analyzed. The results of this analysis are presented in Table E-10 for Philadelphia and for the combined suburban communities comprising the remainder of the watershed. For Philadelphia, the affordability calculation indicates that the incremental cost of the Cobbs improvements would be approximately $10 per household per year, representing 0.03% of median household income. For the combined suburban communities the cost would be $90 per household per year, representing 0.14% of the weighted median household income for those areas. Both of these values are well within USEPA affordability guidelines, and represent relatively limited increases in the current rates being paid for water, sewer, and stormwater in Philadelphia. These calculations represent incremental costs. The overall impact on affordability would need to be evaluated in the context of all the programs comprising water quality improvement within a given community. For example, residents of Philadelphia will ultimately help pay for management programs in five or more watersheds. Residents of the smaller communities may only pay for this one program. Because residents of Philadelphia will ultimately pay for improvements in a number of watersheds, the total cost per household in Philadelphia likely will be similar to the cost for households in the suburban communities.

Tables E-11 and E-12 provide data to assist communities outside Philadelphia in placing projected CCIWMP costs in a local context. Table E-11 expresses estimated costs for communities per acre and per household inside the watershed boundaries; Table E-12 presents costs within the boundaries of all municipalities that intersect the watershed. These cost tables are but one illustration of a possible cost distribution, and are provided to aid municipalities in deciding what funding and institutional mechanisms may be most appropriate given local conditions.

Table E-5 Planning-level Cost Estimates for Target A Options

	Total		Philadelphia		Other Counties	
	Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
Regulatory Approaches						
AR2 On-Lot Disposal (Septic System) Management	$75,000				$75,000	
AR2 Pet Waste, Litter, and Dumping Ordinances[1]						
Public Education and Volunteer Programs	$615,000		$276,000		$340,000	
Municipal Measures						
AM1 Capacity Management Operation and Maintenance (CMOM)[2]						
AM2 Inspection and Cleaning of Combined Sewers	$2,000,000	$21,120,000	$896,000	$8,448,000	$1,104,000	$12,672,000
AM3 Sanitary Sewer Rehabilitation[2]						
AM4 Combined Sewer Rehabilitation[2]						
AM5 Illicit Discharge, Detection, and Elimination (IDD&E)		$22,500,000		$10,125,000		$12,375,000
AM6 Stream Cleanup and Maintenance	$66,000	$31,000	$33,000	$15,000	$33,000	$15,000
AO1 Enhancing Stream Corridor Recreational and Cultural Resources[1]						
AMR Monitoring and Reporting[3]						
Total Cost for Target A Options	$2,756,000	$43,651,000	$1,205,000	$18,588,000	$1,552,000	$25,062,000
Cost per acre for Target A Options	$190	$3,070	$340	$5,220	$150	$2,360

1 - already in place in most locations, or costs difficult to quantify
2 - costs included in option AM2
3 - monitoring and reporting costs not included in this table

Table E-6 Planning-level Costs for Target B Options

	Total		Philadelphia		Other Counties	
	Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
Channel Stability and Aquatic Habitat Restoration[1]	$33,000	$26,400,000	$16,500	$13,200,000	$16,500	$13,200,000
BM1 Bed Stabilization and Habitat Restoration[2]						
BM2 Bank Stabilization and Habitat Restoration[2]						
BM3 Channel Realignment and Relocation[2]						
BM4 Plunge Pool Removal[2]						
BM5 Improvement of Fish Passage		$130,000		$130,000		
Lowland Restoration and Enhancement						
BM6 Wetland Creation[2]						
BM7 Invasive Species Management[2]						
Upland Restoration and Enhancement						
BM8 Biofiltration[2]						
BM9 Reforestation[3]						
BMR Monitoring and Reporting[4]						
Total Cost for Target B Options	$33,000	$26,530,000	$16,500	$13,330,000	$16,500	$13,200,000
Cost per acre for Target B Options	$2.30	$1,870	$4.60	$3,740	$1.50	$1,240

1 – cost based on restoring high-priority reaches at a cost of $700/lineal ft. If actual cost is lower, medium priority reaches may also be restored
2 – costs included under general "Channel Stability and Aquatic Habitat Restoration" costs
3 – costs included in Target C urban tree canopy costs
4 - monitoring and reporting costs not included in this table

Table E-7 Planning-level Costs for Nonstructural Target C Options

	Total		Philadelphia		Other Counties	
	Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
Regulatory Approaches						
Zoning and Land Use Control						
CR2 Requiring Better Site Design in Redevelopment[1]		$300,000		$100,000		$200,000
CR3 Stormwater and Floodplain Management[1]		$350,000		$175,000		$175,000
CR4 Industrial Stormwater Pollution Prevention[2]						
CR5 Construction Stormwater Pollution Prevention[2]						
CR6 Post-construction Stormwater Runoff Management[2]						
CR7 Pollution Trading[2]						
CR8 Use Review and Attainability Analysis[2]						
CR9 Watershed-Based Permitting[2]						
Municipal Measures						
CM1 Sanitary Sewer Overflow Detection[3]						
CM2 Sanitary Sewer Overflow Elimination: Structural Measures[3]						
CM3 Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers[3]						
CM4 Combined Sewer Overflow (CSO) Control Program[4]						
CM5 Catch Basin and Storm Inlet Maintenance	$600,000		$269,000		$331,000	
CM6 Street Sweeping	$135,000		$45,000		$90,000	
CM7 Responsible Landscaping Practices on Public Lands[2]						
CM9 Responsible Bridge and Roadway Maintenance[2]						
CMR Monitoring and Reporting[5]						
Stormwater Management						
Source Control Measures						
CS1 Reducing Effective Impervious Cover Through Better Site Design[2]						
CS2 Increasing Urban Tree Canopy	$1,500,000	$15,000,000	$500,000	$5,000,000	$1,000,000	$10,000,000
Onsite and Regional Stormwater Control Facilities						
CS6 Maintaining/Retrofitting Existing Stormwater Structures	$20,000	$100,000	$10,000	$50,000	$10,000	$50,000
Use Review and Attainability Analysis		$300,000		$300,000		
Total Cost for Target C Options	$2,255,000	$16,050,000	$824,000	$5,625,000	$1,431,000	$10,425,000
Cost per acre for Target C Options	$160	$1,130	$230	$1,580	$130	$980

1 - estimated cost for ordinance development
2 - costs difficult to quantify
3 - costs included in option AM2
4 - costs included in AM2 or in Table E-8
5 - monitoring and reporting costs not included in this table

Table E-8 Range of Costs for Structural Target C Options

Cost	Philadelphia	Other Counties
Lowest	Alternative 1: RTC	Alternative 1: Cost-Effective Stormwater BMPs
	$1,750,000	$5,340,000
Highest	Alternative 5: Focus on Public and Parking BMPs	Alternative 5: Focus on Public and Parking BMPs
	$10,800,000	$25,500,000

Table E-9 Total Watershed Plan Cost

Total		Philadelphia		Other Counties	
Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
$5,000,000	$93,000,000 - $122,000,000	$2,000,000	$39,000,000 - $48,000,000	$3,000,000	$54,000,000 - $74,000,000
$350/ac	$6,550/ac - $8,590/ac	$560/ac	$10,950/ac - $13,480/ac	$280/ac	$5,080/ac - $6,960/ac

Table E-10 Incremental Affordability Measure

		Philadelphia	Suburban Communities *(Combined)*
1	Capital:	$3,770,000	$5,820,000
2	Operating:	$2,000,000	$3,000,000
3	Total Annual Cost Associated with WMP	$5,770,000	$8,820,000
4	Cost per acre in watershed	$1,642	$826
5	2000 Median Household Income	$30,746	$61,962
6	Estimated Annual Sewer User Charge*	$343	$197
7	WMP cost per household in watershed (in entire municipalities)	$146.04 ($9.77)	$185.71 ($87.52)
8	WMP cost as % of MHI in watershed (in entire municipalities)	0.47% (0.03%)	0.30% (0.14%)
9	Existing sewer cost + WMP cost in watershed (entire municipalities)	1.59% (1.15%)	0.62% (0.46%)

* The sewer user charge in Philadelphia includes a stormwater collection and treatment fee. Stormwater-related charges outside Philadelphia were not investigated.

Table E-11 Distribution of Costs Among Rate Payers in Cobbs Watershed in Communities Outside Philadelphia

	Colwyn	Darby	East Lansdowne	Haverford	Lansdowne	Lower Merion	Milbourne	Narberth	Radnor	Upper Darby	Yeadon
Municipality area in watershed (ac)	96	140	132	3,873	111	2,375	44	268	32	2,700	910
Area of municipality in watershed (% of municipality total)	59%	27%	100%	60%	15%	16%	100%	85%	0.4%	56%	88%
Households in municipality and watershed	484	1219	939	12185	755	7151	366	1619	141	18357	4277
Annual cost associated with CCIWMP	$79,252	$115,576	$108,971	$3,197,315	$91,635	$1,960,656	$36,324	$221,245	$26,417	$2,228,957	$751,241
Cost per acre (within watershed)	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54
Cost per household (within watershed)	$163.74	$94.81	$116.05	$262.40	$121.37	$274.18	$99.25	$136.66	$187.36	$121.42	$175.65
Median household income ($/year)	$33,150	$30,938	$44,205	$65,714	$47,017	$86,373	$30,185	$60,408	$74,272	$41,489	$45,450
Cost per household (% of MHI)	0.49%	0.31%	0.26%	0.40%	0.26%	0.32%	0.33%	0.23%	0.25%	0.29%	0.39%

Table E-12 Distribution of Costs Among all Rate Payers in Communities Outside Philadelphia

	Colwyn	Darby	East Lansdowne	Haverford	Lansdowne	Lower Merion	Milbourne	Narberth	Radnor	Upper Darby	Yeadon
Municipality area (ac)	164	522	132	6,406	753	15,265	44	316	4,824	4,824	1,032
Watershed area in municipality (ac)	96	140	132	3874	111	2376	44	268	32	2701	910
Watershed area in municipality (% of watershed total)	0.7%	1.0%	0.9%	27.3%	0.8%	16.7%	0.3%	1.9%	0.2%	19.0%	6.4%
Households in municipality	857	3,411	939	18,069	4,688	22,845	368	1,895	10,383	32,594	4,730
Annual cost associated with CCIWMP	$79,252	$115,576	$108,971	$3,197,315	$91,635	$1,960,656	$36,324	$221,245	$26,417	$2,228,957	$751,241
Cost per acre (whole municipality)	$483.24	$221.41	$825.54	$499.11	$121.69	$128.44	$825.54	$700.14	$5.48	$462.06	$727.95
Cost per household (whole municipality)	$92.48	$33.88	$116.05	$176.95	$19.55	$85.82	$98.71	$116.75	$2.54	$68.39	$158.82
Median household income ($/year)	$33,150	$30,938	$44,205	$65,714	$47,017	$86,373	$30,185	$60,408	$74,272	$41,489	$45,450
Cost per household (% of MHI)	0.28%	0.11%	0.26%	0.27%	0.04%	0.10%	0.33%	0.19%	0.003%	0.16%	0.35%

Section 1: Background

The integrated watershed management plan, developed by the Darby-Cobbs Watershed Partnership, is based on a carefully developed approach to meet the challenges of watershed management in an urban setting. It is designed to meet the goals and objectives of numerous, water resource related regulations and programs, and draws from the similarities contained in many watershed-based planning approaches authored by DEP and EPA. Its focus is on attaining priority environmental goals in a phased approach by making use of the consolidated goals of the numerous existing programs that directly or indirectly require watershed planning.

1.1 What is a Watershed and Why a Plan?

A watershed is a natural formation including land and communities connected by water (Figure 1). Simply said, the health of a stream depends on the quality of the land surrounding it, which in turn relies on the people charged with the care for that land. How do you care for an urban watershed? By addressing practices of the past, including paving the land and piping the stormwater, which took place as the area was urbanized. These practices were deemed an important step in development at the time, but they have had a devastating impact on the natural environment. As scientific knowledge and values have changed over time, the maintenance of both a vibrant community and healthy natural resources can be achieved, and the two can reinforce one another.

To address the impacts of past development on Cobbs Creek, we must define and understand the problems in the watershed. To this end, extensive physical, chemical and biological assessments were carried out, coupled with interaction with stakeholders. These activities helped to define and focus planning objectives and form the basis for the entire planning effort. Our plan explores the nature, causes, severity and opportunities for control of water quality impairments in the Cobbs Creek watershed. The primary intent of the plan, as articulated by the stakeholders, is to improve the environmental health and safe enjoyment of the Cobbs watershed by sharing resources and through cooperation among residents and other stakeholders in the watershed. The goals of the initiative are to protect, enhance, and restore the beneficial uses of the Cobbs waterways and its riparian areas, goals that are currently only partially being addressed by a number of programs. A piecemeal approach through a variety of regulatory programs dealing separately with stormwater quantity, water quality, impacts to streams from sanitary and combined sewers, and wetland protection has proven to be ineffective and inefficient in dealing with the problems associated with urban streams. Integrated planning is the preferred approach.

An integrated watershed management plan is a long-term action plan designed to achieve the twin goals of a healthy community and healthy natural resources. An integrated plan embraces the laws designed to save streams, preserves the streams' ecology, and enhances the parkland and riparian buffers that shelter these streams. This plan reaches out to propose municipal action working in concert with conservation planning that strives to ensure that growth and redevelopment within the watershed proceeds with particular care to the environment. Most importantly, the plan incorporates a diversity of people who live, work, and dream in all areas of the watershed. People provide the catalyst for change, the energy to create the plan, and the vigilance to sustain the plan. These people, the stakeholders, become the watershed’s guardians – the keepers of the integrated plan.

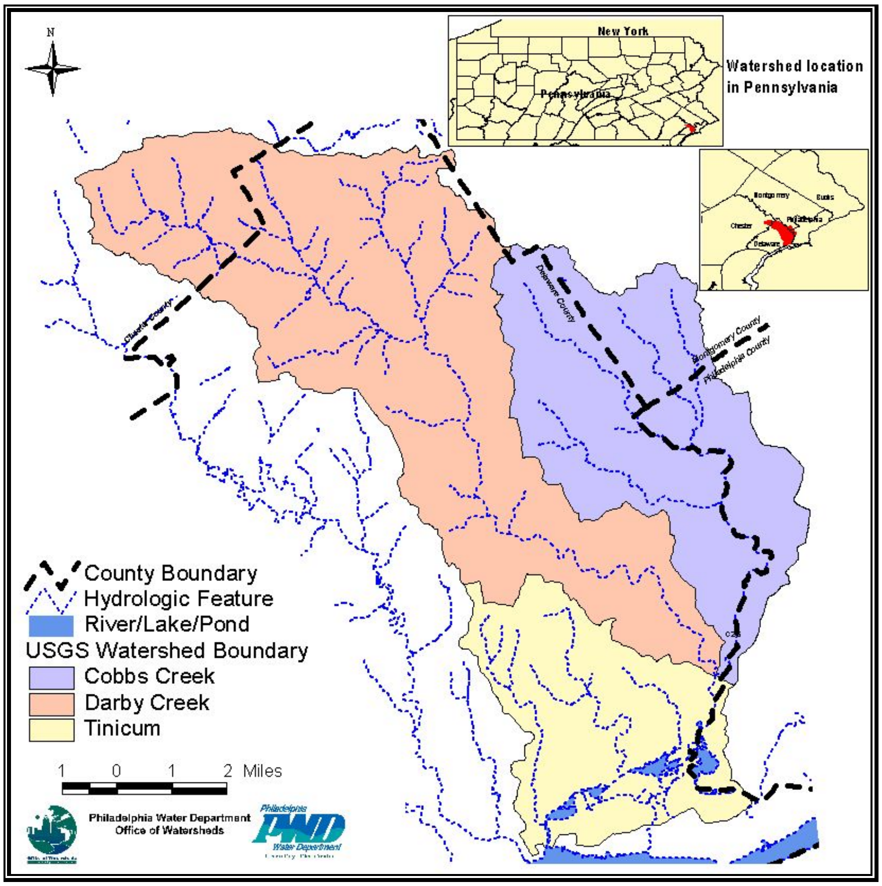


Figure 1-1 Darby-Cobbs Watershed

1.2 Brief History of the Darby-Cobbs Creek Watershed

The history of Cobb's Creek watershed is typical of many similar watersheds on the borders of Philadelphia County--a progression from natural fields and woodlands inhabited only by native peoples, to an agricultural and industrial era fueled by the energy of European immigrants, which eventually gave way to population pressures as open lands were developed into densely-built residential neighborhoods.

Before the beginning of European exploration and immigration, the area was home to Native Americans, particularly the Lenni Lenape tribe. They used Cobb's Creek (which they knew as "Karakung") and its surrounding tributaries and lands for fishing, hunting, transportation, and rudimentary agriculture.

Dutch, Swedish and finally the dominant English Quaker immigrants settled the area beginning in the mid-17th century. Marshes were diked or drained both for health reasons, and to provide dry ground for pastures or growing hay for sale. Streams were diverted into man-made millraces to provide power for a growing number of small mills. These Europeans began what became the wholesale clearing of woodland in the watershed, both to open up farming and pasture lands and to provide lumber for buildings in the growing city of Philadelphia. By the mid-18th century, these "plantations," as farmsteads were then known, were probably the most common landscape feature in and around the City.

It is likely that the removal of forests led to increased runoff and stream flows during storms, and increased sedimentation and erosion. But the actual historical effect of these and other man-made changes in the watershed on the aquatic and terrestrial life is difficult to quantify.

The oldest mill in Philadelphia, built by the Swedish settlers on Cobb's Creek in 1642, stood just upstream from where Woodland Avenue now crosses the creek, and subsequent mills on this site used water power to grind flour into the early 20th century. By the 19th century there were dozens of water-powered mills along Cobb's Creek and its major tributaries, Naylor's Run and Indian Creek. Besides the usual saw, grist and snuff mills, in the early 1800s a thriving gunpowder manufacturing center was located along the creek, in Haverford Township. Keystone Paper Mill stood at the confluence of Indian Creek and Cobb's Creek, and near 63rd and Market, in Millbourne Borough, the Millbourne Flour Mill of the Sellers family stood for more than 100 years. Numerous textile mills existed in the watershed, with clusters of factories in the Angora section of West Philadelphia (near 60th Street and Baltimore Avenue), the Cardington neighborhood of Upper Darby (where Marshall Road crosses the creek), and in the Haddington neighborhood of Philadelphia, where the east and west branches of Indian Creek joined (now Morris Park, at the intersection of 69th Street and Haverford and Lansdowne Avenues). Water used in various industrial processes, such as paper-making and textile dyeing and bleaching, was dumped directly back into the creek, untreated, which certainly had an adverse affect on water quality and aquatic life.

The wholesale transformation of the watershed, from mostly open space with scattered villages and small industrial centers into a mostly-developed residential area, began in the latter part of the 19th century. One factor in this change was the completion of the Mill Creek sewer in West Philadelphia. Entering Philadelphia at 63rd Street and City Avenue, Mill Creek cut a diagonal five-mile valley through West Philadelphia before emptying into the Schuylkill River at 43rd Street. In some places 35 or 40 feet below the current street levels, the creek served as an impediment to development, which tended to stop at its eastern edge. Encapsulation of this creek in a combined sewer, begun in 1869 and completed about 1895, and the subsequent filling and leveling of the valley, allowed the grid of rowhouse development to continue unimpeded toward Cobbs Creek, the City's western edge.

A second important factor in the watershed's transformation was the construction of the Market-Frankford Elevated Railroad. Begun in 1906 and completed by 1908, this line allowed quick access into the city for suburban dwellers, and greatly spurred residential construction in the western parts of Philadelphia and eastern Delaware County. In 1932, a newspaper article stated that more than half of West Philadelphia's 90,000 homes had been built after the El project began. The same article noted that by that time Upper Darby's population had mushroomed to 60,000, with much of that growth coming after 1920.

This rampant development contributed to the degradation of the stream quality in several ways. A number of Cobbs Creek tributaries were completely obliterated, the largest being Thomas Run, which once ran from about 53rd and Walnut streets to Cobbs Creek at about 60th Street; today it runs only underground, in a combined sewer. Thousands of feet of Naylor's Run were channeled into underground culverts to facilitate commercial and residential development in the filled land above the pipes. A massive increase in impervious surfaces in the watershed meant that runoff was reaching the creek more quickly, leading to higher storm flows, increased erosion and scouring of the stream bed.

Furthermore, sewers from the new neighborhoods in the watershed emptied directly into the creek and its tributaries, polluting the water with raw sewage. By 1914 Philadelphia had constructed an interceptor sewer which kept wastes from within its boundaries from entering the creek, but it took decades more before communities in neighboring Delaware and Montgomery counties did the same.

By the 1930s, most of the mills had left the watershed, leaving abandoned buildings as the main reminder of the area's once-thriving industrial heritage. Residential development continued to spread, with large sections of Overbrook Park in Philadelphia built up after World War II, and development continuing into Haverford and Lower Merion Townships in the 1950s and 1960s, although at a considerably lower density. In more recent times, polluted stormwater runoff and inadequate drainage systems, leaking and inadequate septic tanks, lack of open space and adequate recreation, illegal dumping, and an array of other urban ills have also taken their toll on the quality of human and natural life in the watershed.

On the bright side, beginning in the mid-19th century, a number of cemetery companies began buying up large tracts of the watershed, establishing Mt. Moriah, Fernwood, Holy Cross, and Arlington cemeteries. As the farmsteads in the watershed, one by one, were transformed into residential neighborhoods, these cemeteries served to preserve hundreds of acres of open space by keeping them out of the hands of developers.

The creation of Cobbs Creek Park and Morris Park in Philadelphia, in the beginning of the 20th century, also managed to preserve hundreds of acres of open space, and saved Indian Creek from being buried in an underground sewer, as is shown on various planning maps of the era.

Plans for an expressway up the Cobbs Creek valley (I-695), which would have begun at I-95 near Essington and connected with another expressway at Whitby Avenue in West Philadelphia, were finally killed in the mid-1970s, with the money diverted into mass transit projects.

For more historical information on Cobbs Creek see http://www.sewerhistory.net

1.3 Comprehensive Planning and the Regulatory Framework

Water Resource Management in Urban Streams

In many states, numerous federal and state regulations and programs are aimed at improving the water quality and flow patterns in urban streams, while at the same time reducing flooding. Pennsylvania is no exception; the USEPA and the Pennsylvania Department of Environmental Protection (PADEP) have a complex regulatory framework for managing water resources with frequently overlapping demands and requirements. There are several major regulatory programs that contain significant elements related to watershed management in the Cobbs Creek watershed. These are:

- Pennsylvania Title 25, Chapter 93 Water Quality Standards Regulations
- the Total Maximum Daily Load (TMDL) process to improve water quality on impaired streams and water bodies
- the Phase I and Phase II stormwater regulations to control pollution due to stormwater discharges from municipal stormwater systems
- the stormwater management PA Act 167 to address management of stormwater runoff quantity particularly in developing areas
- PA Act 537 sewage facilities planning to protect and prevent contamination of groundwater and surface water by developing proper sewage disposal plans
- EPA's Combined Sewer Overflow (CSO) Control Policy to minimize mixed sewage and stormwater overflowing directly into streams

Each of these regulatory programs supports very specific aspects of water resources management. The specific nature of the regulations sometimes negates the ability of a regulatory program to deal comprehensively with a water quality issue that benefits from more than one of these programs. For the development of this integrated plan, these regulations provide guidelines that are transformed into a series of planning objectives within the watershed management planning process.

These objectives then lead directly to the selection of watershed management options to address the stakeholder-defined goals for environmental quality. In this manner, the plan makes requests of each of these programs to go beyond their programmatic requirements and begin to represent their outcome within the context of the watershed plan goals.

Pennsylvania Title 25, Chapter 93 Water Quality Standards Regulations

Water quality criteria are the numeric concentrations, levels or surface water conditions that need to be maintained or attained to protect existing and designated uses of a stream. They are designed to protect the water uses appropriate to each stream. The streams are classified in Pennsylvania in Chapter 93, Title 25 of the Pennsylvania Code.

Usually the most sensitive of these protected uses are generally water supply, recreation and fish consumption, and aquatic life related. Therefore, criteria designed to protect these uses will normally protect the other uses listed in Chapter 93.

The designated uses for the non-tidal portion of Cobbs Creek include all the state-wide uses plus migratory fishes as shown below:

Symbol	Designated Use
	Aquatic Life
WWF	Warm Water Fishes
MF	Migratory Fishes
	Water Supply
PWS	Potable Water Supply
IWS	Industrial Water Supply
LWS	Livestock Water Supply
AWS	Wildlife Water Supply
IRS	Irrigation
	Recreation
B	Boating
F	Fishing
WC	Water Contact Sports
E	Esthetics

The regulations state that water may not contain substances attributable to point or non-point source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.

Impairment Designations and the TMDL Process

Water quality standards provide the target against which the water quality in Cobbs Creek is measured. If water quality standards are not being met, and technology based controls of point and non-point sources are not sufficient to meet the standards, then the load of pollutants must be reduced. Section 303(d) of the Clean Water Act (CWA) and the USEPA's Water Quality Planning and Management Regulations (40 CFR Part 130) provide a framework for reducing pollutant loads based on calculation of Total Maximum Daily Loads (TMDLs). TMDLs are the sum of individual waste load allocations (point sources) and load allocations (non-point sources) plus a margin of safety. They establish a link between water quality standards and water quality based controls. The objective of TMDLs is to allocate allowable loads among different pollutant sources so that the appropriate control actions can be taken and water quality standards achieved.

The basic steps in the water quality based approach to TMDLs include:

- Identification of the water quality-limited waters and the quality parameters of concern
- Prioritizing the locations by ranking and targeting
- Establishing the TMDL
- Implementing the control actions
- Assessment of the control actions

Pennsylvania has listed water quality-limited waters according to point and non-point sources for toxic, conventional (BOD, TSS, fecal coliform, oil and grease), and non-conventional (ammonia, chlorine, and iron) pollutants. Streams that are listed under Section 303(d) of the CWA are particularly targeted for improvement (PADEP, 2004). The Cobbs Creek watershed is within Subbasin 03G, which also includes Crum Creek, Ridley Creek, and Chester Creek watersheds. Within the Cobbs watershed, the following stream segments are listed as impaired.

- The lower 10.09 miles of Darby Creek and 3.55 miles of unnamed tributaries are impaired due to habitat modification, siltation, and water/flow variability from urban runoff and from storm sewers.
- The entire 18.75 miles of Cobbs Creek and unnamed tributaries within the watershed are impaired due to urban runoff/storm sewers and habitat modification.

The next step in the statewide TMDL process includes prioritization of the list and the development of TMDLs for high-priority water bodies. It is this phase of the TMDL process that is of interest to the integrated watershed planning process.

Prioritization must take into account the severity of the pollution and the designated uses of the water body. It should consider the following:

- Risks pertaining to human health and aquatic life
- Degree of public interest and support
- Recreational, economic, and aesthetic importance

- Vulnerability or fragility of the aquatic habitat
- New permit applications for discharges or revisions to existing permits
- Court orders and decisions
- National policies and priorities

TMDL development requires the quantification of pollutant sources and the allocation of maximum discharge loads to contributing point and non-point sources in order to attain water quality standards. TMDLs are best developed on a watershed basis in order to efficiently and effectively manage the quality of the water. The TMDL process may be developed using a phased approach that includes monitoring requirements and it generally includes the following five activities:

- Selection of the pollutants
- Evaluation of the water body's assimilative capacity
- Assessment of the pollutants discharged from all sources
- Predictive analysis of the water body's response to pollution and determination of the total allowable pollutant load
- Allocation (with a margin of safety) of the allowable pollutant load among the different sources

The National Pollutant Discharge Elimination System's (NPDES) permitting process is used to implement control measures to limit effluent from point sources. In the case of non-point sources, state and local laws can be used to implement best management practices (BMPs), as well as Section 319 state management programs. These programs must be coordinated in order to effectively achieve the required non-point source reductions.

NPDES Stormwater Rules

In response to the 1987 Amendments to the Clean Water Act (CWA), the Environmental Protection Agency (EPA) developed Phase I of the NPDES Stormwater Program in 1990. Phase I required NPDES permits for all stormwater discharging from storm sewers (MS4s) of medium and large urban areas (UAs) with populations of 100,000 or more. It also required permits from eleven categories of industrial activity, including construction activities that disturb five or more acres of land. Permit coverage can be either under an individually tailored NPDES permit (used by MS4s and some industrial facilities) or a general NPDES permit (used by most industrial facilities and construction sites).

Phase II of the NPDES Stormwater Program was published in November 1999. The Phase II Regulation requires NPDES permit coverage - mostly under general permits - for stormwater discharges from most small-urbanized areas (small MS4s) and construction activities that disturb from 1 to 5 acres of land. A list of affected communities has been published in the Federal Register.

There are a minimum of six control measures that communities must implement as part of a municipal stormwater management program whose goal is Phase II compliance. These are:

1. Public Education and Outreach

Distributing educational materials and performing outreach to inform citizens about the impacts polluted stormwater runoff discharges can have on water quality.

2. Public Participation and Involvement

Providing opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen representatives to be part of a stormwater management panel.

3. Illicit Discharge Detection and Elimination

Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system. Includes the developing of a system map as well as informing the community about hazards associated with illegal discharges and improper waste disposal.

4. Construction Site Runoff Control

Developing, implementing, and enforcing an erosion and sediment control program for construction activities that disturb one or more acres of land (controls could include for example, silt fences and temporary stormwater detention ponds).

5. Post Construction Runoff Control

Developing, implementing, and enforcing a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas (e.g. wetlands) or the use of structural BMPs such as grassed swales or porous pavement.

6. Pollution Prevention/Good Housekeeping

Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch-basin cleaning).

The EPA has listed the following municipalities within the Darby-Cobbs watershed for inclusion in the Phase II program. The permit cycle for these permits starts in 2003.

Aldan Borough, Clifton Heights Borough, Collingdale Borough, Colwyn Borough, Darby Borough, Darby Township, East Lansdowne Borough, Easttown Township, Folcroft Borough, Glenolden Borough, Haverford Township, Lansdowne Borough, Lower Merion Township, Marple Township, Millbourne Borough, Morton Borough, Narberth Borough, Newtown Township, Norwood Borough, Prospect Park Borough, Radnor Township, Ridley Park Borough, Ridley Township, Rutledge Borough, Springfield Township, Tinicum Township, Tredyffrin Township, Upper Darby Township, Upper Darby Township, Yeadon Borough.

Act 167 Stormwater Management Act of 1978 (32 PS § 680.3.)

The Stormwater Management Act 167 is administered by PADEP and is designed to address the inadequate management of accelerated stormwater runoff resulting from development. The plan must address a wide range of hydrologic impacts due to development on a watershed basis, and include such considerations as tributary timing, flow volume reduction, base flow augmentation, water quality control, and ecological protection. Watershed runoff modeling is usually a critical component of the study, with modeled hydrologic responses to 2, 5, 10, 25, 50, and 100-year storms.

The primary purposes of the act are to:

- Encourage planning and management of stormwater runoff
- Authorize a comprehensive program of stormwater management designed to preserve and restore the flood carrying capacity of Commonwealth streams;
- Preserve natural stormwater runoff regimes
- Protect and conserve groundwater

The act requires that each county--in consultation with affected municipalities --prepare and adopt a stormwater management plan for each watershed that falls wholly or partially within the county. The act focuses on reduction of stormwater runoff quantities, rather than on water quality. Each stormwater plan will include, but is not limited to:

- A survey of existing runoff characteristics in small as well as large storms, including the impact of soils, slopes, vegetation and existing development;
- A survey of existing significant obstructions and their capacities;
- An assessment of projected and alternative land development patterns in the watershed, and the potential impact of runoff quantity, velocity, and quality;
- An analysis of present and projected development in flood hazard areas, and its sensitivity to damages from future flooding or increased runoff;
- A survey of existing drainage problems and proposed solutions;

- A review of existing and proposed stormwater collection systems and their impacts;
- An assessment of alternative runoff control techniques and their efficiency in the particular watershed;
- An identification of existing and proposed state, federal, and local flood control projects located in the watershed and their design capacities;
- A designation of those areas to be served by stormwater collection and control facilities within a ten-year period;
- An estimate of the design capacity and costs of such facilities;
- A schedule and proposed methods for financing the development, construction and operation of the facilities;
- An identification of the existing or proposed institutional arrangements to implement and operate the facilities;
- An identification of floodplains within the watershed;
- Standards for the control of stormwater runoff from existing and new development which are necessary to minimize dangers to property and life;
- Priorities for implementation of action within each plan; and
- Provisions for periodically reviewing, revising and updating the plan.

After adoption and approval of a stormwater plan, the location, design, and construction within the watershed of stormwater management systems, flood control projects, subdivisions and major land developments, highways, and transportation facilities must all be conducted in a manner consistent with the approved plan.

As noted above, beginning in 2003, municipalities within the Cobbs Creek watershed also will have to obtain a NPDES permit for separate storm sewer systems. PADEP has developed a Protocol which meets the six Minimum Control Measures required of municipal permittees under the Phase II NPDES Stormwater Regulations (40 CFR §§ 122.26 – 123.35). If an MS4 municipality commits to implementing the provisions of the Protocol for any Minimum Control Measure (e.g., Construction Site Runoff Control), it does not need an independent review and approval of its stormwater management program by DEP for that Minimum Control Measure. The federal regulations also allow DEP and MS4 municipalities to use existing qualifying state and local programs to satisfy any of the NPDES General Permit requirements of MS4s. The Pennsylvania Stormwater Management Act ("Act 167") is an existing qualifying program, and integrating the planning required for Act 167 with the planning required to meet the six Minimum Control Measures is a logical approach to take. An integrated Act 167 Plan is presently under preparation for the Darby-Cobbs Creek watershed by Delaware County with assistance from Philadelphia, Chester, and Montgomery Counties.

Act 537 Sewage Facilities Planning

Act 537, enacted by the Pennsylvania Legislature in 1966, requires that every municipality in the state develops and maintains an up-to-date sewage facilities plan. The act requires proper mapping, assessment, and planning for future needs of all types of sewage facilities. In addition, this program provides requirements for the permitting of individual and community on-lot disposal systems, and uniform standards of design.

The main purpose of a municipality's sewage facilities plan is to ensure that the sewage collection and treatment systems have adequate capacity to convey present and future to sewage flows to a wastewater treatment facility. The planning process also requires correction for existing sewage disposal problems including malfunctioning on-lot septic systems, overloaded treatment plants or sewer lines, and improper sewer connections. The program is also designed to prevent future sewer problems and to protect the groundwater and surface water of the locality and specifically requires in-stream water quality to be evaluated during the planning process. To meet these objectives, PADEP uses the Official Sewage Planning requirements of Act 537 that prevent and eliminate pollution of the waters of the Commonwealth by coordinating planning for the sanitary disposal of sewage with a comprehensive program of water quality management.

Official plans contain comprehensive information, including:

- The location of treatment plants, main intercepting lines, pumping stations and force mains, including their size, capacity, point of discharge and drainage basin served.
- Descriptions of problems with existing sewerage facilities and operation and maintenance requirements
- Planning objectives and needs
- Physical description of planning area
- Evaluation of existing wastewater treatment and conveyance systems
- Evaluation of wastewater conveyance and treatment needs

Combined Sewer Overflow (CSO) Control Policy

EPA's CSO Control Policy, published in 1994, provides the national framework for regulation of CSOs under NPDES. The policy guides municipalities and state and federal permitting agencies in meeting the pollution control goals of the CWA in as flexible and cost-effective a manner as possible. As part of the program, communities serviced by combined sewer systems are required to develop long-term CSO control plans (LTCPs) that will result in full compliance with the CWA, including attainment of water quality standards.

As the first step under the CSO policy, nine minimum technology-based controls are required; these are measures that can reduce the prevalence and impacts of CSOs and that are not expected to require significant engineering studies or major construction.

- Proper operation and regular maintenance programs for the sewer system and the CSOs;
- Maximum use of the collection system for storage;
- Review and modification of pretreatment requirements to assure CSO impacts are minimized;
- Maximization of flow to the publicly owned treatment works for treatment;
- Prohibition of CSOs during dry weather;
- Control of solid and floatable materials in CSOs;
- Pollution prevention;
- Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts; and
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls.

In the longer term, the CSO policy includes four requirements to ensure that the CSO systems meet the pollution control goals and local environmental objectives in a cost-effective manner:

- Clear levels of control to meet health and environmental objectives;
- Flexibility to consider the site-specific nature of CSOs and find the most cost-effective way to control them;
- Phased implementation of CSO controls to accommodate a community's financial capability; and
- Review and revision of water quality standards during the development of CSO control plans to reflect the site-specific wet weather impacts of CSOs.

One of the three major components of the City of Philadelphia's CSO Long Term Control Plan (LTCP) strategy involves a substantial commitment by the City to watershed planning to identify long term improvements throughout its watersheds, including any necessary additional CSO controls, that will result in further improvements in water quality and, ultimately, the attainment of water quality standards. The need for this watershed initiative is rooted in the fact that insufficient physical, chemical and biological information currently existed on the nature and causes of water quality impairments, sources of pollution, and appropriate remedial measures. Because of this deficiency, at the time the CSO LTCP was developed, it was impossible to determine what needed to be done for additional CSO control or control of other wet weather sources throughout the watershed. This deficiency, especially with respect to the effects of wet weather discharges and receiving water dynamics, was increasingly recognized nationwide and led to a broader recognition of the need for watershed-based planning and management to properly define water quality standards and goals. The PWD suggested in its LTCP that the National CSO Policy, state and federal permitting and water quality management authorities, cities, environmental groups, and industry, recognized that effective long-term water quality management could be accomplished only through watershed-based planning.

The CSO Control Policy acknowledges the importance of watershed planning in the long term control of CSOs by encouraging the permit writer "... to evaluate water pollution control needs on a watershed management basis and coordinate CSO control efforts with other point and nonpoint source control activities" (1.B). The watershed approach is also discussed in the section of the CSO Control Policy addressing the demonstration approach to CSO control (II.B.4.b; and Chapter 3 of the USEPA Guidance for Long Term Control Planning), which, in recommending that NPDES permitting authorities allow a demonstration of attainment of WQS, provides for consideration of natural background conditions and pollution sources other than CSOs.

The EPA Long Term Control Planning Guidance suggests that EPA is committed to supporting the implementation of a comprehensive watershed management approach. EPA has convened a Watershed Management Policy Committee, consisting of senior managers, to oversee the reorientation of all EPA water programs to support watershed approaches.

Of particular importance to CSO control planning and management is the NPDES Watershed Strategy. This strategy outlines national objectives and implementation activities to integrate the NPDES program into the broader watershed protection approach. The Strategy also supports the development of basin management as part of an overall watershed management approach

The Long Term Control Planning Guidance suggests that the sources of watershed pollution and impairment, in addition to CSOs, are varied and include other point source discharges; discharges from storm drains; overland runoff; habitat destruction; land use activities, such as agriculture and construction; erosion; and septic systems and landfills. The benefits to implementing a watershed approach are significant and include:

- Consideration of all important sources of pollution or impairment
- Clearer definition of water quality benefits resulting from a given level of CSO reduction
- Greater flexibility to reflect the site-specific nature of CSO discharges
- Greater cost effectiveness (through coordination of monitoring programs, for example)

- Fostering of prevention as well as control
- Fairer allocation of resources and responsibilities.

The Guidance notes that the major advantage in using a watershed-based approach to develop an LTCP is that it allows the site-specific determination of the relative impacts of CSOs and non-CSO sources of pollution on water quality. For some receiving water reaches within a watershed, CSOs could well be less significant contributors to non-attainment than stormwater or upstream sources. In such cases, a large expenditure on CSO control could result in negligible improvement in water quality.

The EPA LTCP Guidance outlines a conceptual framework for conducting CSO planning in a watershed context (Figure E-1). The approach is intended to identify CSO controls for each receiving water segment based on the concepts of watershed management and use attainability. The Cobbs watershed planning approach outlined in this document is conceptually identical. It moved from data collection through analysis and modeling to arrive at a set of recommended measures or options designed to meet the goals and objectives agreed upon through the stakeholder process. Figure E-1 also identifies the section of the the Watershed Management Plan that documents each step in the process.

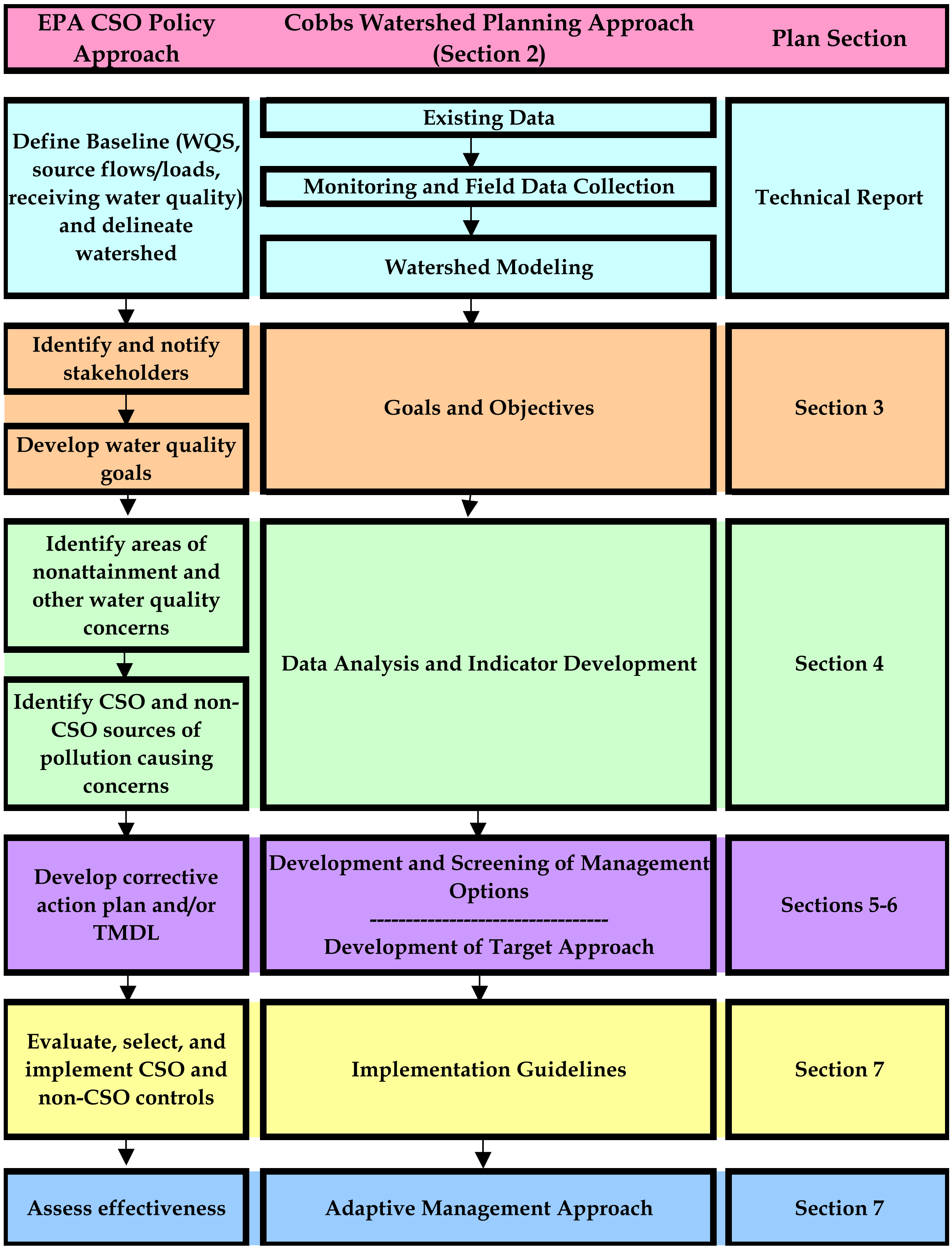


Figure 1-2: Cobbs Planning Approach

Watershed-Based CSO Control Planning Approach for a Receiving Water Segment – from USEPA Guidance for Long Term Control Plan (1995)

1.4 Overlapping Aspects of Regulatory Programs

Integrated watershed planning includes various tasks, ranging from monitoring and resource assessment to technology evaluation and public participation. The scope and importance of each task varies for each watershed, depending on the site-specific factors such as the environmental features of the watershed, regulatory factors such as the need to revise permits or complete TMDLs, available funding, extent of previous work, land use, and the size and degree of urbanization of watershed.

There are numerous activities required under each of the five programs mentioned above. Table 1-1 gives an overview of the types of activities required under each program, and Table 1-2 gives an overview of the types of data needed for each activity. Both tables highlight the fact that the task completed or the data collected under one program is often identical or very similar to the work done under other programs. It is clear that significant savings can be achieved through coordination of the programs and the development of one comprehensive plan for a watershed that meets all five program needs.

Table 1-1 Overview of Planning Tasks Required by Watershed Programs

Planning Tasks	Act 167 Stormwater	Act 537 Sewage Facilities	TMDL Program	NPDES Stormwater	CSO Program	RCP
Preliminary Reconnaissance Survey						
Existing data collection and assessment	X	X	X	X	X	X
Preliminary water quality assessment		X	X		X	X
Present/Future Land use and resource mapping	X	X	X		X	X
Inventory of point and non-point sources		X	X	X		X
Definition of regulatory issues and requirements			X		X	
Preliminary biological habitat assessment			X	X		X
Preliminary problem assessment	X	X	X		X	X
Public Involvement	X	X	X	X	X	X
Individual Watershed Plan						
Survey of runoff characteristics for storm events	X		X		X	
Survey of drainage problems, flood plains, drainage structures	X			X		X
Determination of Sewer System Capacity	X	X			X	
Mapping of point sources, sewer system	X	X	X	X	X	
Monitoring, sampling, and bioassessment			X		X	
QA/QC and data evaluation	X	X	X	X	X	X
Sewer system modeling		X			X	
Watershed Modeling	X		X		X	
Water body Modeling	X		X			
Problem Definition and goal setting	X	X	X	X	X	X
Identification and evaluation of runoff, flood control measures	X			X		
Identification of Combined Sewer Overflow				X	X	
Identification and evaluation of pollution control measures		X	X	X	X	
Economic assessment and funding requirements	X	X	X	X	X	X
Public Involvement	X	X	X	X	X	X
Development of a Watershed Management Plan	X	X	X	X	X	X*

*Note: An RCP includes some but not all elements of a comprehensive watershed management plan.

Table 1-2 Overview of Data Collection Required by Watershed Programs

Data collection	Act 167 Stormwater	Act 537 Sewage Facilities	TMDL Program	NPDES Stormwater	CSO Program	RCP
Geographic Data (Political, Transportation, Topographic, Hydrographic, Land Use, etc.)	X	X	X	X	X	X
Economic and Demographic		X		X	X	X
Meteorological	X	X	X	X	X	
Hydrologic Characteristics	X	X	X	X	X	X
Designated uses and impaired water bodies			X	X	X	X
Water Quality		X	X	X	X	X
Biological and Habitat assessment			X	X	X	X
Floodplains and flooding issues	X					X
Point Sources / Potential sources		X	X	X	X	X
Non-point sources of pollution			X	X		X
Sewer system performance and CSO	X	X	X	X	X	
Storm drainage system	X			X	X	
Historical and cultural resources	X					X

Watershed-based planning is now the preferred approach on both the federal and state level. General water quality and water quantity goals have been established at a state level, and the next step is to develop specific goals for each watershed. Table 1-3 shows the watershed planning goals for Cobbs Creek and how they correspond to many of the overlapping goals of the five major regulatory programs.

Table 1-3 Overview of the Statement of Goals of the Watershed Programs

Goal Description	Act 167 Stormwater	Act 537 Sewage Facilities	TMDL Program	NPDES Stormwater	CSO Program	RCP
Streamflow and Living Resources. Reduce the impact of urbanized flow on the living resources to meet designated uses	X					X
Stream Habitat and Aquatic Life. Improve stream habitat and indices of aquatic integrity.			X	X	X	X
Stream Channels and Banks. Reduce streambank and stream channel deposition and scour to protect and restore the natural functions of aquatic habitat and ecosystems, streambanks, and stream channels.	X					X
Flooding. Decrease flooding.	X					X
Water Quality. Improve dry and wet weather stream quality.		X	X	X	X	X
Pollutant Loads. Decrease pollutant loads to surface waters.		X	X	X	X	X
Stream Corridors. Protect and restore stream corridors, buffers, floodplains, and natural habitats including wetlands.						X
Quality of Life. Enhance community environmental quality of life.	X	X	X	X	X	X
Stewardship. Foster community stewardship.				X	X	X
Coordination. Improve inter-municipal, inter-county, state-local, and stakeholder cooperation and coordination on a watershed basis.	X		X	X	X	X

1.5 PADEP's Watershed Based Planning Approach

The approach and specific tasks behind the Cobbs watershed management plan are intended to meet the needs of the five major programs discussed above. The watershed based planning process utilizes a "Plan-Do-Check-Review" methodology that establishes environmental goals and identifies parameters or indicators with which to measure progress toward those goals. The three Commonwealth-wide environmental goals established are: (1) "sustain, conserve, protect, enhance and restore Pennsylvania's environment, natural resources, and ecological diversity"; (2) "reduce, towards the ultimate goal of eliminating, harmful effects from environmental contaminants and conditions"; and (3) "engage all Pennsylvanians as active and informed stewards of the environment." Problems requiring attention in the Darby, Crum, Ridley, Chester and Cobbs watersheds are outlined in the PADEP's Watershed Restoration Action Strategy (WRAS). WRAS also includes budget allocations for some organizations involved in restoration of the Darby-Cobbs watershed (PADEP, 2002).

The watershed based planning process is intended to:

1. Characterize the condition of the environment by evaluating data sources (i.e., establish a "baseline");
2. Identify possible causes of any impaired conditions;
3. Allow PADEP and stakeholders to develop objectives and activities intended to address the causes in order to improve the existing environmental conditions;
4. Measure progress of activities by using selected indicators to effectively track changes in the environment, and make adjustments to activities as necessary; and
5. Integrate the other planning programs within the watershed based planning program framework.

The Cobbs planning approach seeks to integrate sound science and stakeholder consensus-building to develop an effective plan. The approach is designed to satisfy each of the five elements of the watershed based planning process.

1.6 Other Relevant Programs

Other programs, both regulatory and non-regulatory, influence the watershed management planning approach and are briefly described under this section.

Rivers Conservation Program

One significant non-regulatory program is the Department of Conservation and Natural Resources' (PA-DCNR's) Rivers Conservation Program (RCP), which was developed to conserve and enhance stream resources by implementing locally initiated plans.

The program provides technical and financial assistance to municipalities and stream support groups for the conservation of local streams. Generally the RCP plan intends to assess the cultural and historic resources of a stream corridor, identify potential threats and recommend restoration/maintenance options. It involves the statement of goals to be accomplished and the listing of recommendations for the development and implementation of the plan.

The goals and recommendations from an RCP can be an important building block for a comprehensive watershed management plan (WMP). The programs are similar in structure and approach; they have the same geographic scope, require overlapping data collection, and involve the statement of goals and listing of recommendations. However, the RCP is narrower in scope than the WMP and focuses more on quality of life along the stream corridor rather than on regulatory compliance.

Sanitary Sewer Overflow (SSO) Policy

Requires revisions to the NPDES permit regulations to improve the operation of municipal sanitary sewer collection systems, eliminate the occurrence of sewer overflows, and provide more effective public notification when overflows do occur.

PADEP On-Lot Sewage Disposal Regulations

Require local agencies to administer a permitting program for the installation of on-lot sewage disposal systems.

PENNVEST State Revolving Fund Program

Provides funding for sewer, stormwater, and water projects throughout the Commonwealth.

Delaware River Basin Commission (DRBC) Programs

Regulate both groundwater and surface water use for withdrawals greater than 100,000 gpd based on average 30-day use in a large portion of the study area, which drains to the Delaware River

Delaware Valley Regional Planning Commission (DVRPC) Programs

Address transportation, land use, and environmental protection issues in addition to economic development. Also provide services in planning analysis, data collection, and mapping.

PADEP Greenways Program

An Action Plan for Creating Connections is designed to provide a coordinated and strategic approach to creating connections through the establishment of greenways in the State.

CWA Section 104(b)(3) Program

Promotes the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction and elimination of pollution.

CWA Section 208 Wastewater Planning

Intended to encourage and facilitate the development and implementation of area-wide waste treatment management plans.

CWA Section 319(b) Non-point Source Management Program

Designed to address mine drainage, agricultural runoff, construction/urban runoff, hydrologic and habitat modifications, on-lot wastewater systems, and silviculture.

1.7 Regulatory Agency and Stakeholder Partnerships

In 1999, PWD acted as the municipal sponsor of the Cobbs Watershed Partnership, an exciting and groundbreaking effort to connect residents, businesses and government as neighbors and stewards of the watershed. PWD hired the Pennsylvania Environmental Council (PEC), a well-respected, non-profit institution with a reputation for supporting watershed-based, holistic planning in the form of smart growth planning. PEC pulled together a diverse representation of the watershed – municipalities, "friends" groups, educators, citizens, agencies, and watershed organizations – for the first partnership meeting.

Meetings during the first year were devoted to general education about watershed concepts, about soliciting the visions and concerns of participants as they related to their communities' environmental health and to the creation of three subcommittees to assist in managing the groundwork required for foundation of a watershed management plan. Minutes from these meetings are available at http://www.phillywater.org/Darby-Cobbs under Partnership Involvement.

A steering committee was recruited, representing municipalities that already had some form of watershed planning under way, to develop the road map and timeline for the tackling of a watershed management plan. The steering committee assisted with the selection of topics to be covered, reviewed the technical data and suggested public education/outreach tasks, and helped select the plan's goals and objectives.

The technical committee was open to all members of the partnership; ultimately, participants consisted mainly of local, state, and federal government agencies. This committee reviewed the technical documents produced by PWD, including a watershed reconnaissance of past and existing water quality studies, a current water quality sampling and modeling report, a sediment pollutant loading report, and a bioassessment summary. This technical data is essential for justifying and prioritizing the goals and objectives of the watershed management plan.

The public participation committee, also open to all partnership members, largely consists of watershed organizations, educators, residents, and educational non-profits. The committee established a number of projects to raise general awareness about watershed issues and to recruit further partnership membership. Projects included: a watershed wide survey, press conferences, a state of the watershed report, teacher training workshops, and the development of a watershed video.

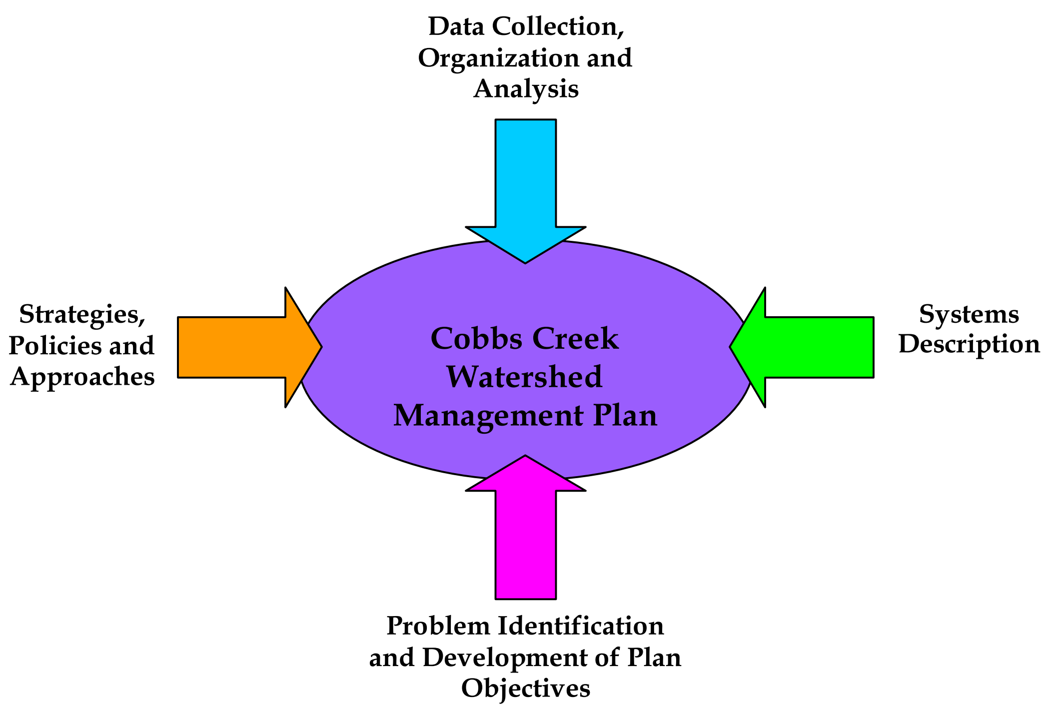
The partnership selected and prioritized the goals and objectives of the watershed management plan. Their role will continue as the recommendations of the plan are implemented in the coming years.

Section 2: Integrated Watershed Management for the Cobbs Watershed

Section 2.1 describes the general approach to watershed planning that serves as the framework for the Cobbs Creek watershed plan. The approach developed by the Darby-Cobbs Watershed Partnership for the Cobbs integrated watershed plan adopts the general approach discussed in Section 2.1 and includes many of the activities included in Philadelphia's Long Term Combined Sewer Overflow Control Plan. Section 2.2 describes the specific activities carried out to complete the plan.

2.1 General Planning Approach

The recommended approach for the Cobbs Creek watershed management plan coordinates each of the five programs discussed on Section 1.3. It has four major elements, each with multiple tasks specific to the planning efforts within the sub-basin of the Cobbs Creek watershed.



Data Collection, Organization and Analysis

The initial step in the planning process is the collection and organization of existing data on surface water hydrology and quality, wastewater collection and treatment, combined sewer overflows, stormwater control, land use, stream habitat and biological conditions, and historic and cultural resources. In addition, existing rules, regulations, and guidelines pertaining to watershed management at federal, state, basin commission, county, and municipal levels also are examined for coherence and completeness in facilitating the achievement of watershed planning goals.

Data is collected by many agencies and organizations in various forms, ranging from reports to databases and Geographic Information System (GIS) files. Field data collection efforts are undertaken early in the study once data gaps are identified.

Systems Description

The planning approach for an urban stream must focus on the relationship between the natural watershed systems (both groundwater and surface water) and the constructed systems related to land use that influence the hydrologic cycle, such as water supply, wastewater collection and treatment, and stormwater collection. A critical step in the planning process is to examine this relationship in all its complexity and to explore the adequacy of the existing regulatory structure at the federal, state, county, and municipal level to properly manage these natural and anthropogenic systems. In urban watersheds, the natural systems are, by definition, influenced by the altered environment, and existing conditions reflect these influences. It is not, however, always obvious which constructed systems are having the most influence, and what that influence is. Analyzing and understanding the water resources and water supply/wastewater/stormwater facilities and their interrelationship provides a sound basis for subsequent planning leading to the development of a realistic set of planning objectives. Concise descriptions of each of the constructed systems are presented, and a series of indicators that adequately describe the watershed and stream characteristics are identified and measured.

Problem Identification and Development of Plan Objectives

Existing problems and issues related to water quality, stream habitat, and streamflow related to the urbanization of the watershed can be identified through analyses of:

- Prior studies and assessments
- Existing data
- New field data
- Stakeholder input

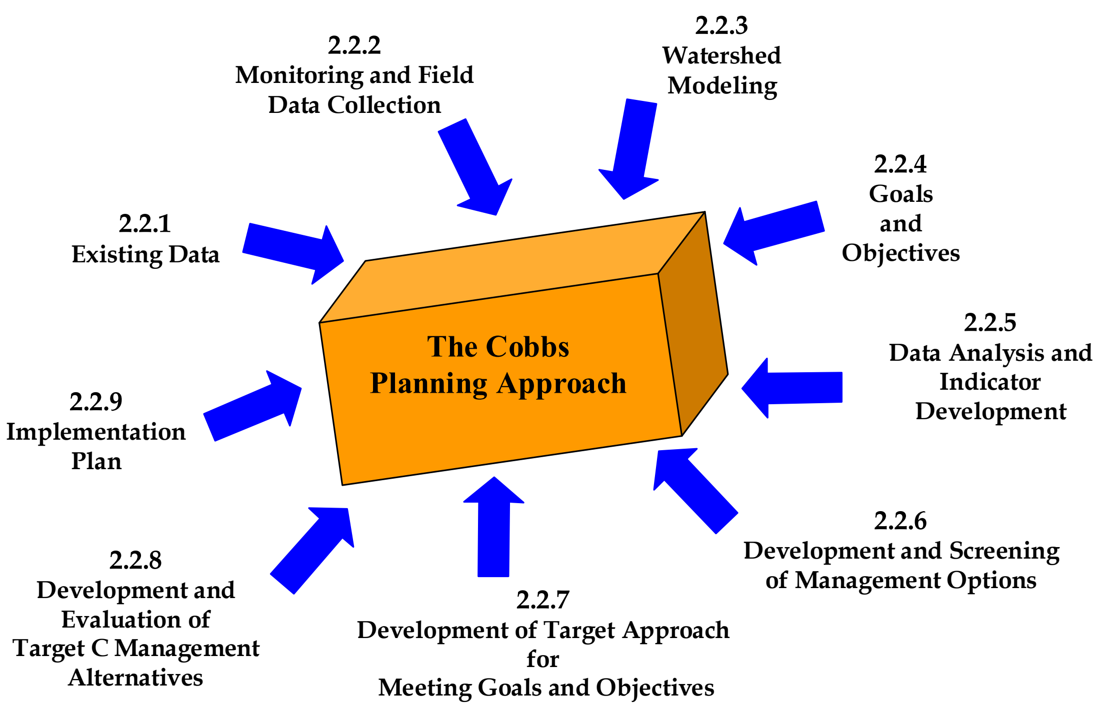
Problems and issues identified through data analysis must be compared with problems and issues brought forward by stakeholders. An initial list of problems and issues then are transformed into a preliminary set of goals and objectives. These goals and objectives may reveal data gaps and may require additional data collection and analysis. Ultimately, with stakeholder collaboration, a final list of goals and objectives is established that truly reflects the conditions of the watershed. These goals and objectives must be prioritized by the stakeholders based on the results of the data analysis.

The priority of objectives becomes the basis for developing planning alternatives. Potential constraints on implementation require that the objectives be broken down into phased targets, in which alternatives are developed to meet interim objectives.

In this way, the effectiveness of implementation can be monitored, and targets adjusted, as more is learned about the watershed, its physical characteristics, and evolving water quality regulations.

Strategies, Policies and Approaches

Once end targets and interim targets are established, with a clear list of associated planning objectives based on sound scientific analysis and consensus among stakeholders, effective sets of implementable management alternatives are developed to meet the agreed upon targets and objectives. These alternatives are a combination of options that may include suggested municipal actions, recommendations on water supply and wastewater collection system improvements, potential measures to protect water quality from point sources, best management practices for stormwater control, measures to control sanitary and combined sewer overflows, changes to land use and zoning, stream channel and streambank restoration measures, etc. These are combined in a coherent fashion within the context of the watershed-wide management alternatives. The alternatives then are evaluated based on cost, effectiveness in achieving priority objectives, and implementation feasibility. The plan ultimately should provide an implementation process to achieve the stated objectives over a specified period of time.



2.2 The Cobbs Planning Approach

The approach and specific tasks for the Cobbs Creek watershed management plan are intended to meet the criteria of the five major programs discussed in Section 1.3 as well as fit with PADEP's watershed based planning program approach.

In order to establish environmental goals and identify the indicators that measure progress toward these goals, the Cobbs planning strategy utilizes the "plan-do-check-review" methodology of the watershed based planning process. To satisfy the five elements included in this procedure, the Cobbs planning process moved from data collection and analysis to plan development in an organized manner, with constant interaction with the established stakeholder groups. The primary data collection, analysis, and technical planning activities of the Cobbs watershed management plan are outlined below, and the stakeholder process is discussed in Section 3.

2.2.1 Existing Data

PWD assembled relevant existing data and information collected in the past by other agencies and by prior studies. Several types of geographic and physical data were collected.

Geographic and Demographic Data. The base map for the project study area was prepared from U.S. Census Bureaus TIGER (Topologically Integrated Geographic Encoding and Referencing) database. These files contain local and state political boundaries, rivers and waterways, roads and railroads, and census block and block group boundaries for demographic analysis.

Meteorological Data. In addition to U.S. Census data, meteorological data was gathered to analyze streamflow responses to seasonal changes, climate variation, and storms, and to model stormwater flows. Long-term rainfall data were obtained from the National Oceanic and Atmospheric Administration's (NOAA) rainfall gage at the Philadelphia International Airport. This gage has over 100 years of hourly precipitation data, from January 3, 1902 through the present. In addition to this long-term rainfall gage, the PWD CSO Program has over 10 years of 15-minute rainfall data from 24 City rain gages. There are six of these gages in the vicinity of the Cobbs Creek watershed. The available rainfall data for each gauge is summarized in Table 2-1, and Figure 2-1 shows their locations. Data from each gage were analyzed for accuracy and completeness, and the data were subjected to statistical analyses to check for changes in the gage location or physical layout, as well as to explore correlations among gages to identify potential over-or under-catch trends.

Table 2-1 Rainfall Data Available for the Cobbs Creek Watershed Gages

Gauge Name	Available Data
RG-01	1991 - 2002
RG-02	1990 - 2002
RG-06	1991 - 2002
RG-09	1990 - 2002
RG-22	1990 - 2002
RG-23	1992 - 1998, 2001 - 2002

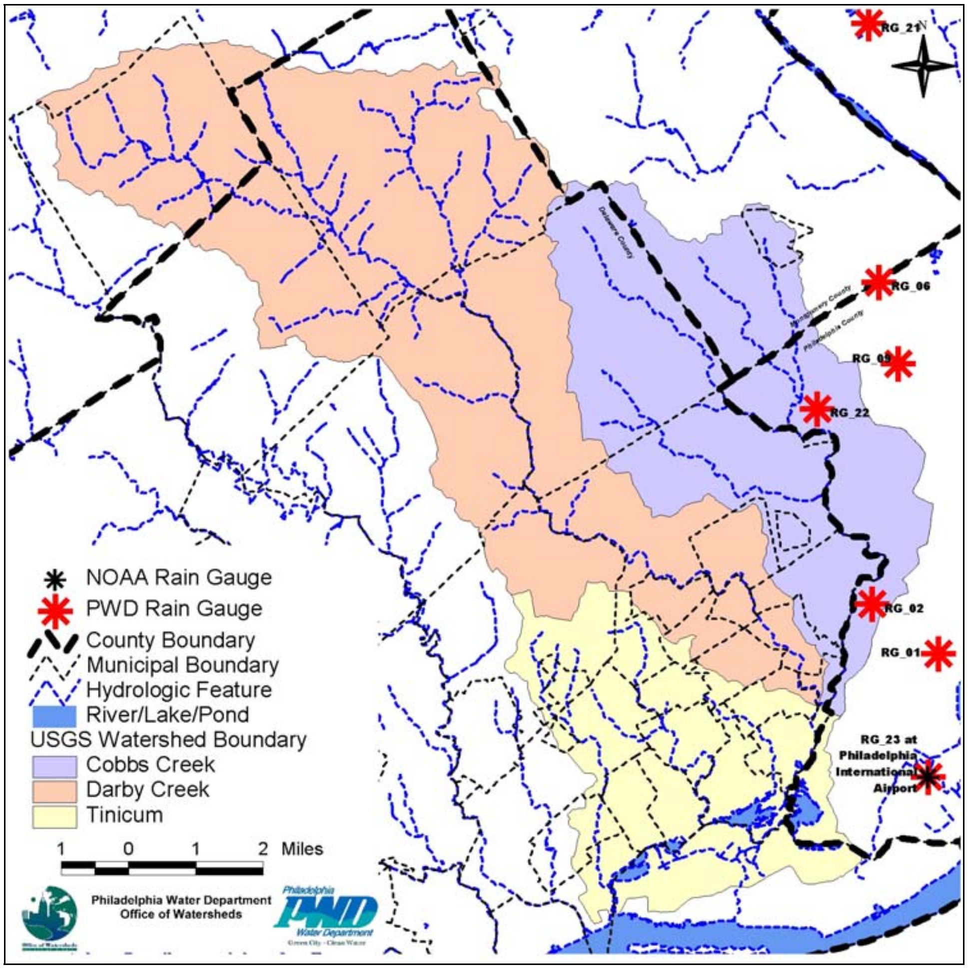


Figure 2-1 City Rain Gages in or near the Watershed

Land Use. Land use information for the Cobbs Creek watershed was obtained from the Delaware Valley Regional Planning Commission (DVRPC) for the counties of Chester, Delaware, Montgomery, and Philadelphia. The DVRPC land use maps are based on aerial photography from March through May of 1995. For a more useful representation of the existing land use information for hydrologic analyses, resulting in a land use map with 20 different categories shown in Figure 2-2.

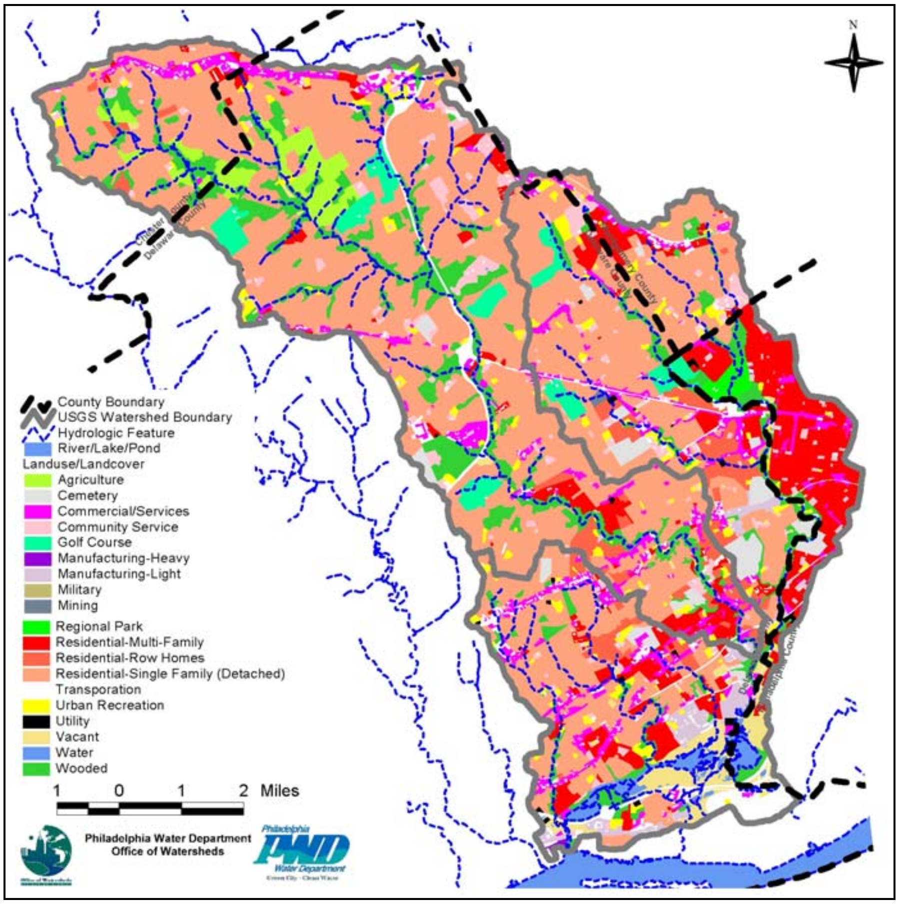


Figure 2-2 DRVPC Land Use Map for the Darby-Cobbs Creek

Streamflow. During the 1960's, the United States Geological Survey (USGS), in cooperation with PWD, established streamflow-gaging stations at six locations in the Darby-Cobbs Creek watershed. While only one of these gages still is active today, the two to three decades of historic record they provided is invaluable in characterizing the hydrologic response of the watershed. The locations of the gages are presented on Figure 2-3 and listed in Table 2-2. Daily streamflow records from the gages were analyzed, and baseflow separation performed to identify patterns along the stream of baseflow and stormwater runoff. The results of these analyses are presented in Section 4.

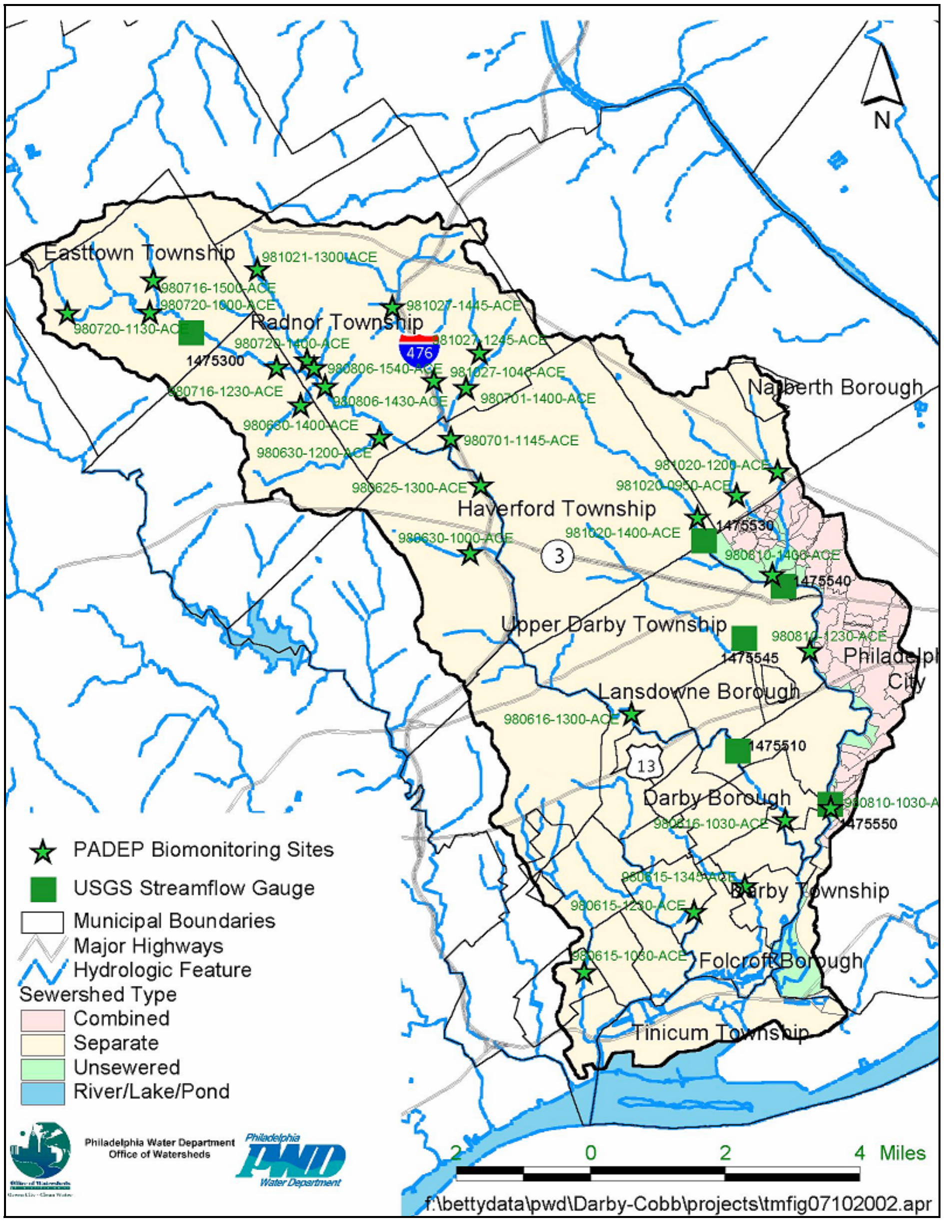


Figure 2-3 USGS Streamflow Gages

Table 2-2 USGS Gages and Periods of Record

Station ID	Location	Quality Data	Streamflow Data
01475300	Darby Creek At Waterloo Mills Near Devon, Pa.		4/28/1972-9/30/1994, 6/28/1996-present
01475510	Darby Creek Near Darby, Pa.		2/1/1964-10/3/1990
01475530	Cobbs Creek At U.S. Highway No. 1 At Phila., Pa.	1/1/1965-3/3/1980	10/1/1964-9/30/1981
01475540	Cobbs Creek Below Indian Creek Near Upper Darby, Pa.	10/10/1967-2/7/1973	10/1/1964-6/30/1973
01475545	Naylor Creek At West Chester Pike Near Phila., Pa.		6/1/1972-10/20/1978
01475550	Cobbs Creek At Darby, Pa.	11/9/70-3/3/80	1/1/1964-10/3/1990

Water Quality. In the early 1970's, the Philadelphia Water Department began a study in cooperation with the U.S. Geological Survey titled, "Urbanization of the Philadelphia Area Streams." The purpose of this study was to quantify the hydrology and pollutant loading of Philadelphia's streams, and possibly relate the degradation in water quality to urbanization. Two of the stations sampled for the study were in the Cobbs Creek watershed at USGS gaging locations: Station 12, Cobbs Creek at U.S. Route 1, and Station 15, Cobbs Creek at Darby. Monthly discrete water quality samples were collected at each site and analyzed for conductivity, BOD_5, total phosphate, ammonia, nitrite, nitrate, and fecal coliform. The program collected about 10 years of monthly samples. The majority of the data currently available from STORET, USEPA's water quality database, were collected as part of this study.

Stream Assessment and Biological Data. Some stream assessment data for the Cobbs watershed were also available. The Philadelphia Academy of Natural Sciences collected stream morphology data for four streams in the Cobbs Creek watershed in August 1998. The data were collected in Fairmount Park for Indian Run, Indian Creek, Bocce Tributary, and Cobbs Tributary 3. The data provide information about streambed slope, cross-sectional properties, and sediment grain size distribution.

At the request of PWD, PADEP performed a biological assessment of the non-tidal portions of the Cobbs Creek watershed. For the assessment, 28 stations were chosen that represent the watershed, based upon land use and stream order. Each station was evaluated using the Rapid Bio-assessment Protocol and USEPA's habitat assessment methods. The assessments occurred between June and late October in 1998. The decisions to consider a station impaired or unimpaired were based upon the quality and quantity of habitat and macroinvertebrates.

2.2.2 Monitoring and Field Data Collection

To supplement existing data, PWD's Office of Watersheds (OOW) conducted an extensive sampling and monitoring program to characterize conditions in the Darby-Cobbs Creek watershed. The program was designed to document the condition of aquatic resources, to provide information for the planning process needed to meet regulatory requirements imposed by EPA and PADEP, and to monitor long term trends as implementation of the plan proceeds.

Water Quality Sampling

Three types of water quality sampling were carried out by PWD for the Cobbs Creek. Figure 2-4 presents the locations of each sampling site along the creek during an initial assessment. Discrete sampling was performed weekly from May through July 1999 at each of the locations. Wet weather sampling involved the collection of discrete samples before and during a wet weather event, allowing the characterization of water quality responses to stormwater runoff and sanitary and combined sewer overflows. Of the ten sampling events, four are considered wet weather events. The third type of sampling was continuous monitoring, carried out by introducing YSI 6600-01 Sondes, shallow depth continuous water quality monitors, and probes that record dissolved oxygen, pH, and turbidity. The equipment was deployed to three locations periodically for a number of days to collect continuous data samples and observe water quality fluctuations.

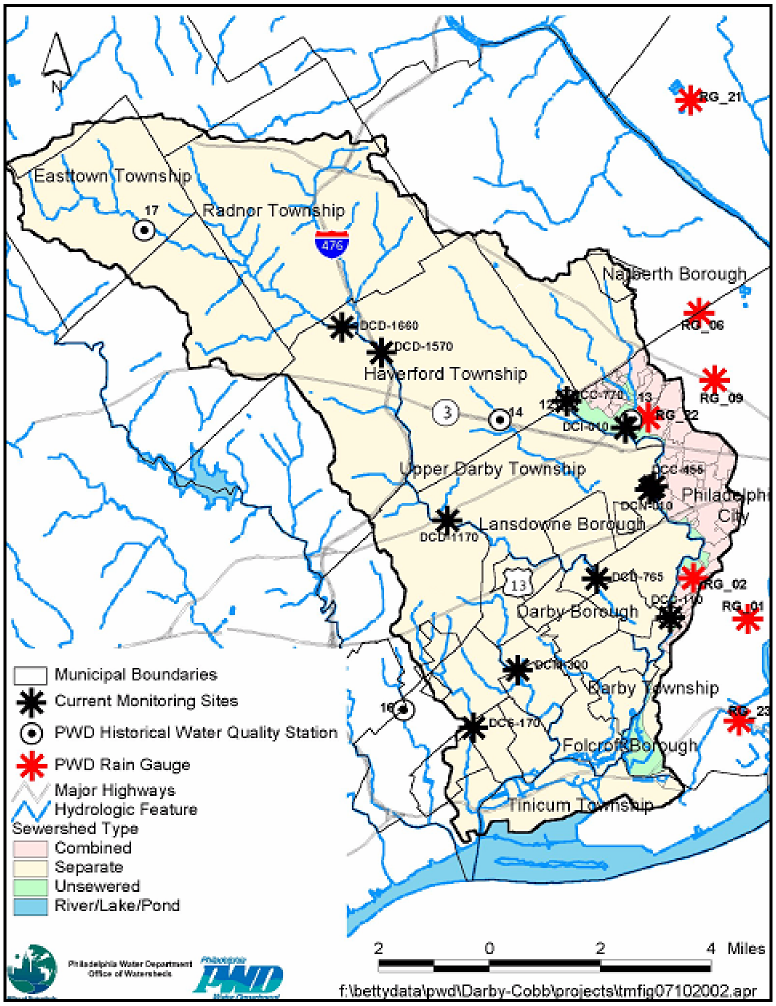


Figure 2-4 Ten Water Quality Monitoring Locations

Biological Monitoring

Biological monitoring is a useful means of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g. benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Plafkin et. al. 1989, Barbour et al. 1995). The Philadelphia Water Department's Office of Watersheds and Bureau of Laboratory Services, along with the Philadelphia Academy of Natural Sciences and the Pennsylvania Department of Environmental Protection have been developing a preliminary biological database to assess the aquatic integrity of the Darby-Cobbs watershed. Macroinvertebrate and ichthyfauna monitoring was conducted at specific locations within the Cobbs Creek watershed.

Geographical Information Systems (GIS) databases and watershed maps were constructed to provide accurate locations of the sampling sites.

An ichthyfauna (fish) assessment occurred at five sampling stations on Cobbs Creek; three on the mainstem, and two on the smaller tributaries: West Branch Indian Creek and Naylor's Run. Six metrics were used to assess the quality of the fish assemblages in Cobbs Creek.

1. Species richness
2. Species diversity
3. Trophic composition relationships
4. Pollution tolerance levels
5. Disease and parasite abundance/severity
6. Introduced (exotic) species

In addition to the fish assessment, the results of a PADEP Rapid Bioassessment Protocol (RBP) assessment of seven sites in the Cobbs Creek watershed were also compiled. PADEP biologists used a combination of habitat and biological assessments to evaluate the Cobbs Creek under the Unassessed Waters Program. Biological surveys included kick screen sampling of benthic macroinvertebrates, which were identified by family and by their tolerance to pollution. Benthic macroinvertebrates mainly are aquatic insect larvae that live on the stream bottom. Since they are short-lived and relatively immobile, they reflect the chemical and physical characteristics of a stream and chronic sources of pollution. The biological integrity and benthic community composition was determined using USEPA guidelines for RBP III.

Upon completion of the total biological scoring, each site was compared to a reference site according to its drainage area and geomorphological attributes. The two reference sites chosen were Broad Run (located at the intersection of Chestnut Lane and Broad Run Road, West Bradford Township, Chester County) and French Creek (located at Coventry Road Bridge, South Coventry Township, Chester County). The comparison of the biological assessment of each site with the reference site was designed to create a baseline for monitoring trends in benthic community structure that might be attributable to improvement or worsening of conditions over time. Several Biological Condition Categories were developed:

- Non-impaired
- Slightly impaired
- Moderately impaired
- Severely impaired

Habitat Assessment

Habitat assessments evaluate how deeply the stream substrate is embedded, the degree of streambank erosion, the condition of riparian vegetation, and the amount of sedimentation. Data from the PADEP surveys were available for both the Darby and Cobbs Creeks. Habitat assessments at seven sites were completed based on the Stream Classification Guidelines for Wisconsin (Ball, 1982) and Methods of Evaluating Stream, Riparian, and Biotic Conditions (Platts et al., 1983). Reference conditions were used to normalize the assessment to the Cobbs Creek (mainstream) "best attainable" situation. Habitat parameters were separated into three principal categories to characterize the site:

- Primary or microscale habitat
- Secondary or macroscale habitat (stream channel)
- Tertiary or riparian and bank structure

Resource based Habitat Suitability Indices (HSI) were developed to add aquatic life-based habitat and flow requirement criteria to the watershed assessment. HSIs integrate the expected effects of a variety of physicochemical and hydrological variables on a target species of environmental or economic concern. Data are used to construct sets of suitability index curves, each of which relates a habitat parameter to its suitability for the species of interest. Curves rate habitat variables on a scale of 0 to 1.0, and were developed to measure food and cover, water quality, and reproduction (e.g. substrate type, percent pools, percent cover, depth of pools, pH, DO, turbidity, temperature).

Fluvial Geomorphological Assessment

For the Cobbs Creek watershed, Philadelphia performed a fluvial geomorphic assessment and baseline determination of stream stability. The measurement of geomorphic parameters and physical and hydraulic relationships were performed at both Level I and Level II of the Rosgen classification methodology (D.L. Rosgen Applied River Morphology 1996).

Level I: Desktop survey was desktop delineation of the stream using generalized major stream types based on available topographic information, geological maps, soils maps, and aerial photographs. The purpose of the inventory was to provide an initial framework for organizing and targeting subsequent field assessments of important reaches where problems are known to occur or are anticipated to occur. Available topographic information, geological maps, soils maps, and aerial photographs were reviewed.

Level II: Reach stream survey was performed for approximately 30 miles of the highest order streams and tributaries within the Cobbs Creek watershed. Field teams of two stream surveyors walked along the designated lengths of each stream and tributary and estimated several parameters related to channel morphology:

- Bankfull Elevation
- Bankfull Width
- Entrenchment Ratio range
- Width/Depth ratio range
- Sinuosity range
- Channel Slope range
- Channel Materials (pebble count)
- Meander Pattern

2.2.3 Watershed Modeling

An important tool for developing the watershed plan is a hydrologic and hydraulic model of the stream and stormwater system. In most streams in the eastern US, stormwater flows can range from less than 30% of total annual streamflow in less-developed watersheds to over 70% in highly urbanized settings. Modeling of stormwater flows is, therefore, a critical component of a watershed management plan. The model should, at a minimum, be built to provide storm-by-storm flows to the streams as well as estimates of pollutant loads carried by the stormwater reaching the streams.

A Stormwater Management Model (SWMM) was built for the entire Cobbs Creek watershed. SWMM is a comprehensive set of mathematical models originally developed for the simulation of urban runoff quantity and quality in storm, sanitary, and combined sewer systems. The model subdivides the watershed into approximately 100 subwatersheds and estimates flow and pollutant loading from each land use type within each of the subwatersheds. It simulates the hydraulics of combined sewers, the open channel of the creek itself, and the floodplain. Thus, the model is useful for simulation of stormwater runoff quantity and quality, combined sewer overflow, and streamflow. The model was calibrated by comparing stormwater runoff to estimated runoff, calculated through hydrograph separation at USGS gage 01475550, on Cobbs Creek upstream of the confluence with Darby Creek. Model simulations included:

- Existing conditions using a long-term rainfall record from Philadelphia Airport
- Annual average pollutant loads for key pollutants found in stormwater. The list of pollutants includes parameters such as nitrate and phosphorus, total suspended solids, heavy metals, BOD, and DO
- Numerous simulations to test the effectiveness of various BMPs within the Cobbs Creek watershed. Effectiveness was judged based on reductions in stormwater discharges, CSOs, and reduced pollutant loading during wet weather

- Simulations of six potential mixes of BMPs to assess the overall effectiveness of alternative watershed management plan approaches to achieving plan objectives

The model results also helped identify areas where stormwater runoff or pollutant loads are particularly high and in need of control. Model flow results, in combination with the results of the fluvial geomorphic assessment, provided excellent tools for identifying areas of the watershed that are undergoing stormwater-related stress and an efficient way of developing alternative integrated watershed management approaches, particularly with regard to the Wet Weather Target C objective.

2.2.4 Goals and Objectives

Early in the planning process, project goals and objectives were developed in conjunction with the stakeholders. In general, goals represent consensus on a series of “wishes” for the watershed. Ten project goals were established that represent the full spectrum of goals from all the programs relevant to the watershed (e.g. River Conservation Plan, TMDL programs, Act 167 Stormwater Plans etc.) A significant effort was made to consolidate the various goals into a single, coherent set that avoids overlap and is organized into clear categories.

Once the preliminary set of goals was developed, a series of associated objectives was developed. Objectives translate the “wishes” into measurable quantities; indicators are the means of measuring progress toward those objectives. This relationship is the link between the more general project goals and the indicators developed to assess the watershed and to track future improvement.

The preliminary planning goals and objectives were presented to stakeholders for initial review. However, the final, prioritized goals and objectives were subjected to final review and approval when the data analysis and modeling work were complete.

2.2.5 Data Analysis and Indicator Development

An important aspect of a watershed management plan is a basic description of existing conditions within the watershed and streams. To accomplish this, a series of indicators were developed to represent the results of the data collection efforts and the data analysis and modeling. An indicator is a measurable quantity that characterizes the current state of at least one aspect of watershed health. Every indicator is directly linked to one or more project objectives. Thus, they serve to describe the current conditions, and provide a clear method of monitoring progress and achievement of objectives as management alternatives are implemented over time. This approach was fashioned after the watershed based planning approach program.

The indicators selected for their potential use both in assessing current conditions, as well as assessing future progress in improving conditions, are shown below.

The Land Use and Stream Health Relationship

Indicators	
1	**Land Use and Impervious Cover**
2	**Streamflow**
3	**Stream Channels and Aquatic Habitat**
4	**Restoration Projects Lists of completed, in progress, and planned projects**
5	**Fish**
6	**Benthos**

Water Quality

Indicators	
7	**Effects on Public Health (Bacteria)**
8	**Effects on Public Health (Metals and Fish Consumption)**
9	**Effects on Aquatic Life (Dissolved Oxygen)**

Pollutants and Their Sources

Indicators	
10	**Point Sources**
11	**Non-point Sources**

The Stream Corridor

Indicators	
12	**Riparian Corridor**
13	**Wetlands and Woodlands**
14	**Wildlife**
15	**Flooding**

Quality of Life

Indicators	
16	**Public Understanding and Community Stewardship**
17	**School-Based Education**
18	**Recreational Use and Aesthetics**
19	**Local Government Stewardship**
20	**Business and Institutional Stewardship**
21	**Cultural and Historic Resources**

2.2.6 Development and Screening of Management Options

Clear, measurable objectives provided the guidance for developing options designed to meet the project goals. A management option is a technique, measure, or structural control that addresses one or more objectives (e.g., a detention basin that gets built, an ordinance that gets passed, an educational program that gets implemented).

The following example clarifies the difference among a goal, an objective, and a management option.

Goal: improve water quality

Objective: maintain dissolved oxygen levels above 5 mg/L

Management Option: eliminate deep, poorly mixed plunge pools where low DO is detected

Lists of management options were developed to meet each of the goals and objectives established for the Cobbs Creek watershed. Only those options deemed feasible and practical were considered in the final list of management options. Options were developed and evaluated in three steps:

1. ***Development of a Comprehensive Options List.*** Virtually all options applicable in the urban environment were collected. These options were identified from a variety of sources, including other watershed plans, demonstration programs, regulatory programs, the literature, and professional experience.
2. ***Initial Screening.*** Some options could be eliminated as impractical for reasons of cost, space required, or other considerations. Options that already were implemented, were mandated by one of the programs, or were agreed to be vital, were identified for definite implementation. The remaining options were screened for applicability to Cobbs Creek. This was accomplished by developing a database and creating every possible combination of options. These were scored based on their relative cost and the degree to which they met the project objectives. Only the most cost-effective options were considered further.
3. ***Detailed Evaluation of Structural Options.*** Structural best management practices for stormwater and combined sewage were subjected to a modeling analysis. Effects on runoff volume, overflow volume, peak stream velocity, and pollutant loads were evaluated at various levels of coverage.

The initial screening looked at the cost effectiveness of over 20 options for controlling stormwater using an automated database approach. The intent was not only to look at each option by itself, but also to assess the effectiveness of each option in combinations with other options. Figure 2-5 shows that the database developed over one million possible combinations of the options, and scored each for their cost effectiveness.

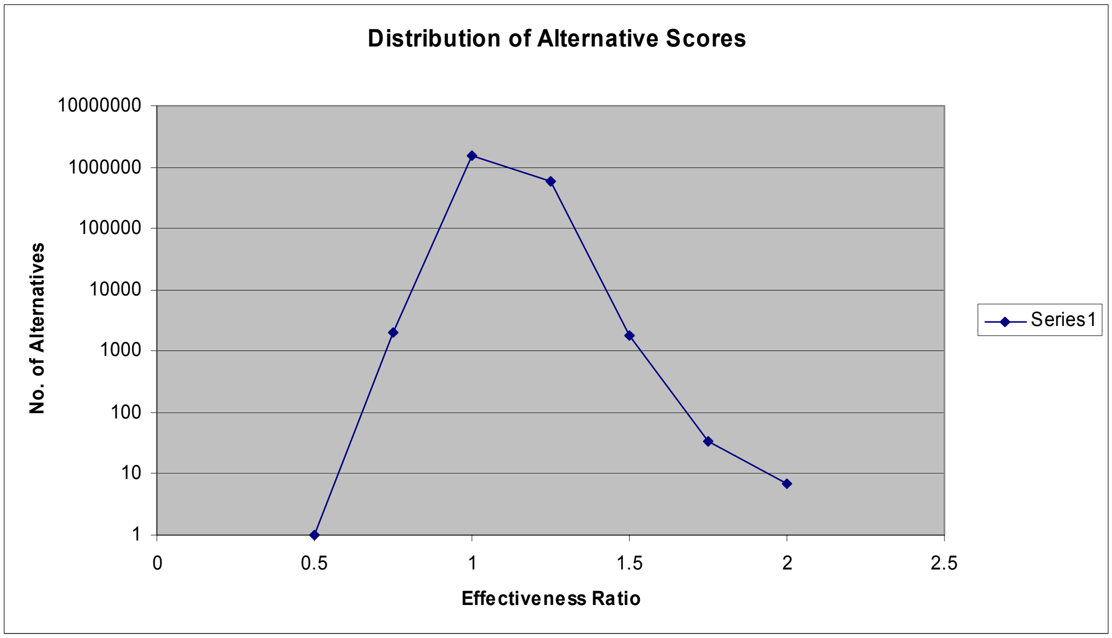


Figure 2-5 Distribution of Effectiveness Scores for Combined Options

The decision to include an option in the final set of alternatives was based on how well it performed in the cost-effectiveness evaluation, both as a stand-alone option, and also in combination with other options.

Detailed evaluation of structural options (step 3) used the SWMM model to assess the effectiveness of each option and by performing a planning-level cost estimate of each option. All options that had an effect on CSOs or stormwater-related pollutant loads were modeled at several degrees of implementation using the SWMM model. Graphs of effectiveness versus degree of implementation were developed, and the results then were combined with more careful cost estimates to provide guidance on selecting effective options or combinations of options.

The modeling and other analyses resulted in six alternatives selected for full evaluation.

2.2.7 Development of Target Approach for Meeting Goals and Objectives

In developing watershed management alternatives and discussing goals and objectives with stakeholders, it became clear that implementation could best be achieved by defining three distinct targets to meet the overall plan objectives. Two of the targets were defined so that they could be fully met with a limited set of options that are fully implemented. The third target fit better with the "plan-do-check-review" methodology of the watershed based planning process. In other words, it was agreed to set interim objectives, recommend measures to achieve the interim objectives, implement those controls to achieve these objectives, and reassess the capability to meet the objectives, or agree to raise the bar to more complete achievement of the final objectives.

Targets are defined here as groups of objectives that each focus on a different problem related to the urban stream system. They can be thought of as different parts of the overall goal of fishable and swimmable waters through improved water quality, more natural flow patterns, and restored aquatic and riparian habitat.

By defining these targets, and designing the alternatives and implementation plan to address the targets simultaneously, the plan will have a greater likelihood of success. It also will result in realizing some of the objectives within a relatively short time frame, providing positive incentive to the communities and agencies involved in the restoration, and more immediate benefits to the people living in the watershed.

The targets for the Cobbs Creek watershed management plan are defined as follows.

TARGET A: Dry Weather Water Quality and Aesthetics

Target A was defined for Cobbs Creek with a focus on trash removal and litter prevention, and the elimination of sources of sewage discharge during dry weather. Streams should be aesthetically appealing (look and smell good), be accessible to the public, and be an amenity to the community. Access and interaction with the stream during dry weather has the highest priority, because dry weather flows occur about 60-65 % of the time during the course of a year on the Cobbs Creek. These are also the times when the public is most likely to be near or in contact with the streams. The water quality of the stream in dry weather, particularly with respect to bacteria, should be similar to background concentrations in groundwater.

In many urban streams, monitoring indicates that the water quality rarely meets the water quality standard for bacteria, and exhibit occasional DO problems, even during baseflow or dry weather conditions. Thus, the first target focuses on dry weather water quality, coupled with the visual aesthetics of the stream, primarily the removal of trash and the elimination of illegal dumping so often associated with degraded, urban waterways. The first target also includes a range of regulatory and nonstructural options that address both water quality and quantity concerns. Because the options under consideration are aimed at the total elimination of dry weather sources of trash and sewage, all options related to this target were included in the implementation plan.

TARGET B: Healthy Living Resources

Based on the results of the water quality monitoring, habitat assessment, and biological monitoring, water quality was not identified as the primary cause of the low diversity and impaired nature of the fish population in the stream. Improvements to the number, health, and diversity of the benthic invertebrate and fish species in the Cobbs Creek need to focus on habitat improvement and the opportunity for organisms to avoid high velocities during storms. Fluvial geomorphological studies, wetland and streambank restoration/creation projects, and stream modeling should be combined with continued biological monitoring to ensure that correct procedures are implemented to increase habitat heterogeneity within the aquatic ecosystem.

Improving the ability of an urban stream to support viable habitat and fish populations focuses primarily on the elimination of remediating the more obvious impacts of urbanization on the stream. These include loss of riparian habitat, eroding and undercut banks, scoured streambed or excessive silt deposits, channelized and armored stream sections, trash buildup, and invasive species. The primary tool to accomplish this target is stream restoration. Restoration focuses on improving channel stability, improving instream and riparian habitat, providing refuges for fish from high velocity conditions during storms, and managing land within the stream corridor. Restoration strategies include:

- Bank stabilization, including boulder structures, bioengineering, root wads, plantings, and log and woody structures
- Bed stabilization, including rock/log vanes with grade control, rock/log cross vanes, and using naturally occurring boulders and bedrock
- Realignment & relocation, used only on severely degraded stream sections
- Dam and debris removal
- Reforestation, with priority to floodplains, steep slopes, and wetlands
- Invasive species management to increase biodiversity
- Wetland creation, often used in conjunction with stream realignment to improve floodplain areas subject to annual flooding
- Forest preservation
- Fish holding areas, with low to no current zones created to provide fish with places to hold position during high flows

Stream restoration measures to meet this target were identified, and all options required to meet the target are planned for implementation.

TARGET C: Wet Weather Water Quality and Quantity

The third target is to restore water quality to meet fishable and swimmable criteria during wet weather. Improving water quality and flow conditions during and after storms is the most difficult target to meet in the urban environment. Because wet weather conditions on Cobbs Creek occur to some degree about 35-40% of the time during the year, measures to improve wet weather quality have a somewhat lower priority than measures designed to address dry weather water quality. During wet weather, extreme increases in streamflow are common, accompanied by short-term changes in water quality. Stormwater generally does not cause immediate DO problems, but sampling data indicate that concentrations of some metals (such as copper, lead, and zinc) and bacteria do not meet water quality standards during wet weather. These pollutants are introduced by both stormwater and wet weather sewage overflows (CSOs and SSOs).

A comprehensive watershed management approach must also address flooding issues. Where water quality and quantity problems exist, options may be identified that address both. Any BMP that increases infiltration or detains flow will help decrease the frequency of damaging floods; however, the size of such structures may need to be increased in areas where flooding is a major concern. Reductions in the frequency of erosive flows and velocities also will help protect the investment in stream restoration made as part of the second target (B).

Target C must be approached somewhat differently from Targets A and B. Full achievement of this target means meeting all water quality standards during wet weather, as well as eliminating all flooding. Meeting these goals will be difficult. It will be expensive and will require a long-term effort. The only rational approach to achieve this target must include stepped implementation with interim targets for reducing wet weather pollutant loads and stormwater flows, along with monitoring for the efficacy of control measures.

Initial load reduction targets for parameters such as metals, total suspended solids (TSS), and bacteria were set in conjunction with the stakeholders. Based on preliminary work by PWD, 10-20% reductions are a challenging but achievable initial interim target.

It is expected that changes to the approach, and even to the desired results, will occur as measures are implemented and results are monitored. This process of continually monitoring progress and adjusting the approach is known as *adaptive management*. The NPDES permit programs for stormwater and CSO outfalls can lead to a cycle of monitoring, planning, and implementation that helps define a time frame to this process.

2.2.8 Development and Evaluation of Target C Management Alternatives

An alternative for meeting Target C, or wet weather water quality objectives, is a group of options designed to meet the established interim target of 10-20% reduction in stormwater flows and/or pollutant loading. For example, a management alternative might consist of a combination of all the following options:

- Establishing a program of uniform and coordinated municipal stormwater ordinances
- Installing rain barrels on 20% of the homes

- Installing porous pavement with underground stormwater storage in half of the parking lots in the watershed
- Developing a public education program

The results of the options screening and evaluation process discussed in Section 2.2.6 were used to assemble Target C alternatives. To develop a management alternative, options are grouped as to maximize effectiveness, minimize cost, and avoid combinations of options that conflict with each other (e.g. two options designed to occupy the same space or utilize the same pipe). Target C alternatives were developed based on unifying approaches such as minimum cost, BMPs on public property and BMPs on private property.

2.2.9 Implementation Guidelines

Six alternatives, each including a package of options to address all three targets, were evaluated using a multi-criteria evaluation program called EVAMIX. The program is designed to evaluate the alternatives against a series of criteria weighted according to priority by the stakeholders. The evaluation, along with the many individual SWMM model simulations, provided significant insight into the best approaches to meeting Target C objectives. The draft implementation plan developed provided:

- Specific recommendations and a schedule for meeting Target A objectives
- Specific recommendations and a schedule for meeting Target B objectives
- Guidance on which BMPs or mixes of BMPs were most effective in Cobbs Creek for meeting Target C objectives.
- Guidance on the needed degree of implementation to achieve Target C objectives
- Guidance on areas of the watershed where BMPs would be most effective
- Recommendations on Target C options for the CSO areas, and recommendations for Target C options for separate storm sewer areas

Section 3: Goals and Objectives

Developing a focused and prioritized list of goals (general) and objectives (specific, measurable) is critical to a successful planning process. Goals and objectives need to be:

- initially developed by stakeholders and regulatory agencies,
- analyzed and informed by the watershed data collection, analysis, and modeling carried out by the project team,
- finalized by the project team and prioritized by the stakeholders.

3.1 Stakeholder Goal Setting Process

Considerable stakeholder input towards developing watershed goals was sought from the beginning of this planning effort. Responses were summarized, and additional stakeholder input organized through further contacts with the stakeholders. The mission statement for the Darby-Cobbs Watershed Partnership planning effort, as well as related goals from other programs were developed by the stakeholders and are listed here.

Darby-Cobbs Partnership Mission Statement

To improve the environmental health and safe enjoyment of the Darby-Cobbs watershed by sharing resources through cooperation of the residents and other stakeholders in the watershed. The goals of the initiative are to protect, enhance, and restore the beneficial uses of the Darby-Cobbs waterways and riparian areas. Watershed management seeks to mitigate the adverse physical, biological, and chemical impacts of land uses as surface and groundwater are transported throughout the watershed to the waterways.

Goals of Related Studies and Programs

Other studies already have provided a list of goals. Generally the goals in this section are those identified through the rivers conservation planning process, supplemented by those goals that are required as a result of various environmental regulatory requirements. Additional goals identified in the Darby-Cobbs stakeholder meetings also were included once consensus was established. Existing goals included:

- Aquatic life designated use attainment goal (warm water fishery)
- Public health: contact recreation (bacteria, noxious plants)
- Aesthetics: visual and olfactory conditions (noxious plants, bank erosion, litter, odor, etc.)
- Riparian corridors
- Wetlands, woodlands & meadows
- Wildlife
- Act 167 plan goals
- Act 537 goals
- TMDL-related goals
- NPDES program goals (including stormwater management and CSO control)
- Environmental Futures Program goals
- River conservation plan goals

3.2 Consolidated Watershed Planning Goals and Objectives

The large list of goals from the existing stakeholder process needed to be organized. This was accomplished by consolidating goals from various sources into a coherent set for the integrated plan. Other considerations included stakeholders' desire to restore the living resources, and the steering committee preference for achieving goals through innovative, land-based, low-impact, and cost-effective management options. Consensus was reached eventually around the following ten goals. Under each goal, more specific objectives are listed.

1. **Streamflow and Living Resources.** Reduce the impact of urbanized flow on the living resources.
   - 1.1. Increase baseflow as a percentage of total flow.
   - 1.2. Increase groundwater recharge.
   - 1.3. Prevent increases in the stormwater flow peaks in future development/redevelopment areas.
   - 1.4. Reduce directly connected impervious cover in developed areas. Reduce the rate of growth in directly connected impervious cover in areas with new development.
   - 1.5. Based partially on Act 167 stormwater planning, revise municipal codes to encourage new development and redevelopment of existing, vacant, and abandoned lands using techniques that help reach stormwater and erosion control objectives.

2. **Stream Habitat and Aquatic Life.** Improve stream habitat and indices of aquatic integrity.
   2.1. Improve stream habitat to restore selected living resources to a pre-development condition.
   2.2. Improve quantitative measures of fishery health.
   2.3. Improve quantitative measures of benthic invertebrate quality.
   2.4. Adapt or develop quantitative measures of attached algae to assess current stream conditions.
   2.5. Improve migratory fish passage.

3. **Stream Channels and Banks.** Reduce streambank and stream channel deposition and scour to protect and restore the natural functions of aquatic habitat and ecosystems, streambanks, and stream channels.
   3.1. Increase miles of stable streambanks and stream channels.
   3.2. Reduce the frequency of occurrence of bankfull flow.

4. **Flooding.** Decrease flooding.
   4.1. Remediation should reduce the effects and frequency of out-of-bank flooding through management of stormwater.
   4.2. Remediate stream-related flooding in known problem areas without increasing the problem in other areas.
   4.3. Increase regular storm drain maintenance and cleaning programs throughout the watershed.
   4.4. Incorporate sound floodplain management principles in flood planning.
   4.5. Minimize the effects of structural floodway and stream encroachments with regard to sediment load and natural streamflow.

5. **Water Quality.** Improve dry and wet weather stream quality.
   5.1. Re-evaluate designated uses and develop a phased achievement approach to revised designated uses by meeting associated water quality criteria in Darby and Cobbs Creeks.
   5.2. Develop a phased approach to meeting appropriate water quality standards in dry weather and wet weather.
   5.3. Prevent fish consumption advisories.

6. **Pollutant Loads.** Decrease pollutant loads to surface waters.
   6.1. Identify "hot spots" of runoff pollution and define pollution reduction measures to decrease loads of targeted water quality parameters.
   6.2. Identify and eliminate SSOs and illicit storm sewer connections in a manner consistent with the Clean Water Act and the Clean Streams Law.
   6.3. Eliminate septic tank failures.
   6.4. Implement the Nine Minimum Controls for CSOs.
   6.5. Minimize CSO volume and frequency in accordance with the National CSO Policy.
   6.6. Decrease inputs of floatables, debris, and litter from all sources.
   6.7. Increase I/I studies, sewer cleanings and inspections.

7. **Stream Corridors.** Protect and restore stream corridors, buffers, floodplains, and natural habitats including wetlands.
   7.1. Decrease loss of open space and habitat by responsibly managing new development.
   7.2. Increase open space and habitat by responsibly managing redevelopment of existing, vacant, and abandoned lands.
   7.3. Inventory and protect existing wetlands.
   7.4. Identify and pursue opportunities for wetland enhancement and wetland creation for stormwater treatment.
   7.5. Improve floodplain conditions through restoration or improvement of the connections between streams and their floodplains.
   7.6. Protect and restore riparian habitat and stream buffer zones with native species where feasible.
   7.7. Protect and restore upland habitats along riparian corridors and throughout the watershed where feasible.
   7.8. Increase the number of municipalities with an invasive species control program.

8. **Quality of Life.** Enhance community environmental quality of life.
   8.1. Increase community green and open space.
   8.2. Increase community access and recreational activities in city parks and streams (e.g., by increasing miles of greenways and trails along stream corridors).
   8.3. Increase the public sense of security along stream corridors (e.g., by increased police presence, lighting, signage, park maintenance).
   8.4. Improve and protect aesthetics along stream corridors(e.g., by litter/graffiti removal, enforcement against illegal practices such as dumping, controls on ATV use).
   8.5. Identify and protect historical and cultural resources along stream corridors.

9. **Stewardship.** Foster community stewardship.
   9.1. Increase public awareness of the value of streams to the community.
   9.2. Improve business and institutional awareness of and accountability for activities that affect water quality.
   9.3. Encourage and support establishment of watershed organizations, EACs, etc. to bear the watershed banner.
   9.4. Engage local officials and planners.
   9.5. Increase volunteer participation in implementing management options.
   9.6. Increase school-based education.

10. **Coordination.** Improve inter-municipal, inter-county, state-local, and stakeholder cooperation and coordination on a watershed basis.
    10.1. Increase watershed-wide adoption of the resolution and expand it to include the goals of the watershed management plan.
    10.2. Gain state and federal support through grant funding. Increase synchronization of and coordination of permits and regulation on a watershed basis.
    10.3. Formally adopt a watershed management plan gaining county commissioners' approval.
    10.4. Improve data and information exchange between municipalities and stakeholders.
    10.5. Improve coordination with downstream communities and governments along the Delaware River and Estuary.

3.3 Goals Prioritization

The goals and objectives represent the collective idea of the stakeholders on what the watershed management plan should achieve. Not all goals, however, are of equal importance. It is important to elicit from the stakeholders a collective opinion on the relative importance of each goal for the Cobbs Creek. Because the achievement of goals is an important yardstick for measuring the effectiveness of the management plan, some numerical representation of the importance of each goal is useful.

To develop a set of numerical weights that represent the importance of each goal relative to the other goals, a workshop was held on October 29, 2002, with members of the partnership participating. The goal of the workshop was to work towards a consensus on a numerical set of weights that best represent the collective opinion on the importance of each goal. Each participant filled in a worksheet that described, as a percent, the individual contribution of each goal to the overall goal of watershed management. These sheets provided a variety of opinions on how the goals should be weighted, and served as a guide to a discussion on the relative importance of each goal. Through the group discussion, a consensus set of goal weights was developed that best represents the importance of each goal as defined by the stakeholders. Table 3-1 shows the weights assigned to each goal. The weights represent a percentage of the overall importance of each goal relative to all goals.

Table 3-1: Stakeholder Priorities as Weights for Goals

Streamflow and Living Resources. Reduce the impact of urbanized flow on the living resources (increase baseflow and recharge, reduce impervious area and runoff peaks, improve stormwater ordinances).	**12**
Stream Habitat and Aquatic Life. Improve stream habitat and indices of aquatic integrity (improve physical habitat, benthic, fish, algae).	**9**
Stream Channels and Banks. Reduce streambank and stream channel deposition and scour to protect and restore the natural functions of aquatic habitat and ecosystems, streambanks, and stream channels (increase stabilized areas, reduce frequency of bankfull flow).	**7**
Flooding. Decrease flooding (improve stormwater management, trouble spots, inlet cleaning, floodplain management and structures).	**11**
Water Quality. Improve dry and wet weather stream quality (meet designated uses, prevent fish advisories).	**9**
Pollutant Loads. Decrease pollutant loads to surface waters (decrease runoff, SSO, septic tank, CSO, and debris loads).	**10**
Stream Corridors. Protect and restore stream corridors, buffers, floodplains, and natural habitats including wetlands.	**11**
Quality of Life. Enhance community environmental quality of life (protect open space, access and recreation, security, aesthetics, historical/cultural resources).	**12**
Stewardship. Foster community stewardship (increase awareness and responsibility, volunteer programs, education).	**11**
Coordination. Improve inter-municipal, inter-county, state-local, and stakeholder cooperation and coordination on a watershed basis.	**8**

In addition to the weights assigned to each goal, the workshop participants also provided some insight into the relative importance of each of the objectives within the goals. These were provided as an opinion on whether a particular objective had a high, medium, or low priority as part of the goal. No consensus building process was attempted for all of the objectives, since these play a lesser role in the overall evaluation. The project team assigned a value of 1 point for a low designation, 2 points for a medium designation, and 3 points for a high designation. The point totals on all the sheets were tallied, and average scores were computed to distribute the overall consensus weight for each goal over its sub-objectives.

The weights assigned to each goal were important in screening and evaluating the many possible alternative water management approaches to arrive at the recommended alternative.

3.4 Target C Evaluation Criteria Weighting

The stakeholders also were asked to help provide weights for the process of evaluating the six alternatives developed to meet the wet weather water quality and quantity objectives (Target C, see section 2). These weights represented the relative importance of each of the criteria used in the evaluation, in much the same way the goals were assigned weights. In this case, however, each member organization's weights were tested using the EVAMIX evaluation program, and no consensus was attempted on a single set of weights. The various weight sets provided a type of sensitivity analysis and helped to clarify the strengths and weaknesses of various combinations of BMPs in meeting the Target C objectives of a 20 percent reduction in stormwater flow to the streams.

4. Darby-Cobbs Study Results

This section summarizes the results of the numerous studies that have already been carried out within the watershed. Many of the studies covered the entire Darby-Cobbs-Tinicum watershed, others only the Cobbs Creek watershed. When available, results are included for the Darby, Cobbs, and Tinicum portions of the watershed, to facilitate future planning for the Darby Creek watershed by Delaware County. The primary focus of the section, however, is to provide more detailed information on the Cobbs Creek watershed as the basis for CCIWMP.

4.1 Watershed Description and Demographics

The Darby-Cobbs watershed is defined as the land area that drains to the mouth of Darby Creek at the Delaware Estuary, encompassing approximately 80 square miles in southeastern Pennsylvania. This area includes portions of Chester, Delaware, Montgomery, and Philadelphia Counties. The watershed may be subdivided into the Cobbs Creek, Darby Creek, and Tinicum subwatersheds. Figure 4-1 includes the watershed boundaries, hydrologic features, and political boundaries. Much of the information is based on the U.S. Census Bureau's TIGER (Topologically Integrated Geographic Encoding and Referencing) database.

Cobbs Creek drains approximately 14,500 acres or 27% of the total watershed area. The upper portions and headwaters of Cobbs Creek, including East and West Branch Indian Creek, include portions of Philadelphia, Montgomery, and Delaware Counties. The lower portion of Cobbs Creek watershed, including the lower mainstem and Naylors Run, drain parts of Philadelphia and Delaware Counties. Cobbs Creek discharges to Darby Creek.

The Darby Creek watershed drains approximately 29,000 acres or 55% of the total study area. The watershed is located primarily in Delaware County. The northwest corner of the watershed, including the headwaters of the mainstem, is located in Chester County. Darby Creek has a number of small tributaries, including Little Darby Creek, Ithan Creek, and Foxes Run.

The Darby-Cobbs watershed discharges to the Delaware River through the wetlands of the Tinicum Refuge. The Tinicum watershed includes portions of Philadelphia and Delaware Counties and totals 9800 acres or 18% of the total. Much of the area consists of low-lying wetlands, including the John Heinz National Wildlife Refuge. Named streams in the subwatershed include Hermesprota, Muckinipattis, and Stony Creeks.

In a relatively undisturbed watershed, watershed boundaries follow topographic high points or contours. The U.S. Geological Survey (USGS) has further subdivided the Darby-Cobbs watershed based on topography, as shown in Figure 4-2. These USGS subwatersheds are determined from the land area draining to a particular point of interest, such as a stream confluence or gauging site. These boundaries allow initial determinations of drainage areas and modeling elements. However, it is important in the urban environment to include the effects of man-made changes to natural drainage patterns.

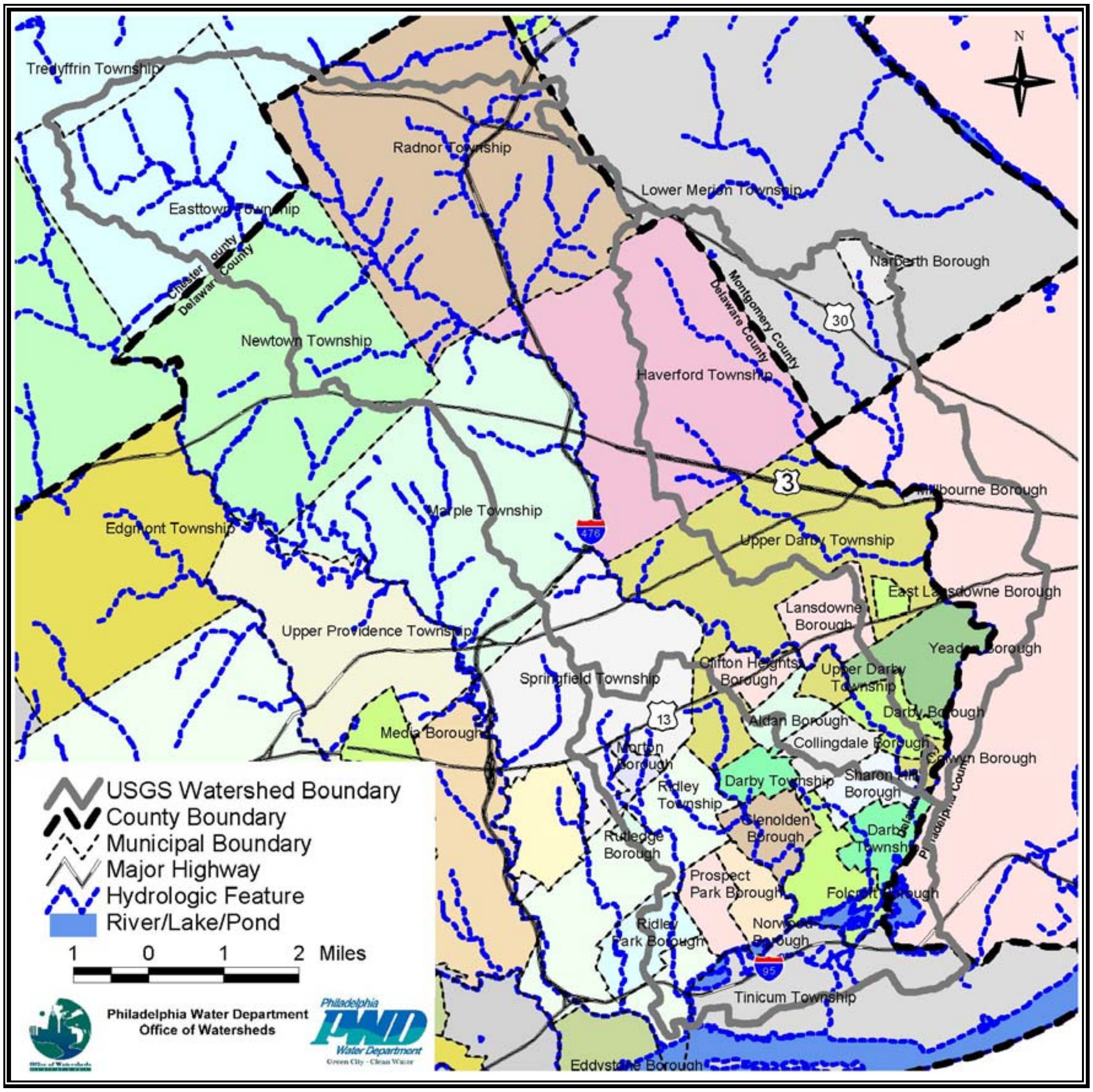


Figure 4-1 Darby-Cobbs Study Area

Geology and Soils

Geology and soils play a role in the hydrology, water quality, and ecology of a watershed. The Darby-Cobbs watershed falls within the Coastal Plain and Piedmont physiographic provinces. Geologic formations on the surface in the area include gneiss, schist, and serpentine formations in most of the watershed (Piedmont) and layers of sediment in the downstream reaches (Coastal Plain) as shown in Figure 4-3. Soils in the upper portions of the Darby Creek subwatershed include loams and silty loams, as shown in Figure 4-4. Soil in much of the rest of the watershed is classified as urban or made land and is not representative of the original undisturbed soil. Wetland soils are present in the Tinicum area.

Demographic Information
Population density and other demographic information in the watershed are available from the results of the 1990 census. Approximately 500,000 people live within the drainage area of the Darby and Cobbs Creeks. Figure 4-5 shows the population density in the watershed at the census block level. Spatial trends in population correspond closely to land use, with multi-family row homes displaying the greatest population density of 20 people per acre or more, single-family homes displaying a lower density, and other land use types displaying the lowest density. In addition to population data, the U.S. Census Bureau provides a range of socioeconomic data that are often useful in watershed planning and general planning studies. Median household income and mean home value (Figures 4-6 and 4-7) are two of the many sample datasets provided.

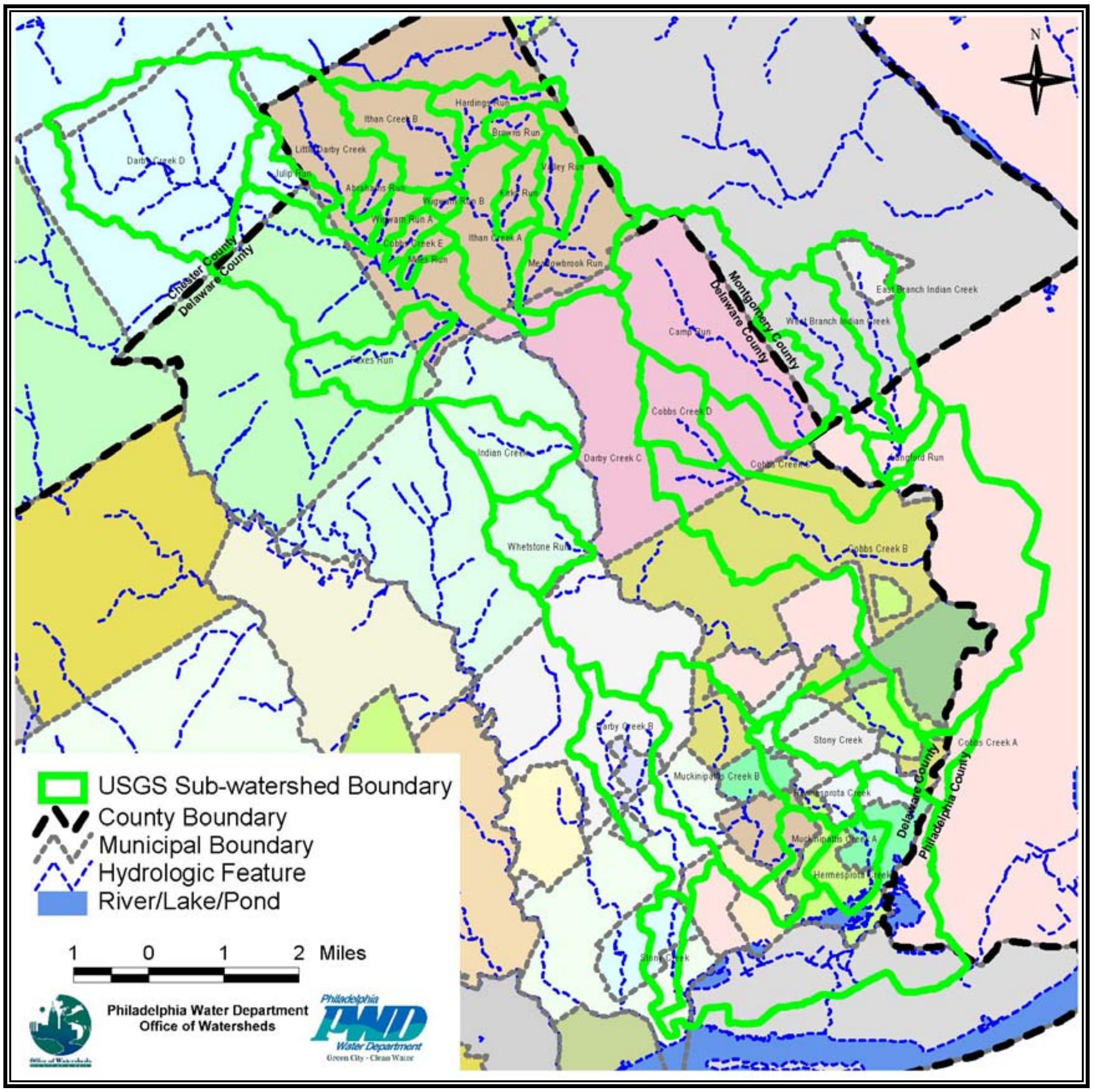


Figure 4-2 USGS Topographic Subwatersheds

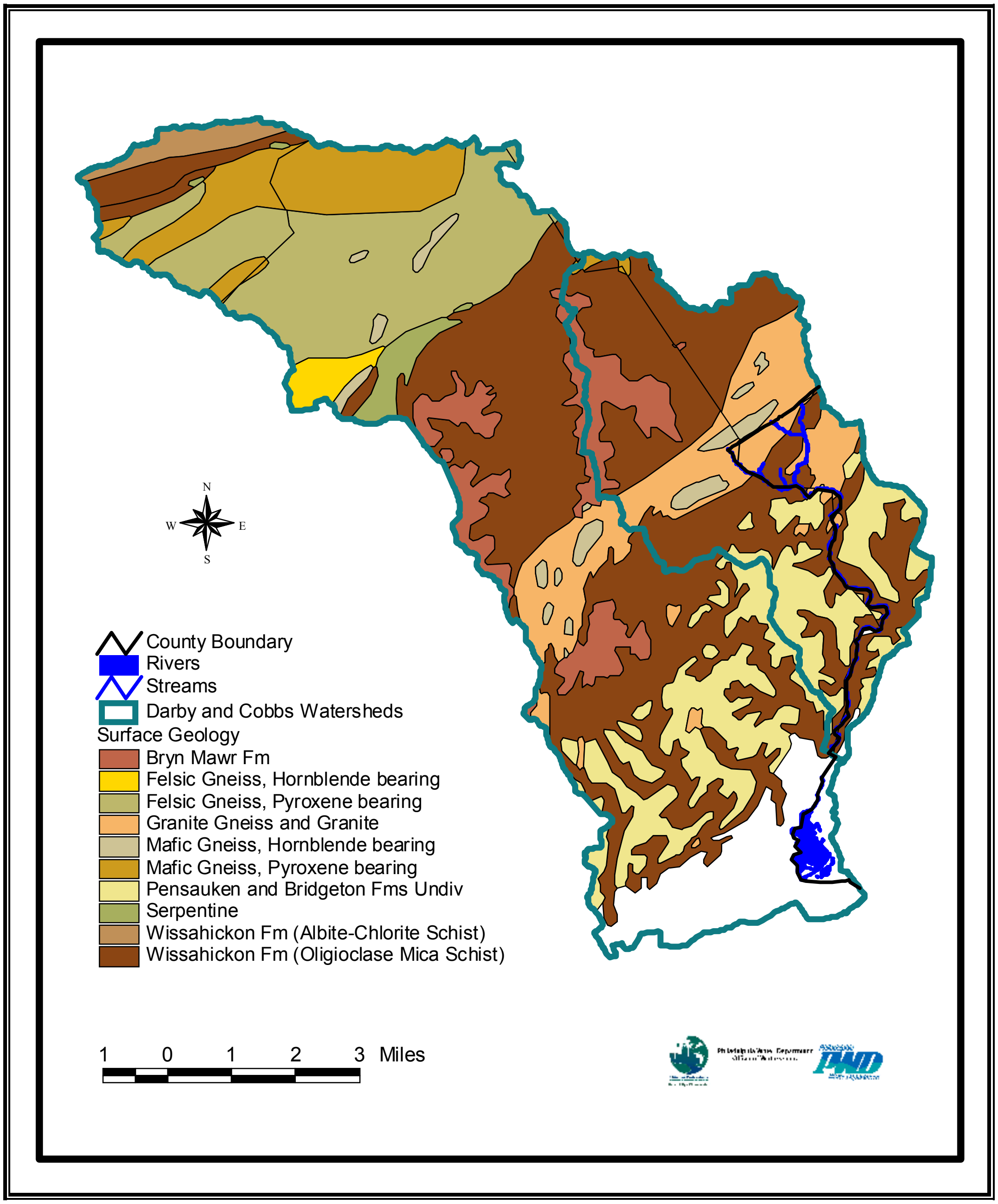


Figure 4-3 Surface Geologic Formations

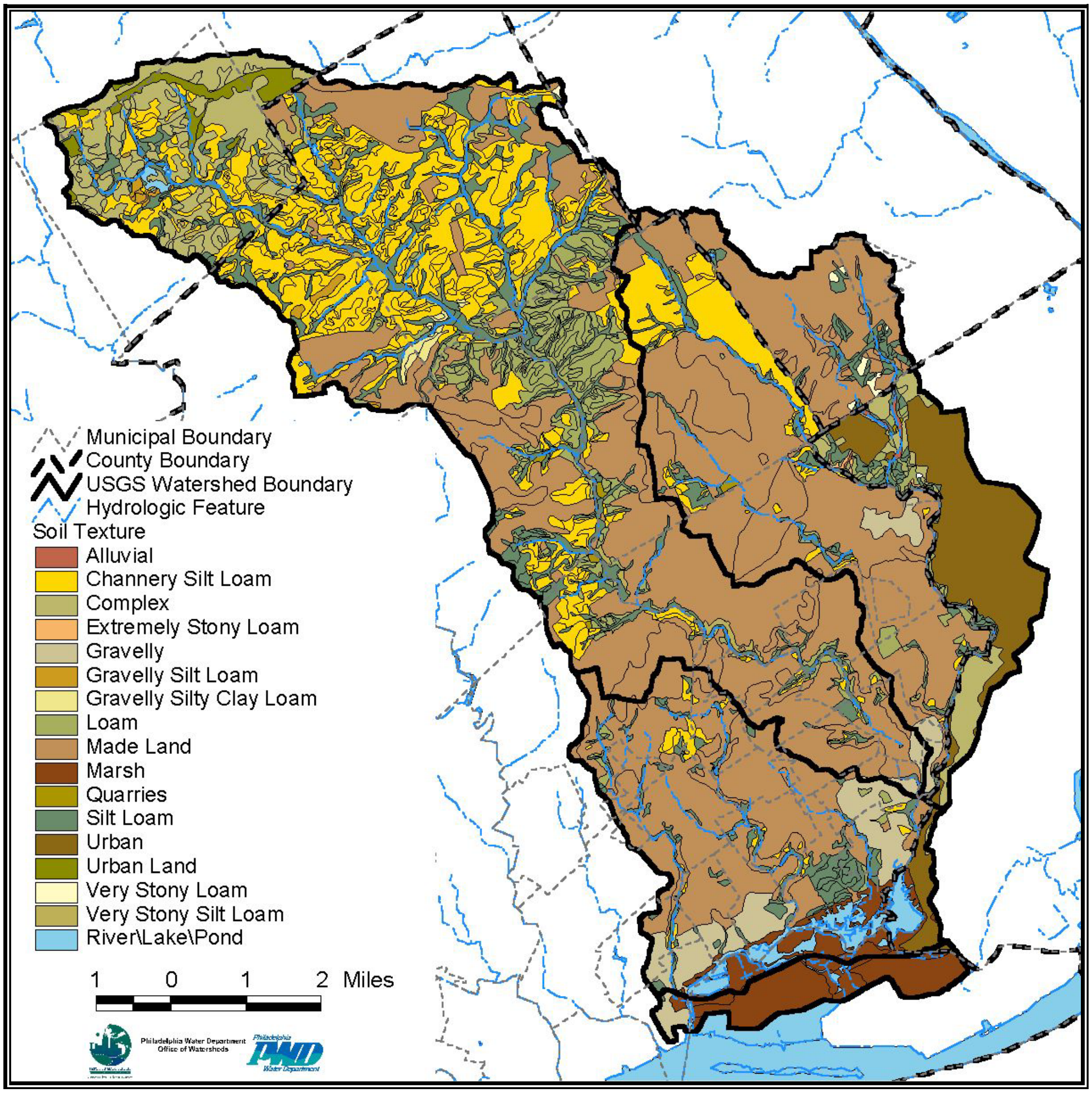


Figure 4-4 Soil Types in the Darby-Cobbs Watershed

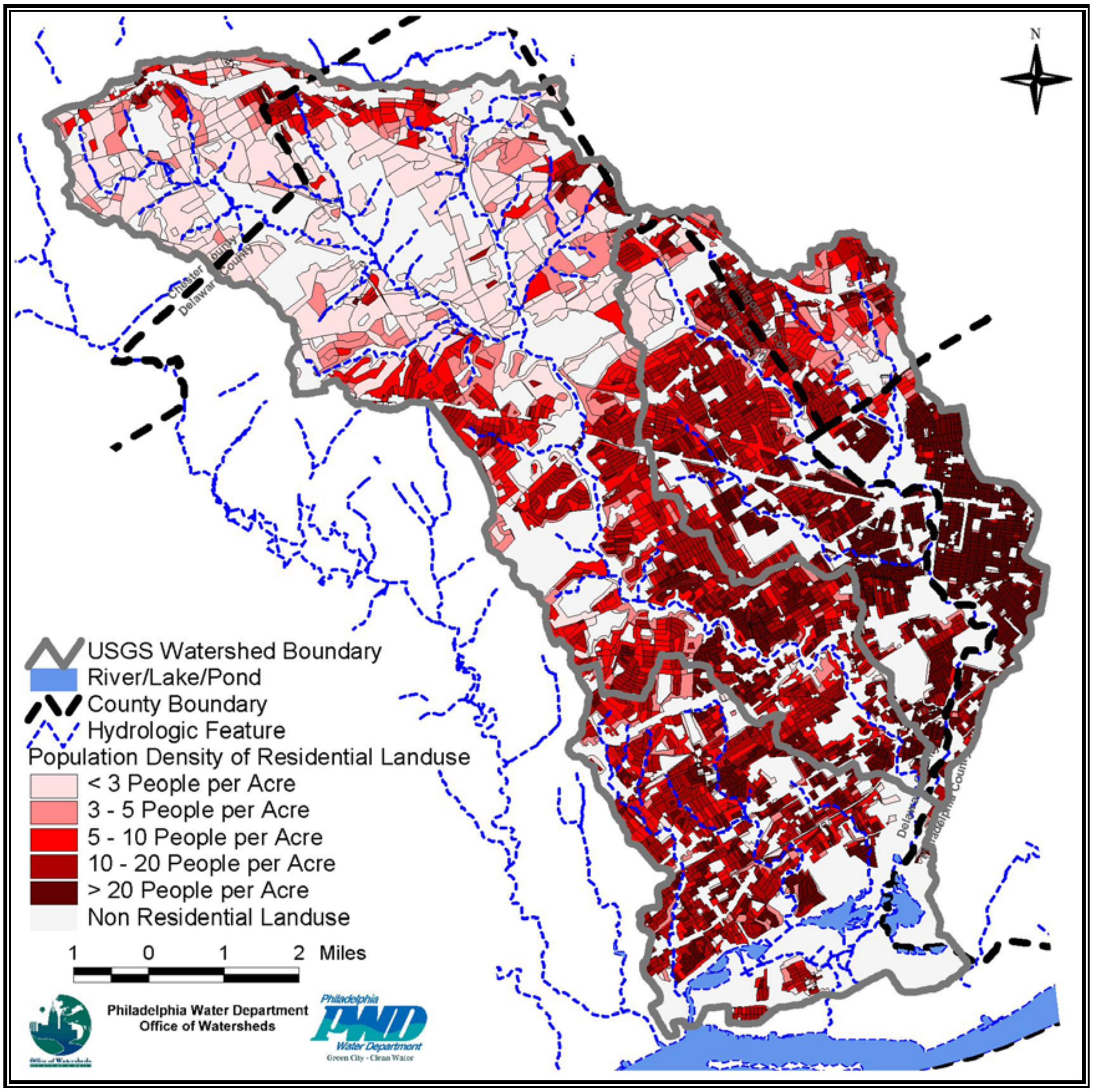


Figure 4-5 Population Density Based on 2000 Census Data

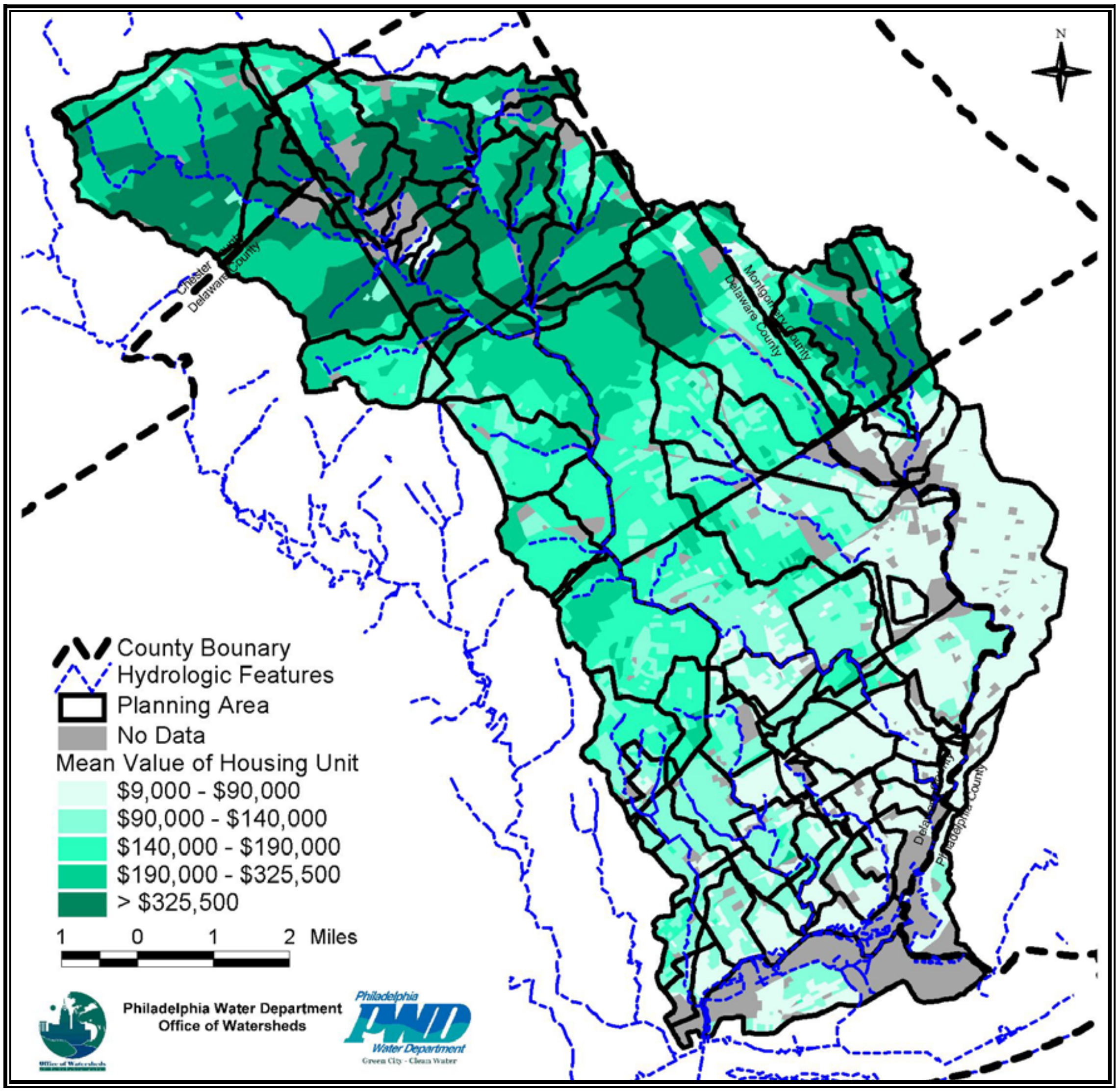


Figure 4-6 Mean Home Value

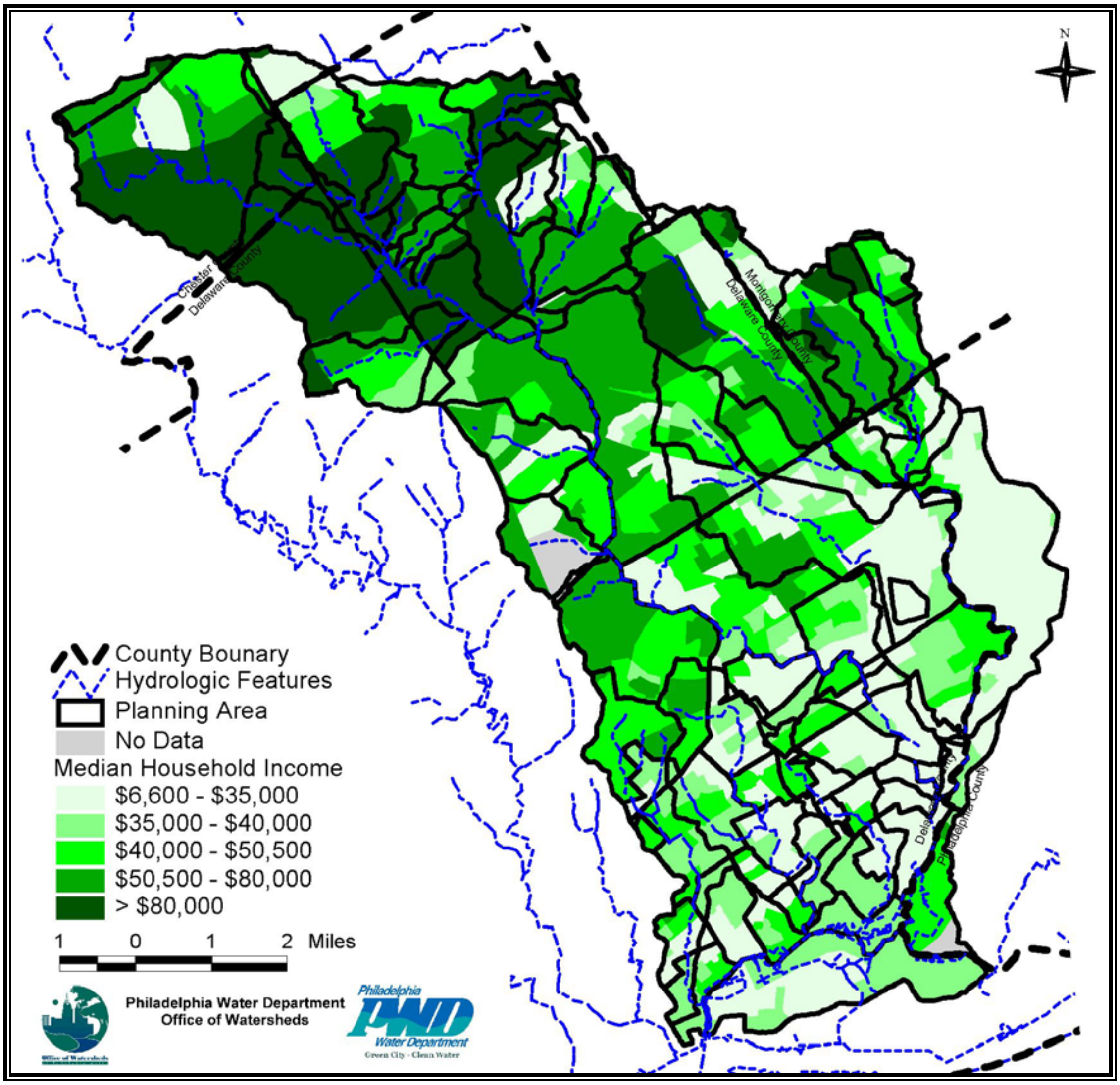


Figure 4-7 Mean Household Income

4.2 Watershed Status and Trends

This section was developed to serve as a basis for understanding the state of the Darby-Cobbs watershed, its relative environmental quality, and trends with respect to the management of factors that influence its quality. The report details the history and current conditions of the watershed and attempts to establish trends associated with a host of progress indicators. The results presented in this report were derived from past studies on the watershed and from recent data collection efforts conducted by the Philadelphia Water Department. 21 indicators were identified:

Land Use and Stream Health Relationship

Indicator 1: Land Use and Impervious Cover

Flow Conditions and Living Resources

Indicator 2: Streamflow
Indicator 3: Stream Channels and Aquatic Habitat
Indicator 4: Restoration Projects Lists of completed, in progress, and planned projects
Indicator 5: Fish
Indicator 6: Benthos

Water Quality

Indicator 7: Effects on Public Health (Bacteria)
Indicator 8: Effects on Public Health (Metals and Fish Consumption)
Indicator 9: Effects on Aquatic Life (Dissolved Oxygen)

Pollutants and Their Sources

Indicator 10: Point Sources
Indicator 11: Non-point Sources

Stream Corridor

Indicator 12: Riparian Corridor
Indicator 13: Wetlands and Woodlands
Indicator 14: Wildlife
Indicator 15: Flooding

Quality of Life

Indicator 16: Public Understanding and Community Stewardship
Indicator 17: School-Based Education
Indicator 18: Recreational Use and Aesthetics
Indicator 19: Local Government Stewardship
Indicator 20: Business and Institutional Stewardship
Indicator 21: Cultural and Historic Resources

Land Use and Stream Health Relationship
Indicator 1: Land Use and Impervious Cover

Urbanization of natural lands affects watershed hydrology, water quality, stream stability, and ecology. One of the primary indicators of watershed health is percent impervious cover in the watershed. Based on numerous research efforts, studies and observations, a general categorization of watersheds has been widely applied to watershed management based on percent impervious cover (Schueler 1995). Table 4-1 summarizes several impacts of traditional development on streams and watersheds, most of which are created by increased impervious cover.

Table 4-1 Impervious Cover as an Indicator of Stream Health (Schueler 1995)

Characteristic	Sensitive	Degrading	Non-Supporting
Percent Impervious Cover	0% to 10%	11% to 25%	26% to 100%
Channel Stability	Stable	Unstable	Highly Unstable
Water Quality	Good to Excellent	Fair to Good	Fair to Poor
Stream Biodiversity	Good to Excellent	Fair to Good	Poor
Pollutants of Concern	Sediment and temperature only	Also nutrients and metals	Also bacteria

This indicator measures:

- **GIS-estimated impervious cover of each subwatershed (% of total area)**
- **Model-estimated Directly Connected Impervious Area (DCIA) of each subwatershed (% of total area)**
- **Open space in each subwatershed (% of total area)**
- **Publicly-owned land in each subwatershed (% of total area)**

Where We Were:
By 1935, most of the early mills had left the lower Darby Creek watershed. Although its industrial base was in decline, large portions of the Darby Creek watershed area became occupied by dense housing developments, many of which were constructed before the emergence of zoning controls and other environmental and land management methods. As a result, the natural resources of the Darby Creek were negatively impacted by inadequate and polluted stormwater runoff and drainage systems, leaking and inadequate septic tanks, lack of open space and adequate recreation, illegal dumping, and an array of other urban ills.

Where We Are:
The upper reaches and headwaters of the Cobbs Creek watershed are characterized primarily by a mix of residential areas, while the lower portions are primarily high-density residential areas with commercial areas along highway corridors (Figure 4-8). Riparian lands within the City consist mainly of parkland left in a natural state. Land uses in the Darby Creek watershed consist of residential areas in the lower portions and a combination of low-density residential, commercial, parkland, and golf course uses in the upper reaches. The Tinicum watershed consists of residential and commercial development to the northwest and protected wetlands to the southeast. Based on these land uses, impervious cover is estimated for each portion of the watershed and listed in Table 4-2.

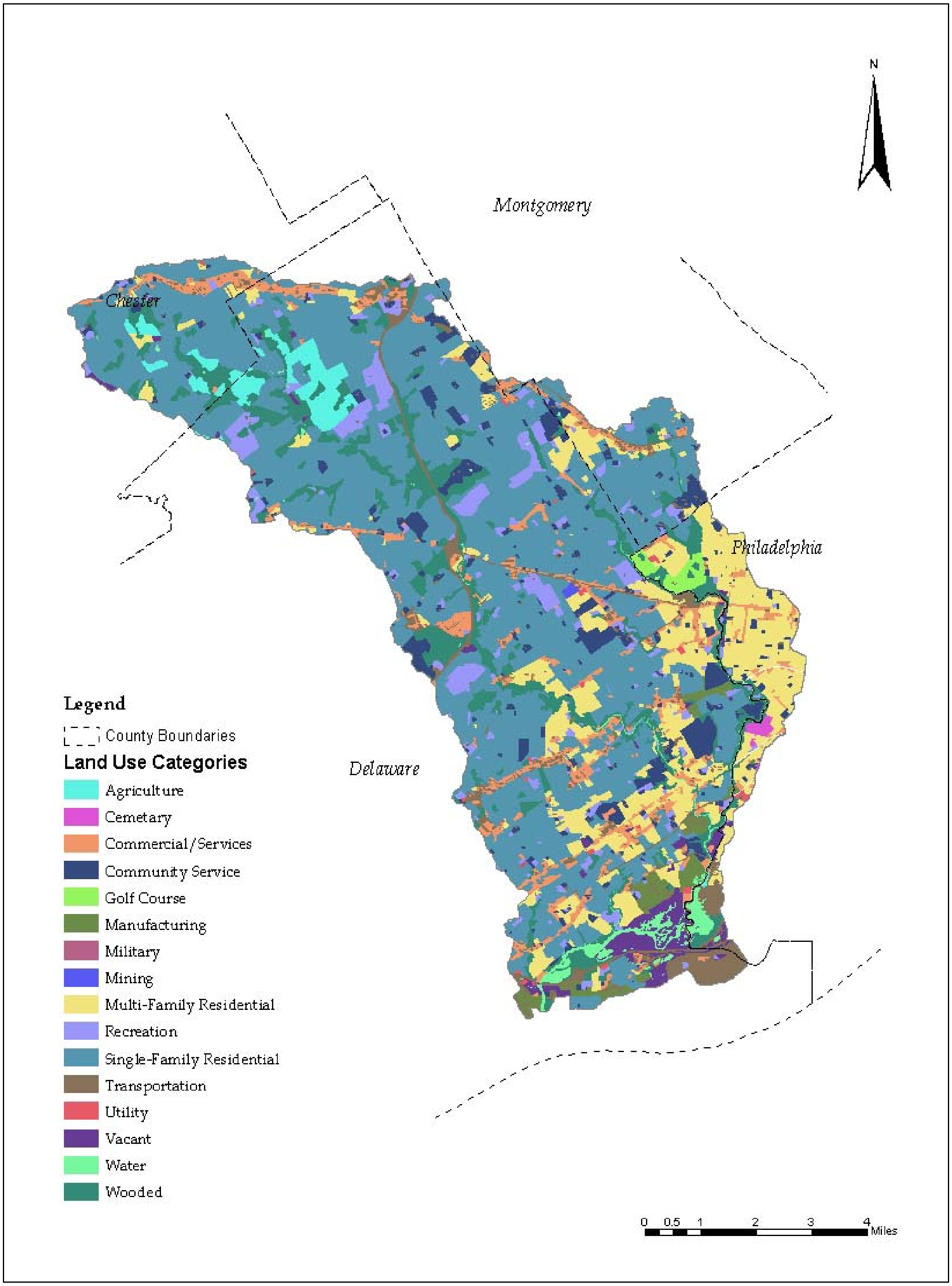


Figure 4-8 1995 DVRPC Land Use in the Darby-Cobbs Watershed

Table 4-2 Estimated Total Impervious Cover

Watershed	County	Area (ac)	% Impervious
Cobbs	Delaware	8,041	46.7%
Cobbs	Montgomery	2,644	40.6%
Cobbs	Philadelphia	3,562	60.2%
Darby	Chester	4,217	25.7%
Darby	Delaware	24,503	38.7%
Darby	Montgomery	70	44.2%
Darby	Philadelphia	558	66.7%
Tinicum	Delaware	5,811	49.4%

Tables 4-1 and 4-2 together suggest that the more developed areas of the watersheds are already degraded and that the developing portions can be expected to become degraded if action is not taken. The headwaters of Darby Creek in Chester County have the lowest estimated impervious cover at 25%. At this level, water quality and ecological health may still be fair to good, but erosion and sedimentation of the stream channel begin to become a problem. Philadelphia portions of the Cobbs and Darby Watersheds are the most impervious at over 60%. At this level, stream channels are highly unstable, and both water quality and ecological health tend to be poor. Remaining areas fall between these two extremes. It is estimated that about 50-75% of impervious area is directly connected (DCIA) to the drainage system.

The proportion of open space and publicly owned land are also informative indicators (Table 4-3). Analysis of the land use data reveals that over 90% of the Darby Creek watershed and the northern portion of the Cobbs Creek watershed is privately owned land. While the northern portion of the Darby Creek Watershed also has a high percentage of open space, it is made up primarily of privately owned land such as agricultural areas and golf courses. Other than the upper portion of the Darby Creek watershed, areas that have the most open space also tend to be those sections of the watershed with the most publicly-owned land. These include the Lower Cobbs, which has the most publicly-owned space due to Cobbs Creek Park, followed by Tinicum marsh which contains the John Heinz National Wildlife Refuge. Figure 4-9 indicates how the watershed is broken into subwatersheds.

Table 4-3 Estimated Open Space and Publicly Owned Land

Subwatershed	Total Area (acres)	Publicly Owned (% of total)	Open Space (% of total)
Upper Cobbs	6,473	7%	14%
Lower Cobbs	7,698	26%	25%
Upper Darby	16,910	6%	26%
Lower Darby	8,521	7%	21%
Tinicum	9,804	25%	27%

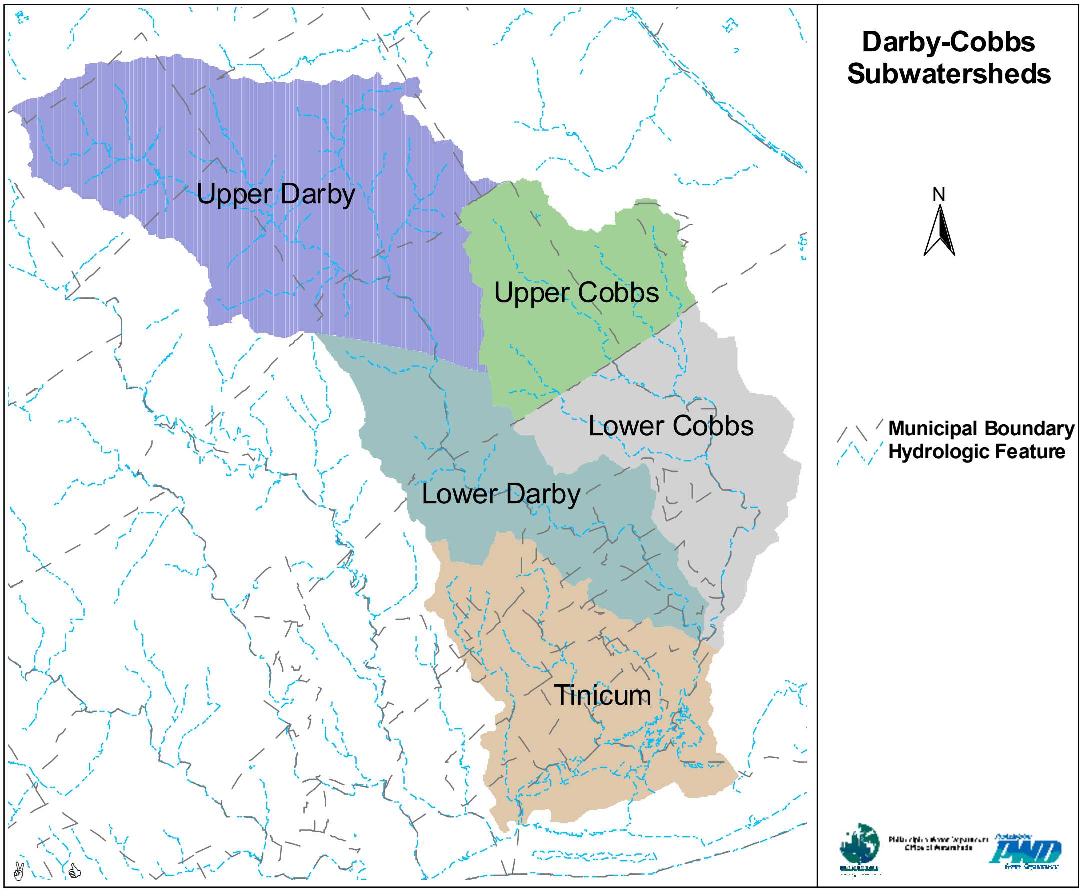


Figure 4-9 1995 Subwatersheds in the Darby-Cobbs Watershed

Flow Conditions and Living Resources
Indicator 2: Streamflow

As discussed in Indicator 1, urbanized land uses in a watershed affect stormwater runoff, streamflow, condition and shape of stream banks and channels, water quality, and aquatic habitat and ecosystems. Increases in impervious cover affect stream hydrology in a variety of ways:

- Increased magnitude and frequency of severe floods
- Increased frequency of erosive bankfull and sub-bankfull floods
- Reduced groundwater recharge leading to reduced baseflow
- Greater stream velocities during storm events

This indicator measures:

- **Average annual baseflow (% of total flow)**
- **Average annual baseflow (% of annual precipitation)**
- **Average annual stormwater runoff (% of annual precipitation)**

The Cobbs Creek watershed and the lower portions of the Darby Creek watershed are highly urbanized and contain a large proportion of impervious cover. Hydrologic impacts of urbanization can be observed through analysis of streamflow data taken from USGS gauges on Darby and Cobbs Creeks. In addition, data from French Creek in Chester County provide a picture of a nearby less-developed watershed.

Where We Were:
The analysis below represents a long-term period of record for each stream gauge. It is difficult to establish a trend over time, but an attempt will be made when the watershed is reassessed.

Where We Are:
Streamflow data were separated into their two main components: baseflow and stormwater runoff. In perennial streams, baseflow is the portion of streamflow caused by groundwater inflow and is present in dry and wet weather. Stormwater runoff is the portion of streamflow contributed by excess rainfall flowing over the land surface and through the drainage system. The results of this hydrograph decomposition exercise (Table 4-4) support the relationships between land use and hydrology discussed above. Based on the French Creek gauge and the two Darby Creek gauges, the hydrologic behavior of these two systems is similar. Pervious cover allows sufficient groundwater recharge to give streamflow relatively natural characteristics; a mean of approximately 20% of annual rainfall contributes to the stormwater component of streamflow, and baseflow represents approximately 65% of total annual streamflow. It is interesting to note that baseflow, as a percentage of precipitation, is higher in Darby Creek than in French Creek. Cobbs Creek exhibits behavior typical of a highly urbanized stream, with over 25% of rainfall contributing to stormwater runoff in a mean year and with mean baseflow comprising only 43% of mean annual streamflow.

Table 4-4 Summary of Hydrograph Separation Results over the Period of Record

	Period of Record (yrs)	Baseflow (% of Total Flow)	Baseflow (% of Precip)	Stormwater Runoff (% of Precip)
French Creek 01475127	33.0	64	31	17
Cobbs Creek 01475550	26.7	42	19	25
Darby Creek D/S 01475510	26.7	62	34	21
Darby Creek U/S 01475300	25.4	66	37	19

Indicator 3: Stream Channels and Aquatic Habitat

Healthy populations of fish and invertebrates require physical habitat features that allow them to feed, reproduce, and seek shelter during episodes of high flow. In the urban environment, where significant erosion and deposition occur, these features often are not available (Figure 4-10).

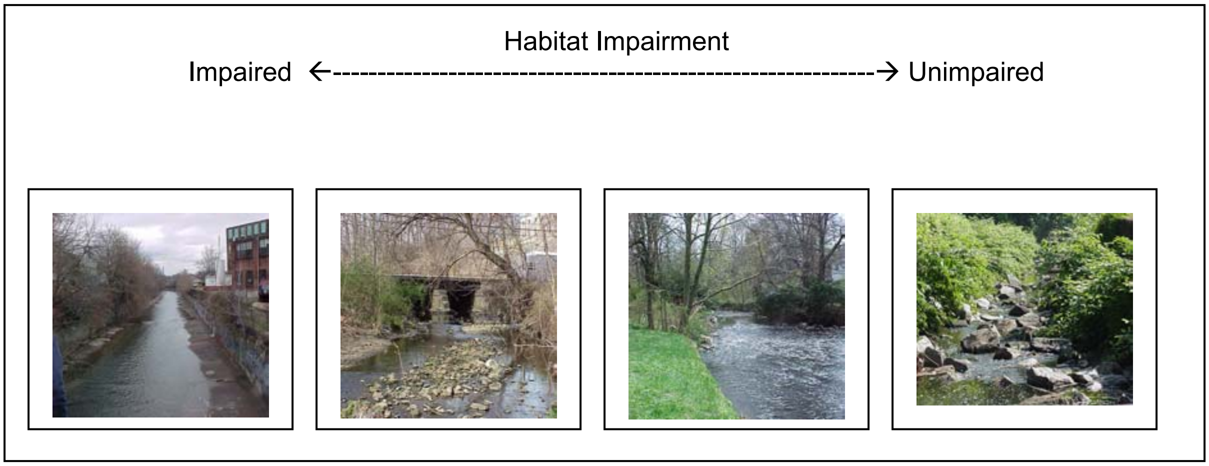


Figure 4-10 Habitat Impairment Comparisons

Fluvial geomorphology is the study of landforms associated with river channels and the processes that form them. The Rosgen classification system is commonly used to assess physical channel conditions. Of the channel types found in Cobbs, channels classified as "F" are highly impacted by urban flows, subject to erosion and deposition of sediment, and generally do not support diverse ecosystems. Channels classified as "B", "C", and "E" are generally stable under natural flow conditions and can support healthy stream habitats. Channels currently classified as one of the stable types may degrade into F channels over time when subjected to urban flows. Likewise, "F" channels can slowly start establishing new floodplains and can become "C" channels.

This indicator measures:

- **Habitat score relative to reference condition at various sites**
- **Channel type and expected trend**

Where We Were:
There is no historical data available for this indicator. Habitat and stream channels most likely degraded over a long period of time as the watershed developed. A trend will be established the next time this area is reassessed.

Where We Are:
In 1999, habitat at 7 sites throughout the Cobbs watershed was surveyed by PWD biologists (Figure 4-11). The sites were rated based on comparison to a reference reach, French Creek. The five sites in the headwaters received ratings of "Comparable to Reference" (1 site), "Supporting" (1 site), and "Partially Supporting" (3 sites), while the two downstream sites were determined to be "Partially Supporting" of aquatic communities.

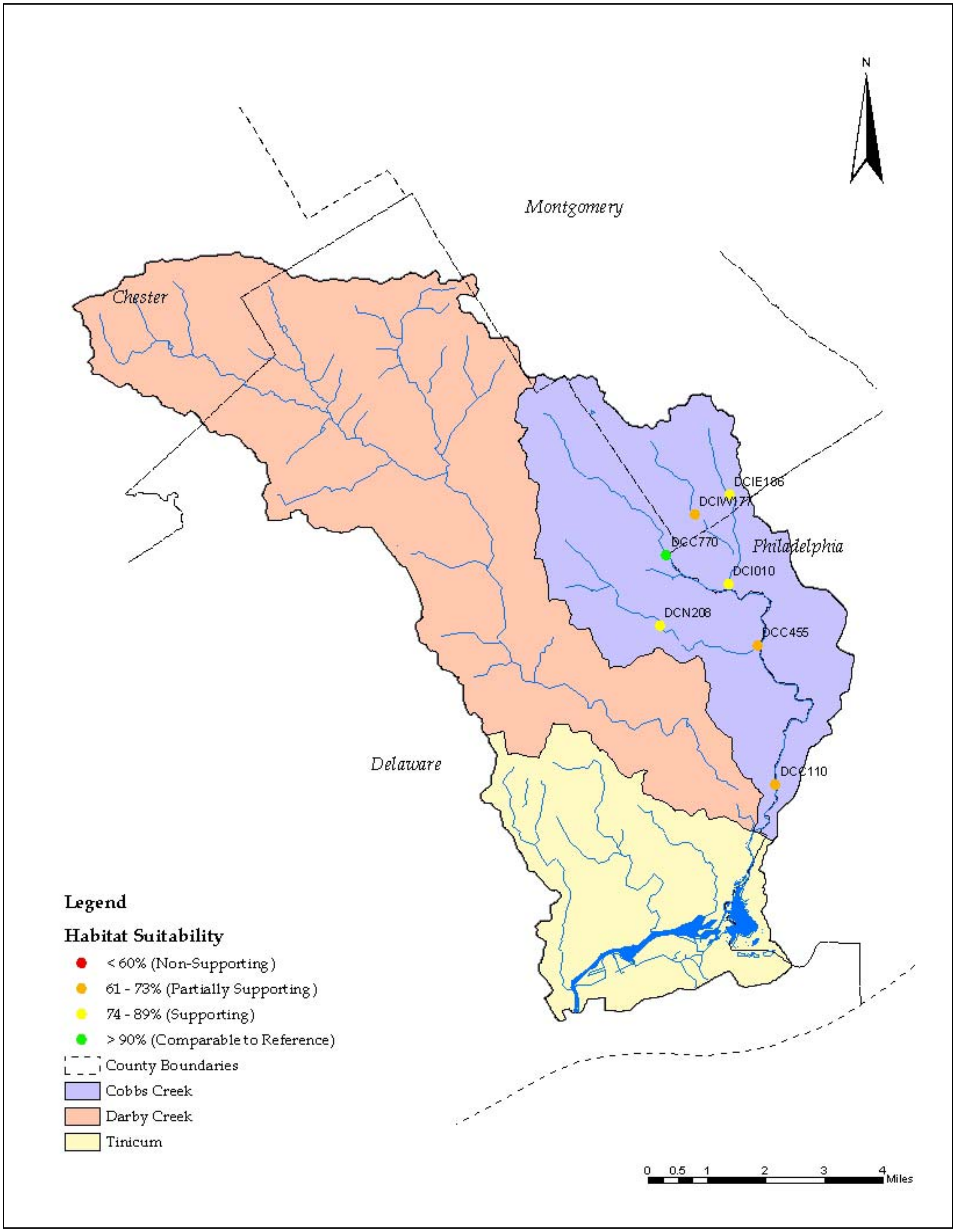


Figure 4-11 Cobbs Habitat Assessment (Philadelphia Water Department, 1999)

In 2002, Rosgen techniques were used to measure channel geometry and stability parameters to determine stream classification. Over 17 miles of stream were evaluated and selected reaches of Cobbs Creek, West Branch Indian Creek, and East Branch Indian Creek were classified.

Approximately 80% of the studied length was classified as a Rosgen type "F" channel (Figure 4-12). "B", "C", and "E" types are found in the headwaters, while the "F" types are found along most of the lower main stem. The Cobbs main stem is expected to continue widening through bank erosion, and upstream portions are expected to start downcutting and become more entrenched.

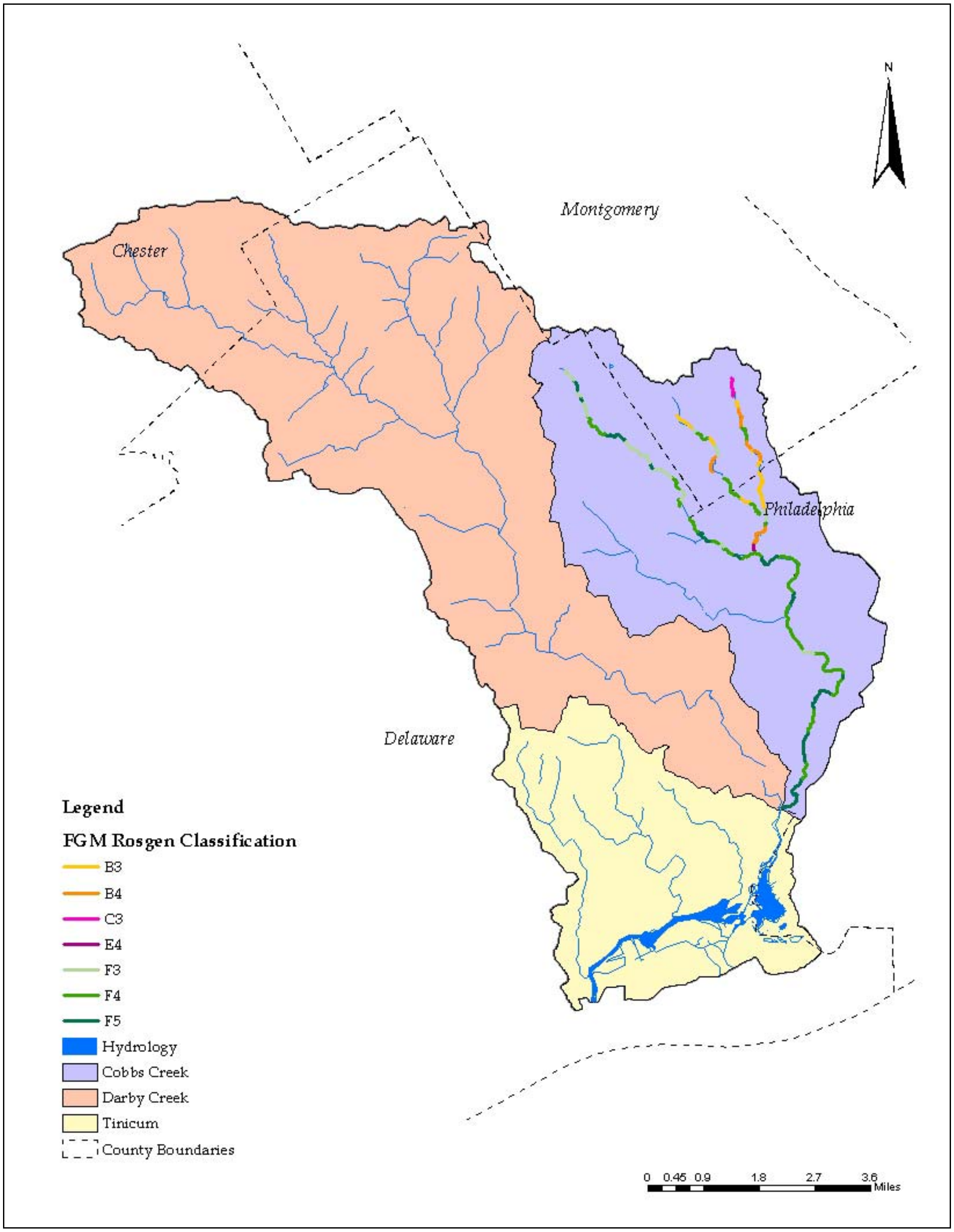


Figure 4-12 Fluvial Geomorphology Study - Rosgen Classification of Cobbs Reaches 2003

Indicator 4: Restoration and Demonstration Projects

Funding for watersheds and water–related projects has been increasing throughout the country in recent years. Grants are being issued to support various types of projects throughout the state of Pennsylvania. Begun in 1999, Pennsylvania's Growing Greener program has been an enormous source of environmental funding over the last few years. In fact, this program has become the largest single investment of state funds in Pennsylvania's history. There are also many other organizations and governmental agencies offering grant money and technical assistance for communities and other organizations to accomplish their environmental projects for improving our watersheds. Figure 4-13 depicts a stream reach that is planned for eventual restoration.

This indicator measures:

- **Lists of completed, in progress, and planned projects**

Figure 4-13 Bank Erosion in the Cobbs Creek Restoration Area

Where We Were:
The number of restoration projects in this watershed has increased with the introduction of the Growing Greener program and other funding programs.

Where We Are:
Many environmental projects have been funded in the Darby-Cobbs Watershed, from streambank restoration to environmental education programs. A list of grants issued over the last 6 years has been assembled. Table 4-5 represents a profile of the grants received and the projects being performed; this is in no way is a comprehensive list of all the projects in the watershed. 25 projects were identified with a total amount of received funding totaling over $1.5 million.

Table 4-5 Grants in the Darby-Cobbs Watershed

Funding Agency	Funding Program	Year	Lead Agency	Project	Amount Awarded
DCNR	Rivers Conservation Grants	1998	Darby Creek Valley Association and DelCo Anglers and Conservationists	Develop a river conservation plan for Darby Creek.	$69,000
DEP	Watershed Restoration Assistance Program (WRAP)	1998	Delco Anglers and Conservationists	Riparian enhancement of Darby, Ridley and Goose Creeks.	$1,000
DEP	Watershed Restoration Assistance Program (WRAP)	1998	Radnor Township	Restore 100 feet of Little Darby Creek streambank.	$24,470
DEP	Growing Greener	1999	Darby Borough	Restoration of streambanks and riparian buffers at a public park using various bioengineering techniques.	$25,000
DEP	Watershed Restoration Assistance Program (WRAP)	1999	Darby Borough Council	Bartram Memorial Park streambank and erosion control and riparian planting project	$25,000
DEP	Growing Greener	1999	Tinicum Township Delaware County	Replace existing Jansen Avenue tide gate with self-regulating tide gate	$261,203
DEP	Growing Greener	1999	Villanova University, Radnor	Villanova Stormwater Management Practice Demonstration Park -- Phase One Planning.	$10,120
DEP	Growing Greener	2000	Delco Anglers and Conservationists	Darby Creek Riparian Restoration Continuation	$1,047
DEP	Growing Greener	2000	Pennsylvania Environmental Council Inc.	Darby-Cobbs Watershed Partnership Education and Outreach Survey	$35,000
DEP	Growing Greener	2000	Marple Township	Lawrence Road/Darby Creek Bank Stabilization	$68,225
DEP	Growing Greener	2000	Friends' Central School	Cobbs Creek Watershed Monitoring and Restoration	$75,913
DEP	Growing Greener	2000	Pennsylvania Environmental Council, Inc.	Development of a series of informational products on environmental issues for municipal officials	$79,199

Funding Agency	Funding Program	Year	Lead Agency	Project	Amount Awarded
DEP	Growing Greener	2000	City of Philadelphia Water Department	Sustainable Approach to Stream Habitat Restoration in an Impaired Urban Stream (Cobbs Cr.)	$150,000
DEP	Growing Greener	2000	Villanova University	Villanova stormwater bioretention traffic island	$59,112
League of Women Voters	Water Resources Education Network (WREN)	2001	Township of Lower Merion and Environmental Advisory Council	Produce a brochure entitled "Safeguarding our Streams" and produce a live television town meeting.	$5,000
DEP	Growing Greener	2001	Environmental Fund for Pennsylvania / Greenworks	The Value of Water	$24,174
DEP	Growing Greener	2001	Environmental Fund for Pennsylvania	Life on the Delaware River	$60,000
DEP	Act 167 Stormwater Management	2001	City of Philadelphia Water Department	Development of a Multi-Objective Model Framework for the Cobbs Creek Watershed	$62,100
DEP	Growing Greener	2001	Cobbs Creek Community Environmental Education Center	Cobbs Creek Watershed Stewards Initiative	$187,160
DEP	Growing Greener	2001	Villanova University-Institute for Environmental Engineering Research	Villanova stormwater porous concrete demonstration site	$85,500
EPA	104b3	2001	City of Philadelphia Water Department	Cobbs Creek Habitat Model	$250,000
EPA	Wetland Program Development Grants	2002	City of Philadelphia Water Department	Wetlands Program Inventory and Assessment	$175,000
DEP	Growing Greener	2002	Friends' Central School	Education and outreach on Cobbs and Darby Creeks	$31,380
DEP	CZM	2002	Delaware Riverkeeper Network	Bartram Park Streambank Restoration & Buffer Enhancement Project	$71,400
DEP	Growing Greener	2003	Villanova University	Project uses the Clean Water Fund to install storm water best management practices.	$39,300
Total Award for Darby-Cobbs (Years 1998 – 2003)					**$1,875,303**

Indicator 5: Fish

Fish are good indicators of stream health because their presence requires favorable environmental conditions within a certain range of stream flow, water temperature, water quality, and channel habitat. Abundance and diversity of fish are great indicators of water quality. Other indicators are the number of pollution tolerant fish and the proportion of fish with abnormalities. Dominance by a small number of pollution-tolerant species may indicate habitat and water quality degradation.

This indicator measures:

- **Abundance and pollution tolerance of species found at various sites**
- **Fish community integrity relative to reference condition at various sites**
- **Whether stream meets criteria for trout-stocking**

Where We Were:
There is no historical data available for this indicator. A trend will be established the next time this area is reassessed.

Where We Are:
During a 1999 Cobbs Creek assessment, fisheries data indicated that the fish community was numerically dense yet species poor. Figure 4-14 shows the percentage of pollution tolerant fish at each site. Both pollution tolerant and moderately pollution tolerant fish were found at each site. There was a range of diversity, with one site receiving a rating of good, two receiving a rating of moderate diversity, one a low diversity rating, and one a poor diversity rating (Figure 4-15). In all, 14 different species of fish were collected from in Cobbs Creek, West Indian Creek and Naylor's Run. (Figure 4-16).

Changes in trout stocking patterns have occurred over the last few years. The Cobbs Creek area has not been recently stocked with trout by the Philadelphia Fish and Boat Commission and does not meet quality criteria necessary to be stocked. During 2001-2003, Darby and Stony Creeks were stocked.

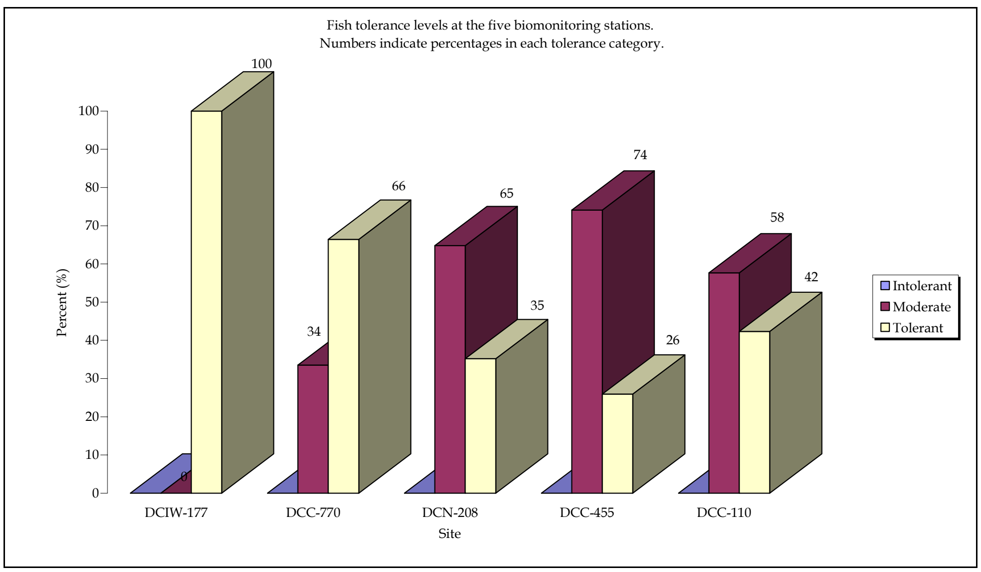


Figure 4-14 Fish Tolerance at Specific Monitoring Sites (1999)

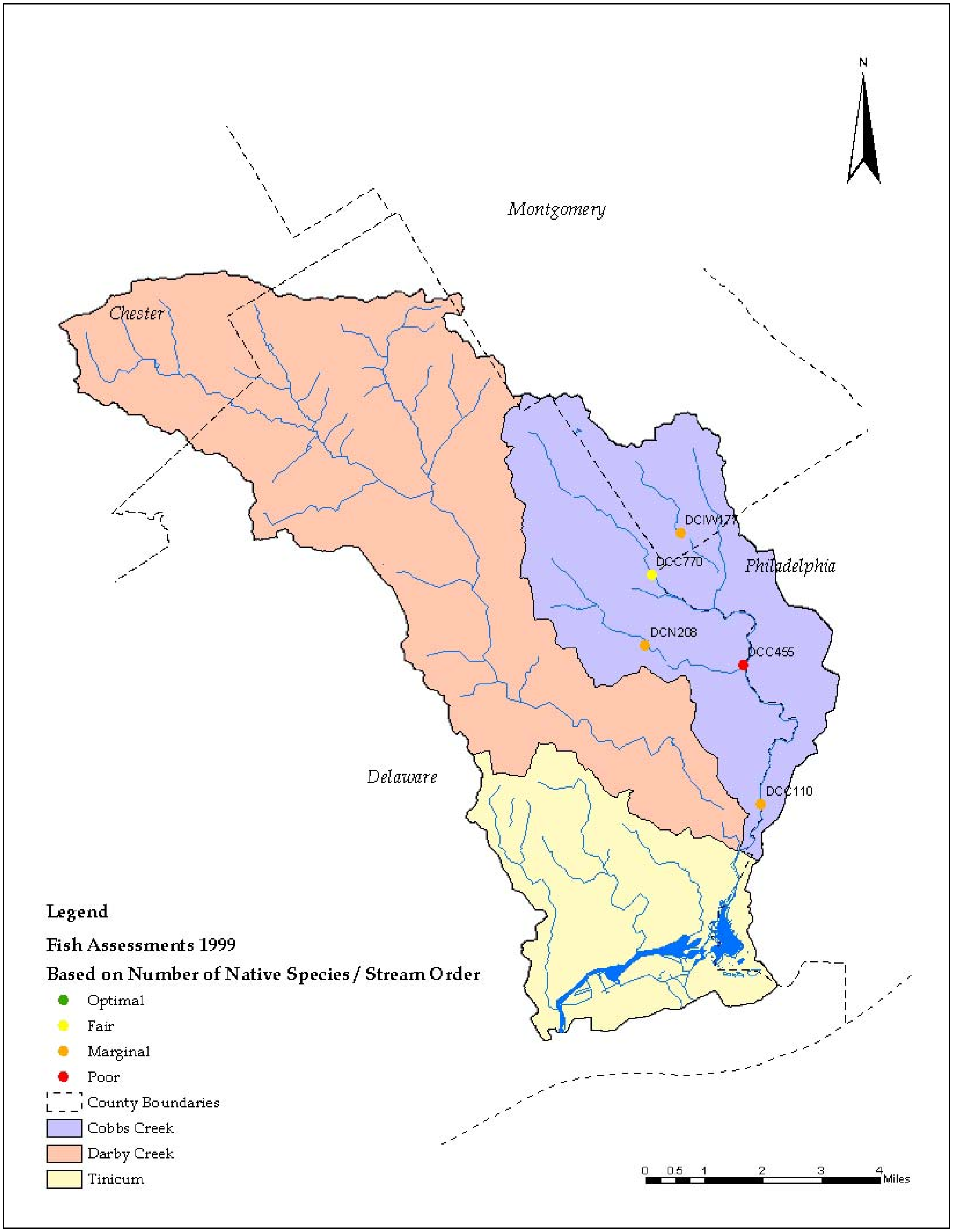


Figure 4-15 Cobbs Fish Assessment (Philadelphia Water Department, 1999)

Indicator 5: Fish

	1	2	3	4	5		
	Site #						
Species	**DCC-455**	**DCC-770**	**DCC-110**	**DCN-208**	**DCIW-177**	**Pollution Tolerance**	**Picture**
American Eel	R	R	R	R	N	M	
Banded Killifish	N	N	R	N	N	M	
Common Shiner	R	C	R	R	N	M	
Pumpkinseed	R	R	R	R	N	M	
Redbreast Sunfish	N	N	R	R	N	M	
Spottail Shiner	R	N	R	N	N	M	
Swallowtail Shiner	C	R	R	C	N	M	
Blacknose Dace	R	C	R	C	A	T	
Brown Bullhead	N	N	R	N	N	T	
Creek Chub	N	R	R	N	R	T	
Fathead Minnow	N	N	R	N	N	T	
Green Sunfish	N	N	N	R	N	T	
Mummichog	R	N	C	R	N	T	
White Sucker	R	R	R	N	R	T	

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Flow Conditions and Living Resources

Indicator 5: Fish

Species Abundance	Symbol	%
Abundant	A	60% -100%
Common	C	30% - 60%
Rare	R	0% - 30%
None	N	0
Pollution Tolerance	**Symbol**	
Moderate	M	
Tolerant	T	

Figure 4-16 Fish Types and Abundance

Indicator 6: Benthos

The community of organisms on the bottom of water bodies is a good indicator of long-term water quality and the overall health of an aquatic system. Benthic organisms play roles in the aquatic ecosystem similar to the ones terrestrial small plant and animal species play in land-based communities. Benthic communities respond to changes in the aquatic environment and often provide an indication of concerns or evidence of successful restoration projects. Shown in Figure 4-17 is the life cycle of a mayfly, one example of a benthic macroinvertebrate.

This indicator measures:

- **State designation of attained and unattained reaches**
- **Benthic community integrity relative to reference condition at various sites**

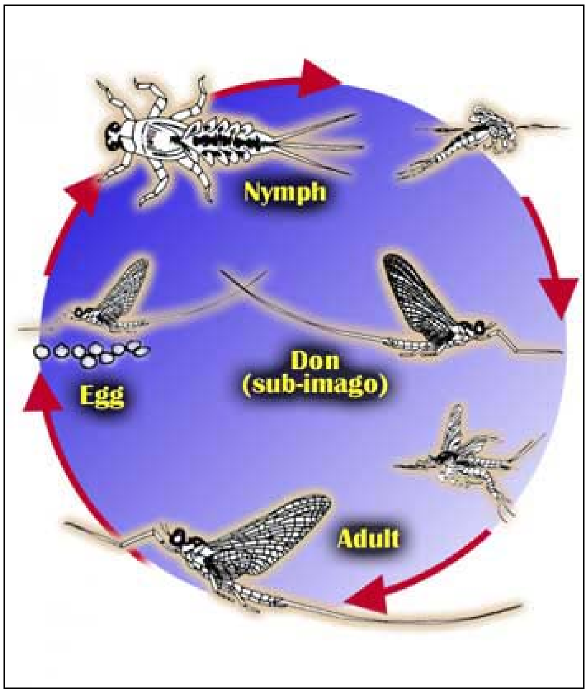


Figure 4-17 Life Cycle of a Mayfly

Where We Were:
There is no historical data available for this indicator. A trend will be established when this area is reassessed.

Where We Are:

PADEP classifies streams in the watershed as impaired, with the exception of upper Darby Creek. In Figure 4-18, the color green represents stream reaches that are not impaired and have attained designated water quality criteria; reaches in red are impaired and do not meet their designated criteria. Work by PWD biologists in the Cobbs portion (colored dots in Figure 4-18) confirm that benthic communities are moderately to severely impaired. According to the year 2004 proposed 303(d) list, sources of impairment are primarily habitat modification, municipal point sources, and urban runoff/storm sewers (PADEP, 2004). Impairment is caused by siltation, water/flow variability, habitat alterations, or other unknown causes in all cases. Much of the

Cobbs Creek impairment listing is based on assessment work in 2000, while Darby Creek was last assessed in 1996 or earlier.

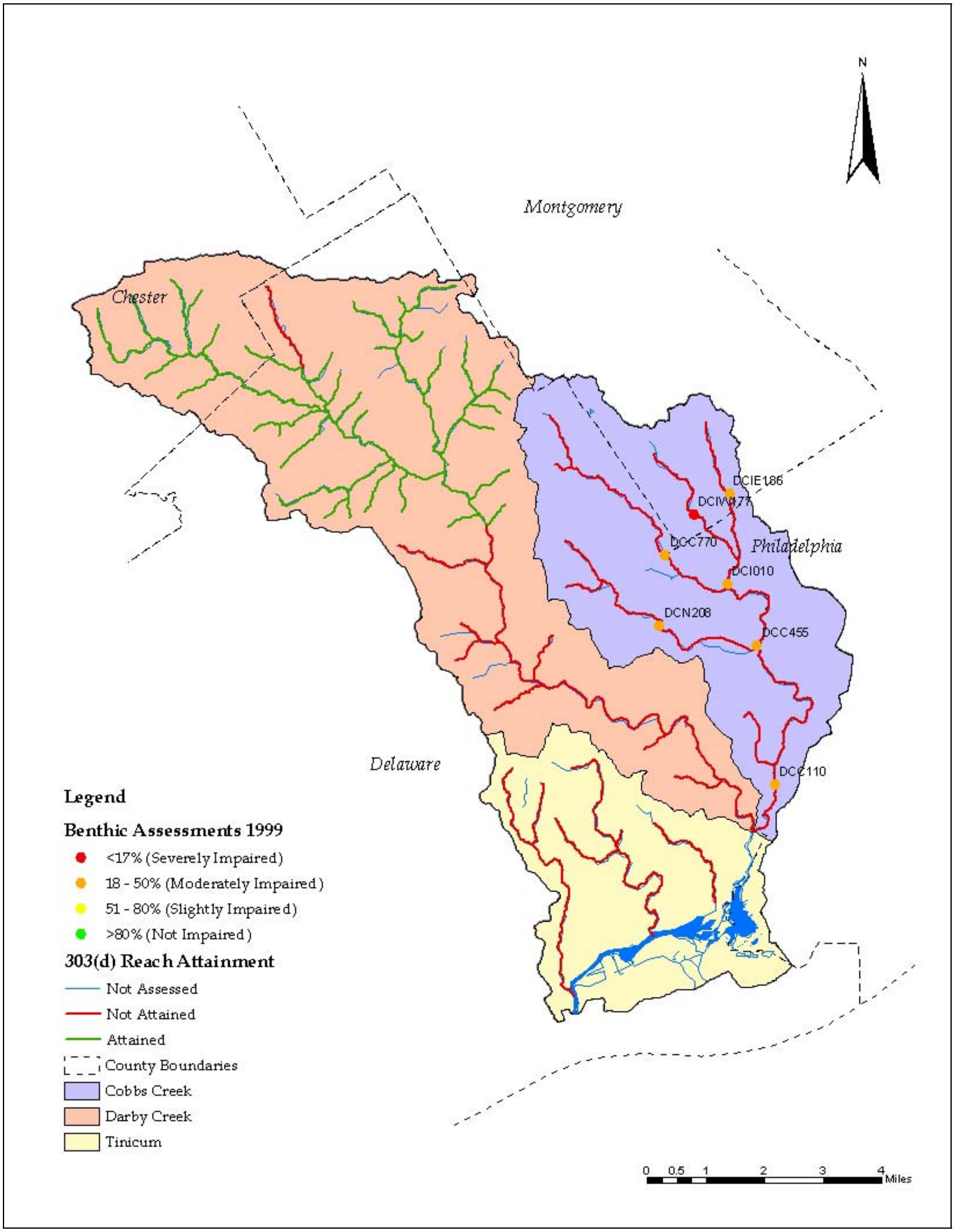


Figure 4-18 PWD Benthic Assessment Sites and State-Designated Impaired Reaches

Flow Conditions and Living Resources

Indicator 6: Benthos

During a 1999 bioassessment of the Darby and Cobbs Watershed, pollution tolerance levels of macroinvertebrate communities showed all sites were dominated by moderately pollution-tolerant or pollution-tolerant macroinvertebrates, with a minimal number of pollution-intolerant macroinvertebrates. Due to increased flow over riffle systems, where most benthic organisms are found, reproductive and feeding strategies have been affected.

Water Quality

Indicator 7: Effects on Public Health (Bacteria)

Fecal contamination of natural waters may originate from both human and animal sources and may pose a threat to human health. Surface runoff transports waste material from pets, livestock, and wildlife to surface waters. Wet weather sewer overflows (both SSOs and CSOs) introduce domestic wastewater constituents to surface water. Illegal or accidental connection of sanitary sewers to storm sewers may also result in discharges of raw wastewater. Municipal wastewater treatment plants and septic systems release some bacteria to surface waters, but these inputs are generally small.

Fecal coliform bacteria are consistently very abundant in the intestines of warm blooded animals, including humans. Presence of fecal coliform bacteria is a fairly reliable indicator of fecal contamination of natural water, drinking water, and wastewater. Historically those bacteria have been used to indicate the possibility that other pathogens (e.g., bacteria, viruses, protozoa, etc.) may also be present. Measures taken to reduce the input of fecal coliform to natural waters are likely to reduce the input of other potential pathogens found in sewage and surface runoff.

Pennsylvania's water quality standard for fecal coliform bacteria in waters of the Commonwealth is as follows: during the swimming season (May 1 through September 30), the maximum fecal coliform concentration shall be a geometric mean of 200 CFU per 100 mL based on five consecutive samples each sample collected on different days; for the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2000 CFU per 100 mL based on five consecutive samples collected on different days.

This indicator measures:

- **Percent of fecal coliform samples meeting state standards at various sites**

Where We Were:
Approximately 100 surface water samples were tested for fecal coliform between 1970 and 1990 at a variety of sites. For samples taken in the headwaters of the system, approximately one-third to one-half met the current standard. At Cobbs Creek just above the confluence with Darby Creek, less than 10% of samples met the current standard.

Where We Are:
Samples were collected in 1999 and 2000 at several sites in the watershed (Figure 4-20). All these samples were taken in the summer months, when the strictest standard is in effect. In general, 0-20% of dry weather samples met the standard, and at most sites none of the wet weather samples met the standard. At Cobbs Creek site DCC-110, just above the confluence with Darby Creek, dry weather conditions seem to have improved over time; 25% of dry weather samples met the standard in 1999-2000 as compared to 4% in the 1970's. Overall, in the watershed, concentrations of fecal coliform bacteria seem to have remained about the same or increased slightly over time.

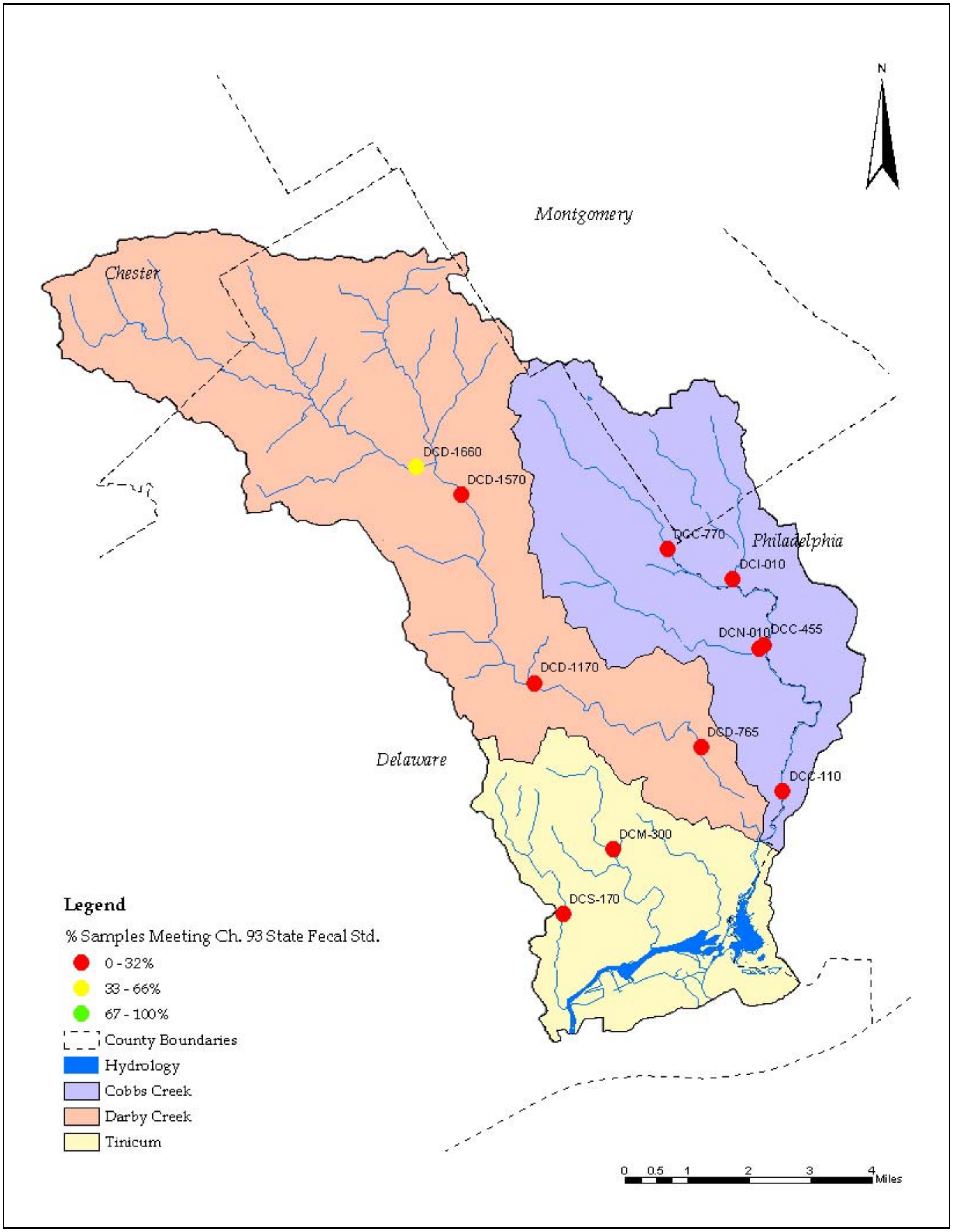


Figure 4-19 Water Quality Data for Fecal Coliform (1999)

Indicator 8: Effects on Public Health (Metals and Fish Consumption)

Toxic substances, including metals such as lead and organic substances such as PCBs, are sometimes introduced into the aquatic environment as a result of human activity. These substances exist in some sediments as a result of historical discharges, are introduced to the atmosphere through burning of fossil fuels, and are deposited on land surfaces through industrial and transportation activities. Precipitation and surface runoff introduce small concentrations of these substances to surface waters. Relatively small amounts of certain toxic substances can kill aquatic life through acute poisoning. Chronic exposure to toxins may be harmful at even smaller concentrations. Over time, fish may accumulate toxins from the water they live in and the food they eat. In some cases toxins may be present in harmful concentrations in their tissues.

Because toxic substances in the environment can affect aquatic life and humans who consume fish, PADEP has established maximum concentrations that are allowable in the water column. Standards based on aquatic life protection are generally much stricter than standards based on human health. In addition, Pennsylvania DEP samples fish tissue and issues fish advisories designed to warn the public as to what species may contain toxic chemicals. These contaminants can build up in the human body over time, possibly leading to health risks.

This indicator measures:

- **Percent of Cd, Cr, Cu, Pb, and Zn samples meeting state standards at various sites**
- **Areas with fish consumption advisories**

Where We Were:
Historical information on concentrations of toxins in fish tissue is not readily available. Information on concentrations of some metals was collected in the 1970's, and this can be compared to current water quality standards. Approximately 50 samples were collected at several sites between 1970 and 1980 for cadmium, lead, chromium, copper, and zinc together. Concentrations were generally low in the headwaters of the system but frequently exceeded standards in the downstream portions, especially during wet weather. Approximately 85-90% of dry weather samples and 75-80% of wet weather samples taken in the headwaters of the system met standards intended to protect aquatic life. At Cobbs Creek just above the confluence with Darby Creek, about 75% of dry weather and 60% of wet weather samples met standards.

Where We Are:
Comparing estimated historical loading rates data from the 1970's with data collected in 1999, the estimated loads for metals for the 1999 period are lower, with two exceptions. The loading rate for nitrate increased and the estimated upstream cadmium load is slightly higher.

Fish advisories are most often due to metals or organic chemicals. The April 2001 fish advisory for this watershed advises to limit consumption of white perch, striped bass, and carp to one meal a month, and to limit consumption of channel catfish to one meal every two months. American eel should not be eaten at all. This is all due to PCB pollution.

The number of permitted discharges in the watershed appears to have decreased over recent decades, but there are some indications of residual contamination due to past industrial activity. A search of US EPA's BASINS database identified 12 permitted industrial and municipal dischargers that have been active at some time in the last few decades. However, only 7 of these permits are currently active, indicating that five sources have become inactive since records were first kept. However, the lower portion of the Darby Creek watershed has recently been listed as a Superfund site, indicating the potential for introduction of toxic chemicals.

In 2000, between 50 and 100 samples were collected at each site for cadmium, lead, chromium, copper, and zinc together (Figure 4-20). The data indicate that standards intended to protect aquatic life are still sometimes exceeded. The data also shows that the situation has improved at all sites when compared to the 1970's. For most sites, 90-100% of samples meet the standards. At Cobbs Creek just above the confluence with Darby Creek, 93% of dry weather and 72% of wet weather samples meet the standard.

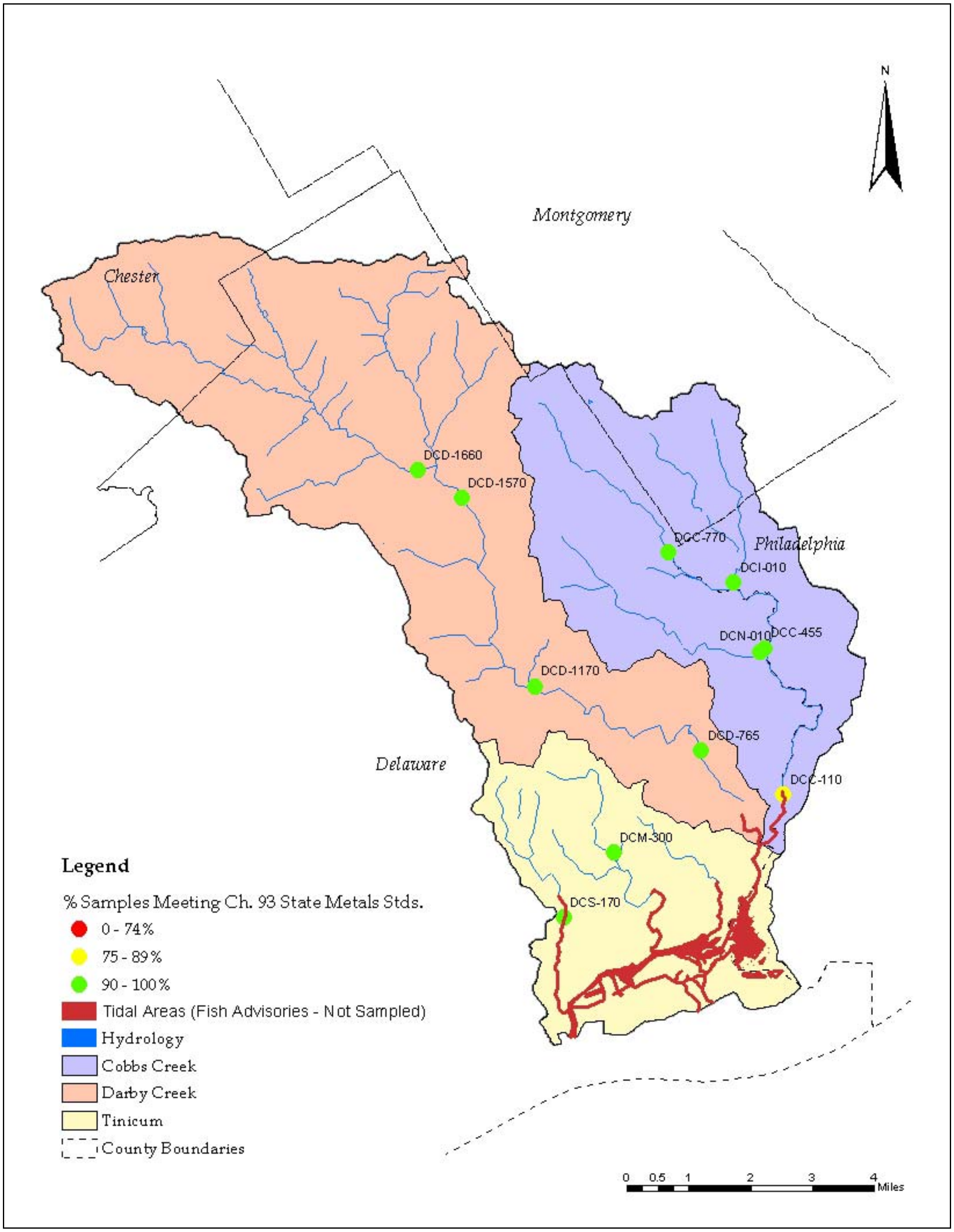


Figure 4-20 Water Quality Data for Metals (1999)

Indicator 9: Effects on Aquatic Life (Dissolved Oxygen)

Just as humans require oxygen gas for respiration, most aquatic organisms require dissolved oxygen (DO) in order to perform vital functions. Oxygen dissolves in water through air-water interaction at the surface of the flow and through photosynthesis of plants and algae. At the same time, DO is depleted through the respiration of microorganisms, animals, plants, and algae. In a healthy system, the balance between oxygen-depleting and oxygen-providing processes maintains DO at a level that allows aquatic organisms to survive and flourish. In a less healthy system, dissolved oxygen may be depleted below levels needed by aquatic organisms. The minimum dissolved oxygen concentration required by many common fish species found in rivers and streams is approximately 5 mg/L. PA DEP has set a water quality standard, or minimum allowable concentration, of 5 mg/L as a daily average and 4 mg/L as an instantaneous value for Cobbs Creek. Criteria in portions of Darby Creek are stricter to accommodate trout.

This indicator measures:

- **Percent of DO samples meeting state standards at various sites**

Where We Were:

Approximately 100 samples of DO were taken between 1970 and 1990. For all sites except one, DO was never less than 5 mg/L. On Cobbs Creek just above the confluence with Darby Creek, site DCC-110, low-DO conditions appear to have been common. Measurements were less than the standard approximately 20% of the time in dry weather and 10% in wet weather. These conditions may have been related to more frequent dry and wet weather sewer overflows. The low-DO conditions probably had an adverse impact on aquatic life.

In an aquatic biological investigation performed in 1995-1996, the overall water quality in Darby Creek was determined to be good. Iron, aluminum, total suspended solids, and fecal coliform were occasionally above the limit, but not at levels harmful to aquatic life. Some samples taken from Cobbs Creek showed low dissolved oxygen and elevated levels of ammonia, phosphorus, iron, lead and manganese. In the areas where fish quality was reported, the quality ranged from fair to good.

Where We Are:

Both discrete and continuous samples were collected between 1999 and 2003. Discrete samples produce a single DO value at the time the sample is taken. Continuous monitoring is preferred, as it records data from early morning, when DO is typically lowest due to respiration. Discrete samples suggest that dissolved oxygen is rarely below the instantaneous minimum allowable concentration standard under dry or wet conditions. Two sampling sites recorded concentrations below the standard of 4 mg/L. At DCD1660, in the headwaters of Darby Creek, 1 discrete sample out of 5 total indicated DO below 4 mg/L under wet weather conditions; continuous samples did not indicate any low DO values. At site DCC110, just above the confluence of Cobbs and Darby Creeks (Figure 4-21), 1 of 9 dry weather samples and 6 of 24 wet weather samples did not meet the 4 mg/L standard. This site is just below the Woodland Avenue dam and is most likely affected by poorly mixed water just above the dam.

Continuous DO data have been collected over approximately 10,000 hours between 1999 and 2003. Between 1999 and 2002, DO measurements were observed to be below the state criteria only at sites DCC110 and DCC115, just below and above the dam, respectively. At DCC-115, 19% of observations were less than 5 mg/L and 5% were less than 4 mg/L. At DCC110, 5% of samples were less than 5 mg/L and less than 1% were below 4 mg/L. The most recent data, collected in August-September 2003, show similar trends. DO reaches a minimum of 3-4 mg/L during wet weather at DCC110. The dry weather diurnal range, or difference between maximum and minimum DO concentration over the 24-hour cycle, varies from 1-2 mg/L at upstream sites to as high as 8-9 mg/L at DCC110. This difference suggests a high level of algal activity in the pool behind the dam. Figure 4-22 displays the trends mentioned above: an increase in diurnal amplitude as biological activity increases in dry weather, and a drop in DO as low-DO water is flushed over the dam in wet weather. A possible explanation is that upstream inputs of nutrients from sewage and stormwater sources lead to increased biological activity in the slow-flowing conditions found at sites DCC110 and DCC115.

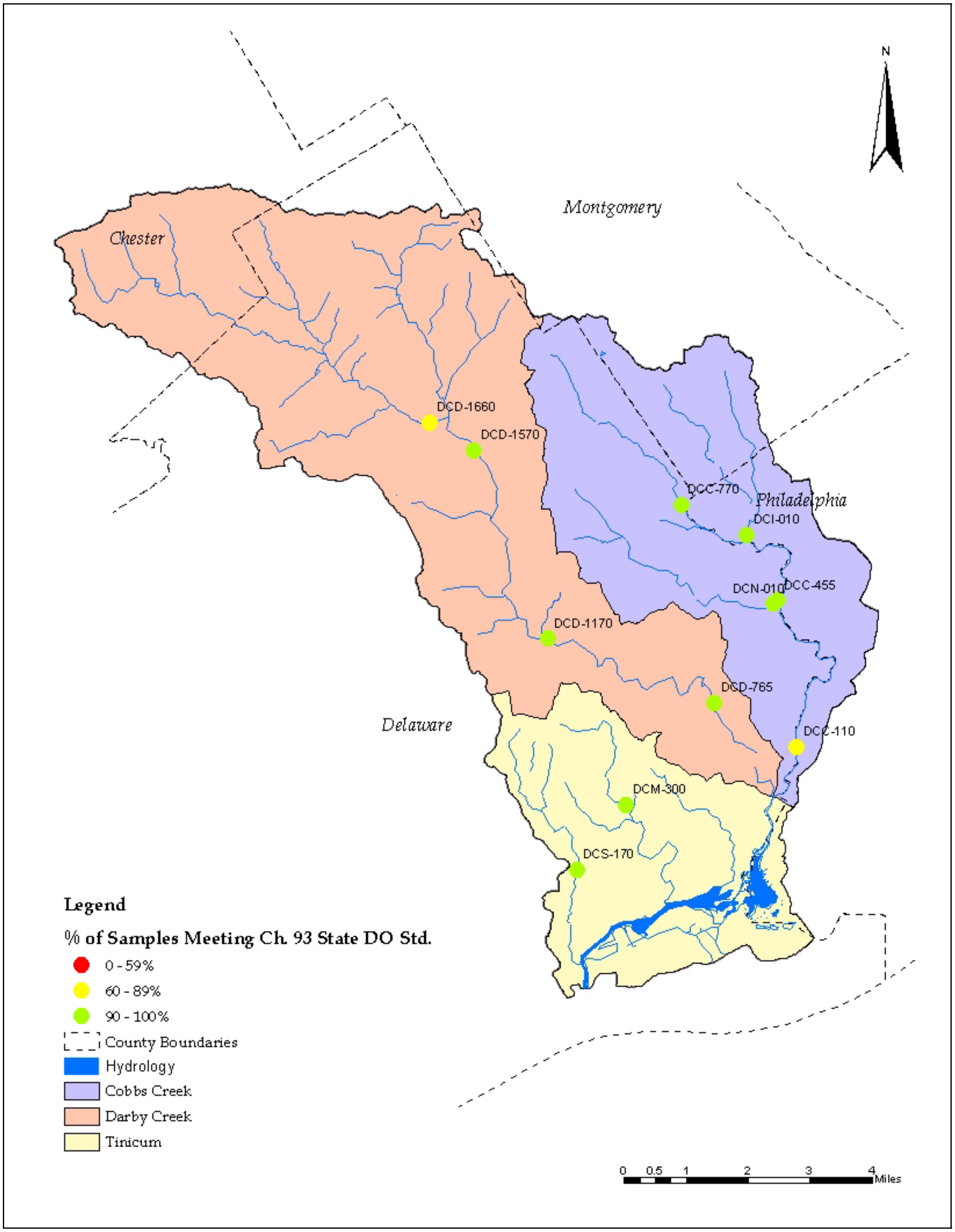


Figure 4-21 Water Quality Data for Dissolved Oxygen

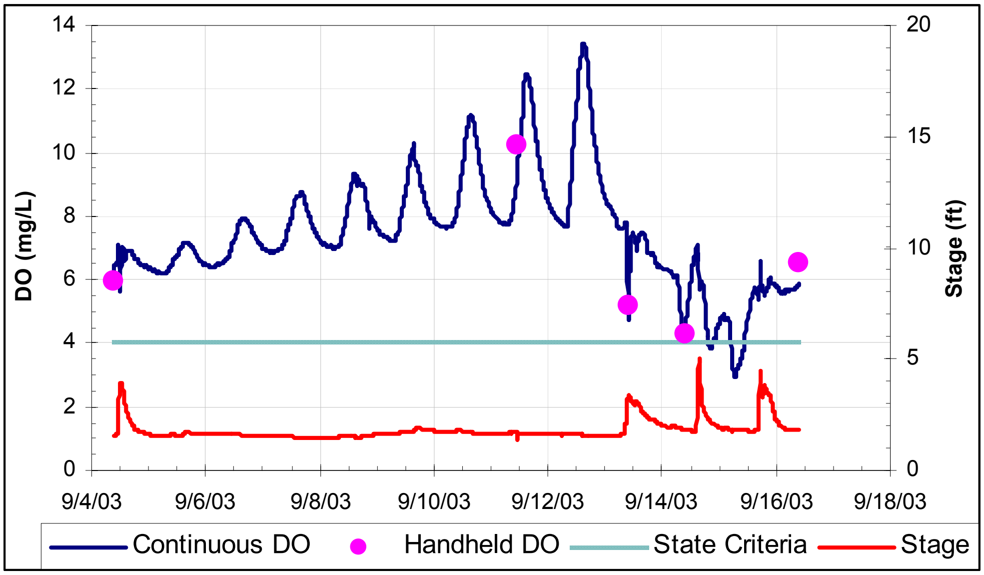


Figure 4-22 Stage and Dissolved Oxygen at DCC110 in September 2003

Pollutants and Their Sources
Indicator 10: Point Sources

A point source is any point where discharged water and pollutants can enter a water body, such as a pipe, channel, or ditch (Figures 4-23 through 4-25). Point source discharges that could include treated municipal wastewater, combined sewer overflows (CSO), separate sanitary overflows (SSOs), industrial process water, municipal separate storm sewer system (MS4) discharges, and/or cooling waters. Point sources are regulated under the Clean Water Act by the National Pollutant Discharge Elimination System (NPDES).

Figure 4-23 Stormwater Outfall

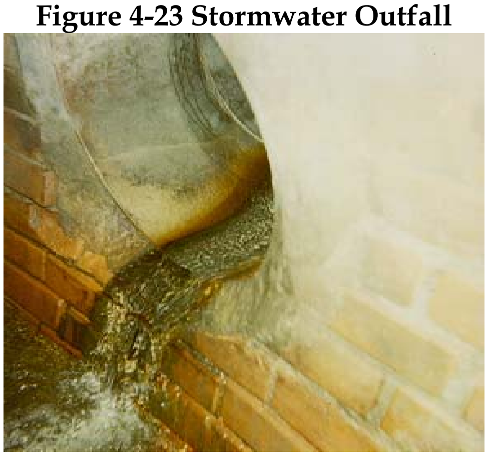


Figure 4-24 CSO Outfall

Figure 4-25 Municipal Wastewater Treatment Plant

A **municipal separate storm sewer system (MS4)** collects stormwater runoff from the land surface and discharges it directly to a receiving stream.

Combined sewer systems use one pipe to convey sanitary sewage and stormwater runoff to a combined sewage regulator chamber. The regulator captures all of the sanitary sewage in dry weather, and some of the combined sewage in wet weather, sending it to a wastewater treatment plant. The balance of wet weather flow is discharged to an area water body through a CSO outfall.

Sanitary Sewer Overflows (SSOs) occur when a municipal separate sanitary sewer system becomes overcharged in wet weather and overflows unintentionally to an area water body.

Municipal Wastewater Treatment Plants are facilities that process municipal sanitary waste and industrial and commercial discharges to the sewer system. These facilities treat the waste stream and discharge it to a local stream.

Industrial processes use water in manufacturing, power generation, or other activities to produce a product. By-products from the process can be discharged to area waterways with varying levels of treatment.

This indicator measures:
- **Number of permitted industrial and municipal point sources**
- **Estimated annual percent capture of combined sewage**
- **Estimated pollutant contributions of industrial/municipal, CSO, and stormwater sources**

Where We Were:
Point source discharges from treatment plants and industrial facilities were a priority for increased control during the 1970s and 1980s as secondary wastewater treatment requirements and industrial pre-treatment regulations were imposed. Historical data indicate that there were 35 facilities in the watershed with National Pollutant Discharge Elimination System (NPDES) Permits.

Historical SSO and CSO discharges are not well documented, and there is only limited current data on SSOs. However, it can be inferred from water quality data that dry weather sewage discharges were much more common in the past (see Indicator 8). It is reasonable to conclude that the frequency and volume of CSO discharges in the Philadelphia portion of the Cobbs watershed have decreased over the past 20 years due to improved sewer maintenance and CSO control measures. These measures are discussed in detail later in this section.

Where We Are:

Active Industrial and Municipal Point Source Dischargers
There are believed to be 8 active industrial point source dischargers in the Darby-Cobbs Watershed. Current facilities with NPDES permits to discharge into the watershed are believed to be Sun Oil Company, SEPTA Victory Terminal, Meenan Oil Company, Mobil Oil Company, Boeing Defense and Space Group, Tinicum Township Sewerage Authority, and Township of Haverford Public Works Landfill. Several of the facilities that were once listed as active dischargers have since been eliminated. Kistler Fredrick, 2 Sunoco Service Stations, and Mobil Oil Corporation are no longer active dischargers. Wastewater treatment plants that once discharged in the watershed no longer do so, such as Township of Haverford public.

Estimated Annual Percent Capture of Combined Sewage
Portions of Philadelphia County, including 20% of the Cobbs Creek watershed, are serviced by combined sewers. The City of Philadelphia has 38 regulator structures within the watershed, as shown in Figure 4-26. Since the 1980s, PWD has made significant progress in reducing CSO discharges to Cobbs Creek. As required under EPA's CSO Control Policy, PWD has developed and implemented a CSO Long-Term Control Plan (LTCP) to improve and preserve the water environment in the Philadelphia area. Table 4-6 lists estimated capture percentages for regulator structures in the Cobbs Creek watershed, based on the modeling results listed in PWD's CSO Annual Reports.

Capture percentage is defined as the percentage of combined sewage (mixed sanitary sewage and stormwater) that is sent to a treatment plant during rainfall events over the course of a year. 85% capture is considered to be an ultimate goal for many communities as they implement CSO long term control plans. It is important to note that percent capture for a given year is strongly dependent on the frequency and magnitude of rainfall events during that year. The seven years of data listed in Table 4-6 are not sufficient to determine whether an increasing or decreasing trend has taken place. However, as the amount of data increases throughout implementation of the Long Term Control Plan, it will ultimately be possible to evaluate the effectiveness of control measures.

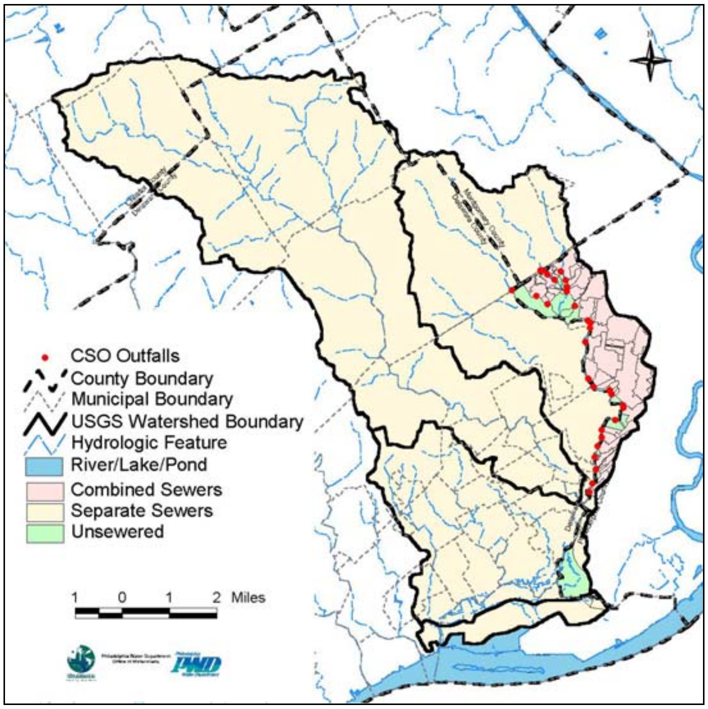


Figure 4-26 Types of Sewer Service and Locations of Regulator Structures

Table 4-6 Estimated Annual Combined Sewage Capture Percentages

Year	Precipitation (in)	Capture (%) – Lowest and Highest Structure	
		Cobbs Creek High Level	Cobbs Creek Low Level
2001	31.1	61 – 62	84 – 85
2000	43.2	51 – 52	74 – 75
1999	48.6	49 – 50	73 – 74
1998	30.7	65 - 67	87 - 88
1997	32.0	59 – 63	88 – 92

Model-Estimated Pollutant Contributions of Different Sources

Estimated annual pollutant contributions for the Darby and Cobbs watersheds are shown in Figure 4-27. For both systems, stormwater outfalls are the largest source of pollutants associated with urban and suburban runoff, including nutrients such as phosphorus and metals such as lead. For the Cobbs Creek watershed, CSO is a smaller but significant source of these constituents. CSO discharges are the dominant source of fecal coliform in the Cobbs watershed. Permitted industrial and municipal point source discharges make up less than 2% of annual streamflow in both systems. SSOs are thought to occur in both watersheds but have not been well documented to date.

Darby-Cobbs Watershed Status Report 2003

Pollutants and Their Sources

Indicator 10: Point Sources

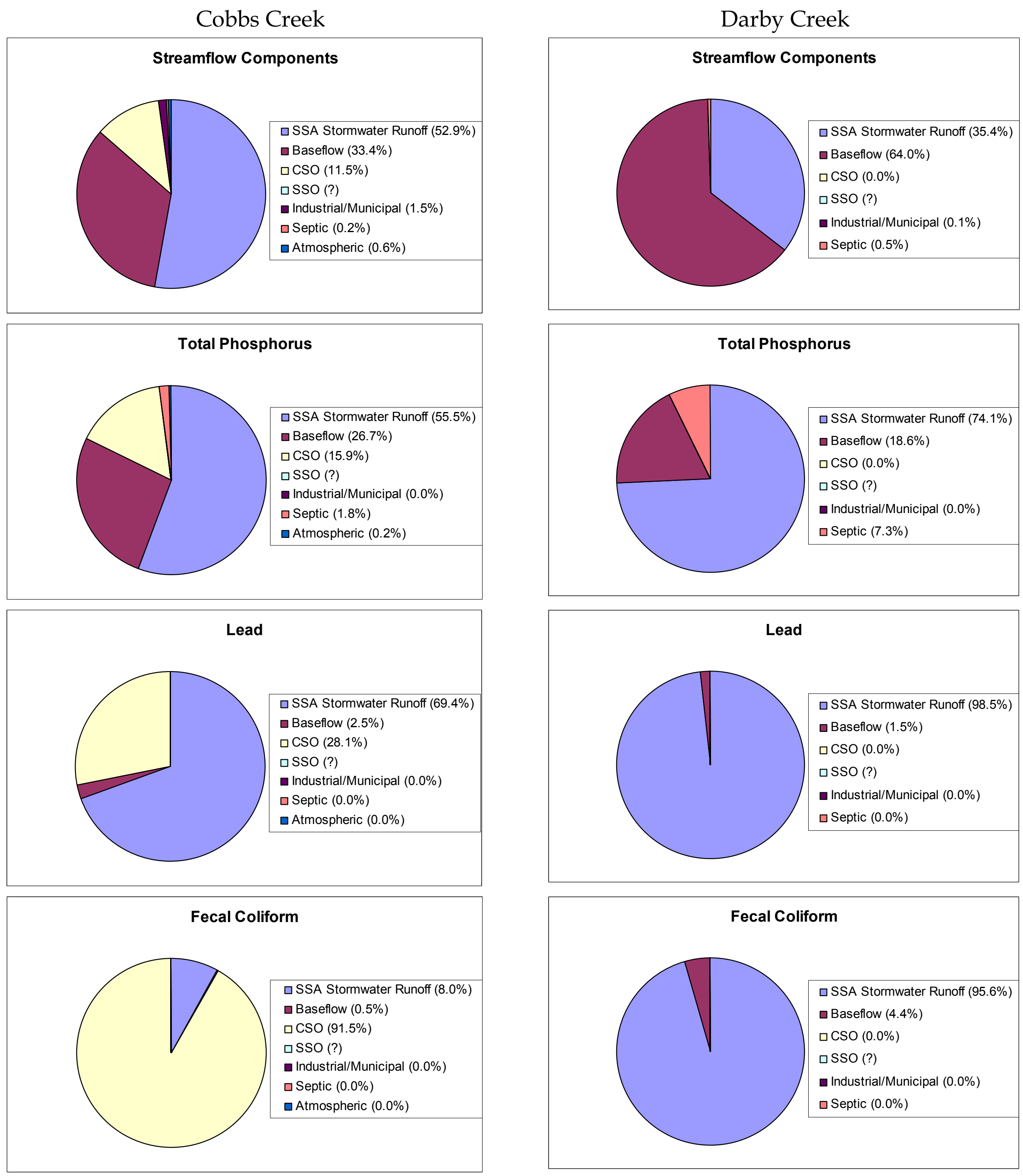
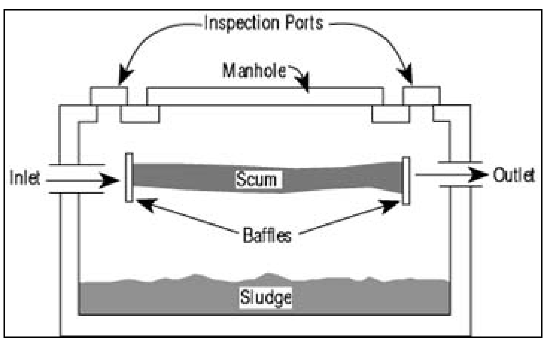


Figure 4-27 Estimated Annual Proportional Contribution of Pollutant Source (Watershed Pollutant Loading Model)

Indicator 11: Nonpoint Sources

Nonpoint source pollution is any source of water contamination not associated with a distinct discharge point. This type of pollution is a leading cause of water quality degradation in the United States. Nonpoint sources include atmospheric deposition, stormwater runoff from pasture and crop land, and individual on-lot domestic sewage systems discharging through shallow groundwater. Stormwater from urban and suburban areas is considered a point source for regulatory purposes because it is collected in a pipe system and discharged at a single point.

Figure 4-28 Pasture Land



Source: Ohio State University Extension
Figure 4-29 Septic System

Agricultural activity is a major source of nonpoint source pollution in many areas. Animal manure and fertilizers applied to crops may lead to pollutant inputs to surface water and groundwater.

A properly sited and maintained **septic system** should not result in excessive inputs of nutrients to groundwater. However, failing septic systems are common and can result in nutrient inputs to shallow groundwater and ultimately to stream baseflow.

Background concentrations of some water quality constituents are present in groundwater and may be transferred to stream baseflow. Some constituents may be introduced through agricultural activity or failing septic systems, while others may be present as a result of local geology.

This indicator measures:

- **Model-estimated percent of total pollutant loads contributed by septic tanks**
- **Evidence that sanitary sewers are leaking during dry weather, or are in direct contact with the stream**

Where We Were:
Since most point sources were addressed in the 1970s and 1980s, regulatory agencies have been turning attention towards controlling nonpoint sources of pollution. Many of these sources began to be addressed only during the 1990s.

Where We Are:
Nonpoint sources in the Darby-Cobbs Creek watershed include atmospheric deposition, stormwater runoff from a very small amount of agricultural land, background concentrations in groundwater, and individual on-lot disposal systems (OLDS) discharging through shallow groundwater. The number of septic tanks within the watershed is hard to accurately quantify; 1990 census data indicated that about 2000 septic tanks were present in the watershed; this number is believed to be a high estimate of the actual number. Based on modeling estimates (Figure 4-30), septic tanks contribute up to 2% of total nitrogen and phosphorus loads. Atmospheric loads to wetlands and open water were estimated only for the Cobbs Creek system and were less than 1%. Background groundwater concentrations of total nitrogen were the largest source of that constituent in streamflow (60-70% of the estimated annual load). Dry weather contributions from leaking sanitary sewers could not be estimated based on current data, however, evidence that leaking is occurring is presented below.

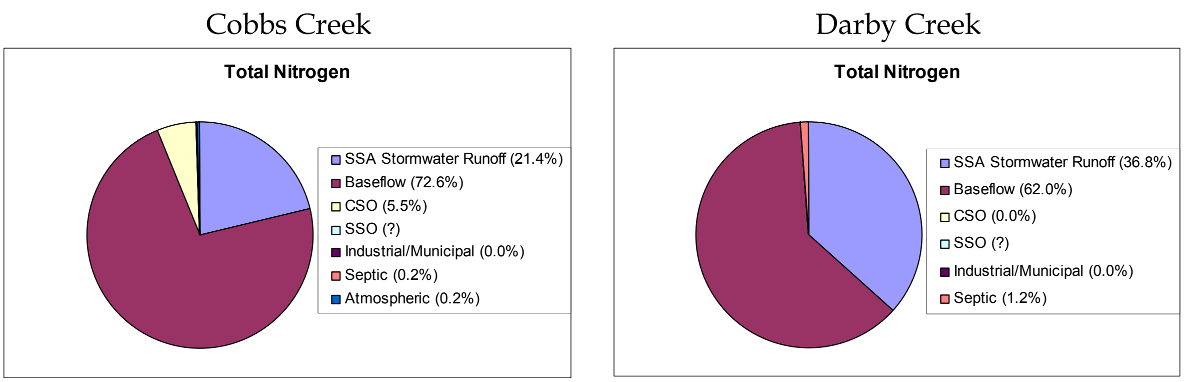


Figure 4-30 Estimated Nutrient Inputs from Septic Tanks

Stream Corridor
Indicator 12: Riparian Corridor

The riparian areas buffering streams, rivers, lakes, and other water bodies are especially sensitive watershed zones. In their naturally vegetated and undisturbed state, floodplains and riparian areas provide stormwater management and flood control functions, both in terms of water quantity and water quality. An example of floodplain and riparian zone conservation and protection is Cobbs Creek Park (Figure 4-31). Philadelphia had the foresight years ago to establish greenways along Cobbs Creek and its tributaries, both for conservation and recreational purposes. With the exception of Heinz National Wildlife Refuge, Cobbs Creek Park and related facilities constitute the most significant conservation and recreation zone in the Watershed.

This indicator measures:

- **Miles of stream with a minimum buffer of 50 feet and 50 percent canopy cover**

Figure 4-31 Riparian Corridor in Cobbs Creek Park

Where We Were:
There is no historical data available for this indicator. A trend will be established the next time this area is reassessed.

Where We Are:
The areas adjacent to the creeks in Fairmount Park have been used as picnic and recreational areas, leading to alteration of natural vegetation. This invasive plant has a shallow root mass that does not affectively anchor the soil. Stream banks that are disturbed or dominated by invasive plants may be more vulnerable to erosion during storms. These disturbed areas are very susceptible to colonization by invasive plants, especially Japanese knotweed. The areas in Fairmount Park are superior in quality compared to most of the areas in the watershed. Many other areas in the watershed have completely lost their riparian buffers.

Buffers along stream corridors can be an important factor in enhancing stream habitat and preventing erosion. In 2002, the Heritage Conservancy was funded to develop a rapid assessment method to identify and map sections of stream lacking riparian forest buffers. The conservancy then assessed watersheds in southeastern Pennsylvania and mapped waterways lacking riparian forest buffers. Interpretation of 1" = 200' black-and-white high altitude aerial photographs and videotape from helicopter overflights were used to determine the presence or absence of a forested buffer for 975 miles of stream. For this analysis, a stream bank was classified as having a forested buffer if it was determined to have a 50 foot wide buffer of trees and 50 percent canopy cover. Each stream bank was analyzed independently. Table 4-7 shows that there are about 30 miles of stream within the watershed that are lacking forested riparian buffers on one or both banks.

Table 4-7 Lack of Riparian Forested Buffer

Riparian Buffer	Length (Stream Miles)
Buffer Lacking on One Bank	15.8
Buffer Lacking on Both Banks	13.7

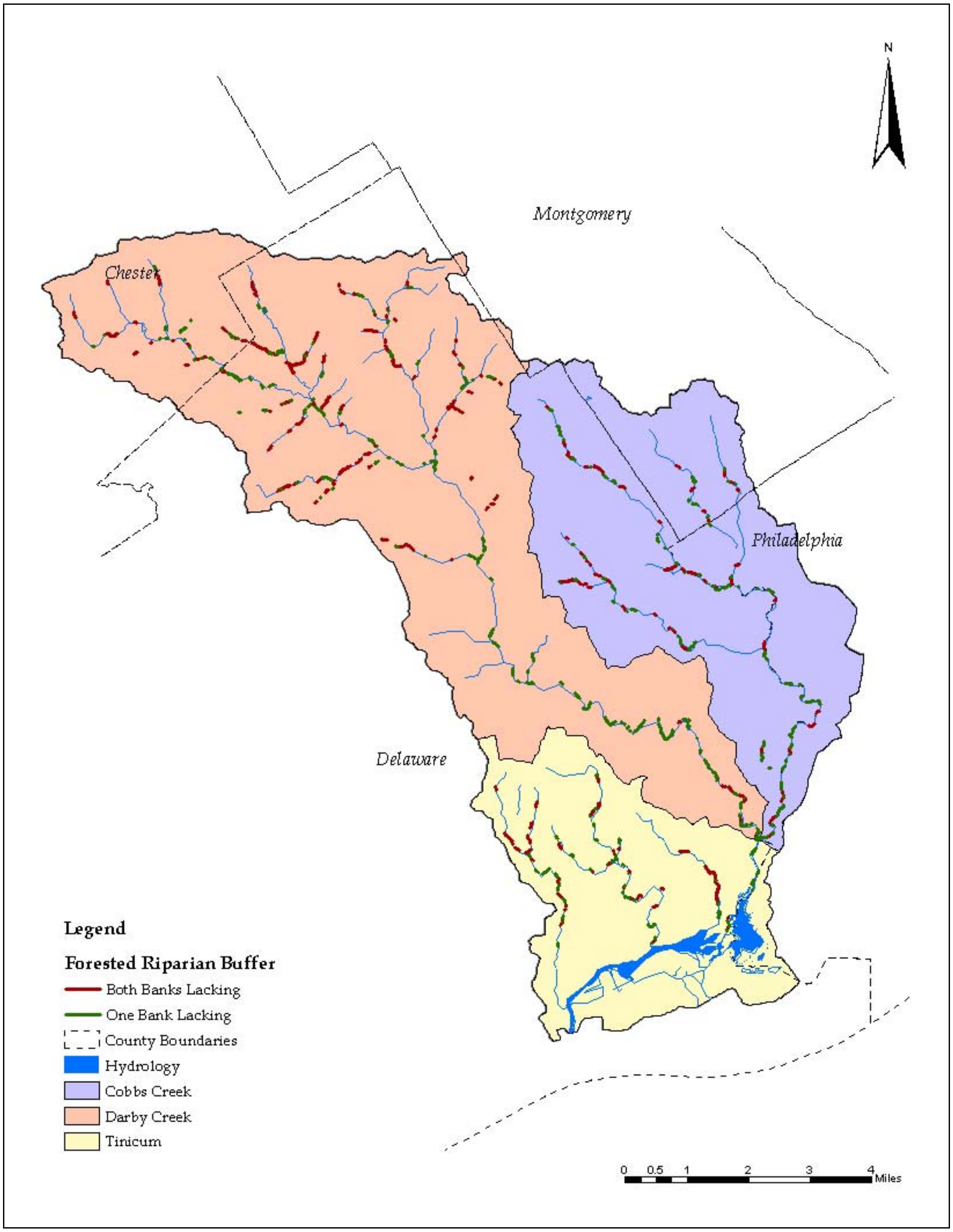


Figure 4-32 The Heritage Conservancy's Forested Riparian Buffer Analysis (2002)

Indicator 13: Wetlands and Riparian Woodlands

Wetlands and riparian woodlands are important natural filters for pollutants in stormwater. Wetlands and woodlands increase vegetation diversity, providing feeding and nesting habitat for birds and animals. They are important in preventing slope erosion and mitigating flood peaks by controlling runoff, and they allow for natural infiltration of rainfall and groundwater recharge.

The most significant functions that wetlands perform are:

- Wildlife Habitat
- Fish Habitat
- Water Quality Improvement (nutrient and toxicant reduction)
- Hydrologic (flood flow) modification
- Groundwater recharge

The location and size of a wetland may determine what functions it will perform. For example, the geographic location may determine its habitat functions, and the location of a wetland within a watershed may determine its hydrologic or water-quality functions. Many factors determine how well a wetland will perform these functions; such as climatic conditions, quantity and quality of water entering the wetland, and disturbances or alteration within the wetland or the surrounding ecosystem. Wetlands of the Cobbs Creek watershed were evaluated for the first four of the functions noted above, and were further studied to understand their sensitivity to future disturbance and their potential for enhancement and improvement, where they may have experienced degradation.

This indicator measures:

- **Acres of wetland in the watershed**
- **Area of riparian buffer along waterways**
- **The quality of the wetlands**
- **The ability of the wetland and woodlands to improve water quality**

Figure 4-33 Example of a Wetland Area

Where We Were:

There is little data available about the historical presence of wetlands and riparian woodlands in the watershed. The Fairmount Park Commission's Natural Lands and Restoration and Environmental Education Program (NLREEP) compiled some information regarding historic wetlands in their 1999 Natural Lands Restoration Master Plan. NLREEP reported that Philadelphia had an abundance of wetlands along the Delaware and Schuylkill Rivers in pre-colonial times. These included a variety of intertidal channels, marshes and mudflats, and gravel bars. Much of the south and southwestern parts of the city, including what is now FDR Park, were a mix of tidal channels and marshes. Nontidal wetlands were present inland from the tidal marshes and along streams (NLREEP,1999).

Urban and suburban development has resulted in the piping of historic streams, destruction of wetlands, and deforestation and modification of historic floodplains. Stormwater is piped directly to waterways rather than flowing overland through vegetation, wetlands, and woodlands. Also, because stormwater runoff frequently flows over impervious surfaces, and is then piped to the streams, the flow and volume of runoff is intensified. Stream channels of the Cobbs Creek watershed exhibit many effects of urbanization: degradation of the stream channel (including overwidening), erosion, loss of sinuosity, loss of the floodplain, stream connection, and loss/degradation of aquatic habitat. Because most stormwater is piped directly to the waterways of the Cobbs watershed, there is no longer a source of water to maintain many of the wetlands that once existed.

In a geomorphologic study of Cobbs Creek conducted in 2002, the creek was divided into 63 stream segments for analysis. Results suggest that increases in stormwater runoff intensity have widened the waterway channel, and reduced its depth. Stability of the streambed was evaluated, and 26 stream segments were observed to experience continuing streambed deterioration. In many reaches, the stream channel now occupies much of the land that once functioned as floodplain and wetland, reducing the presence of wetlands and riparian woodlands.

Finally, extensive development in the Cobbs Creek watershed has resulted in conversion of natural riparian lands to residential and active recreational land use. Primary land uses in the watershed, for the most part, preclude the existence of natural vegetated areas, due to the high density of development. For example, 25%of the residential land uses are row or multi-family homes, which typically have relatively little vegetated open area to control and improve stormwater runoff.

In summary, the number and combined areas of wetlands and riparian woodlands in the Cobbs Creek watershed have fallen over time as a result of development close to the stream edges and changes to the floodplain from concentrated stormwater flows.

Indicator 13: Wetlands and Riparian Woodlands

Where We Are:
Wetland information presented here for the Darby and Tinicum subwatersheds is based on limited information found in the National Wetlands Inventory; information presented for the Cobbs is based on a much more detailed study conducted by the Philadelphia Water Department. As shown in Figure 4-34 and Table 4-8, small, scattered wetlands are present throughout the riparian areas of Darby Creek and its tributaries. Cobbs Creek has far fewer riparian wetland areas. A large wetland system is present in the Tinicum subwatershed. Wetland communities of native vegetation are scarce in the Fairmount Park system.

Based on land use data, approximately 10% of the Darby-Cobbs watershed land area may be considered woodland. However, the greatest proportion of woodland occurs in the Darby subwatershed, although forested areas in the Cobbs watershed are more contiguous due to Cobbs Creek Park lands. There are large areas of woodland found in the park, though they are more extensive in the northern portion. In areas where trash dumping and encroachment of recreational activities occur, wooded areas have become fragmented, creating open habitat for exotic, aggressive tree species. Regrowth of understory and herbaceous layers is usually limited once these exotic species become established. Exotic control, replanting and trash removal are components of woodlands restoration.

The Cobbs Creek watershed is 14,200 acres in size, or about 22 square miles. The watershed in nearly totally developed - 92% of the watershed now supports homes, businesses, industries, and utilities. Of the land that is not developed (i.e., wooded, waterway, or vacant), only 5% still exists as riparian wetland and woodland, most of it serving as public open space (see Indicator 1: Land Use and Impervious Cover).

If runoff from the developed parts of the watershed (92%of the watershed) were settled and filtered using all of the vegetated riparian wetlands and woodlands in the watershed (5% of the watershed), almost 80% of the total solids in the stormwater could be removed before it discharged into the stream. However, most of the stormwater in Cobbs Creek watershed is piped directly to the stream channel, bypassing the wetlands and riparian woodlands that could improve the water quality through detention and trapping sediment. Also, the riparian woodlands along Cobbs Creek and its tributaries are now largely public open spaces (or in some cases, privately owned residential yards). Return of these lands to their original function of filtering and improving the quality of stormwater requires a public examination and decision-making process for resolving competing uses for riparian lands.

The total area of wetland in the Cobbs Creek watershed is relatively small considering the 22.4 linear miles of waterways. Field investigation of wetland presence and quality in the watershed indicates that only 46 wetlands, totaling 36.4 acres, remain along Cobbs Creek and its tributaries. The wetlands range in size from 0.01 acre to approximately 6 acres. Most wetlands are small; 26 of the wetlands surveyed were less than one-quarter acre in size.

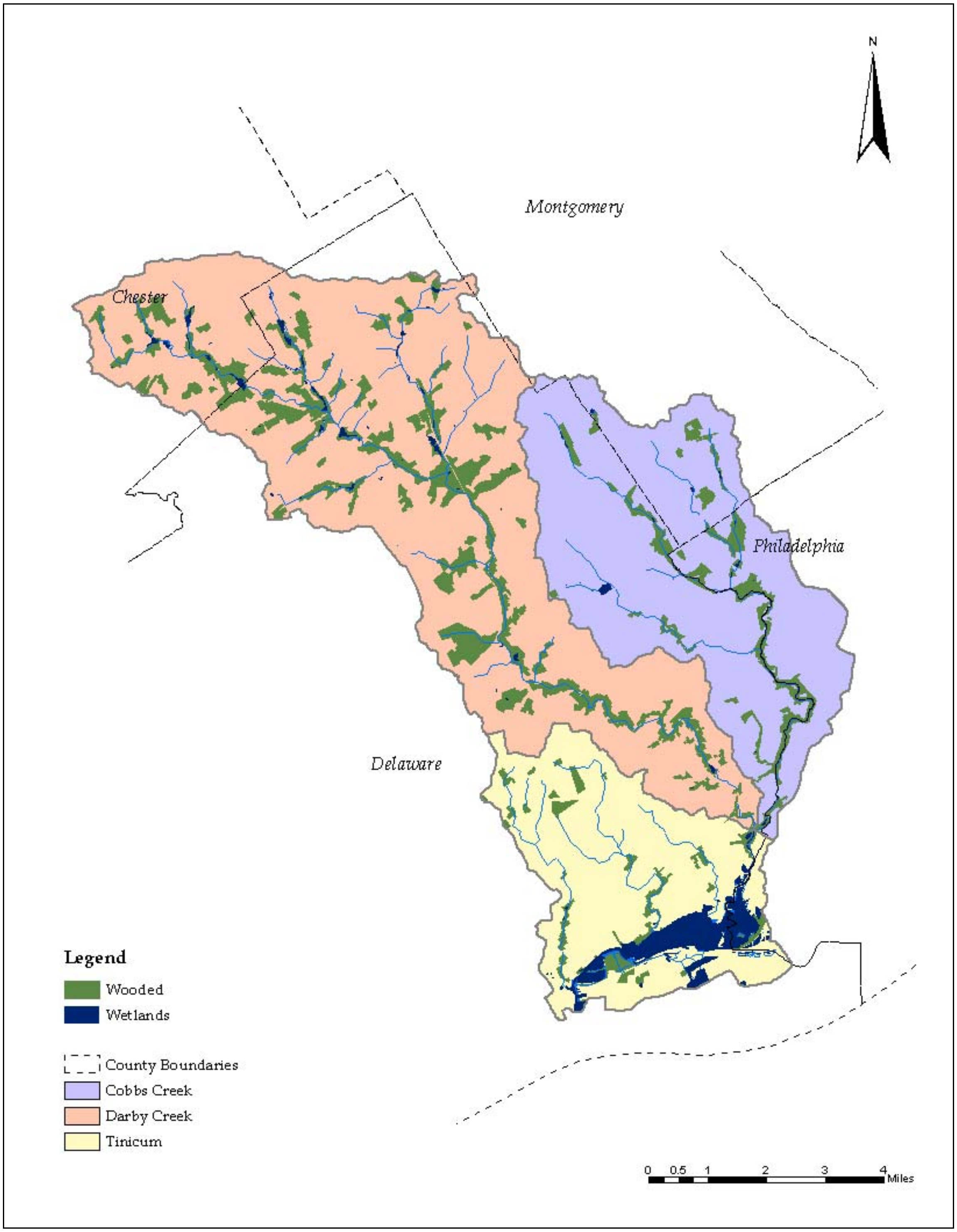


Figure 4-34 National Wetlands Inventory and PWD Surveyed Wetlands (2002 – 2003)

Table 4-8 Estimated Woodland and Wetland Area

Subwatershed	Total Area (acres)	Woodland (% of total)	Wetland (% of total)
Upper Cobbs	7500	4%	0.4%
Lower Cobbs	6700	13%	0.1%
Upper Darby	16,910	14%	1%
Lower Darby	8,521	14%	0.2%
Tinicum	9,804	6%	11%

The remaining Cobbs Creek wetlands were evaluated for their value as wildlife habitat, fish habitat, water quality improvement (nutrient and toxicant reduction), and hydrologic (flood flow) modification. Nearly all wetlands in the Cobbs Creek watershed exhibit impaired functions that indicate extensive disturbance and deterioration.

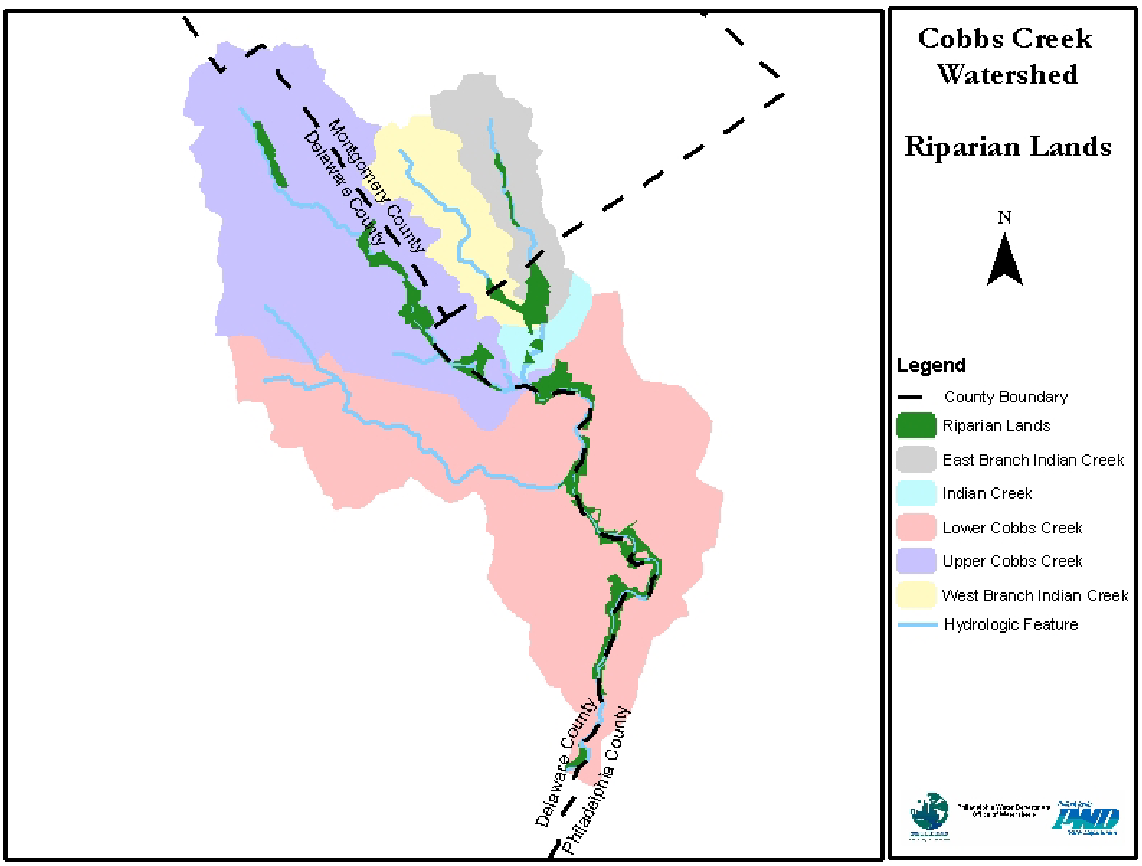


Figure 4-35 Open Lands in the Riparian Corridor

Results of the functional assessment indicate that the remaining wetlands in the Cobbs Creek watershed are degraded, and cannot serve as high quality habitats or perform many of their water quality improvement functions. If stormwater was redirected to the small areas of remaining wetlands, rather than being rerouted directly to the streams in the Cobbs Creek watershed, water quality improvement would be minimal given the current compromised conditions of the wetlands.

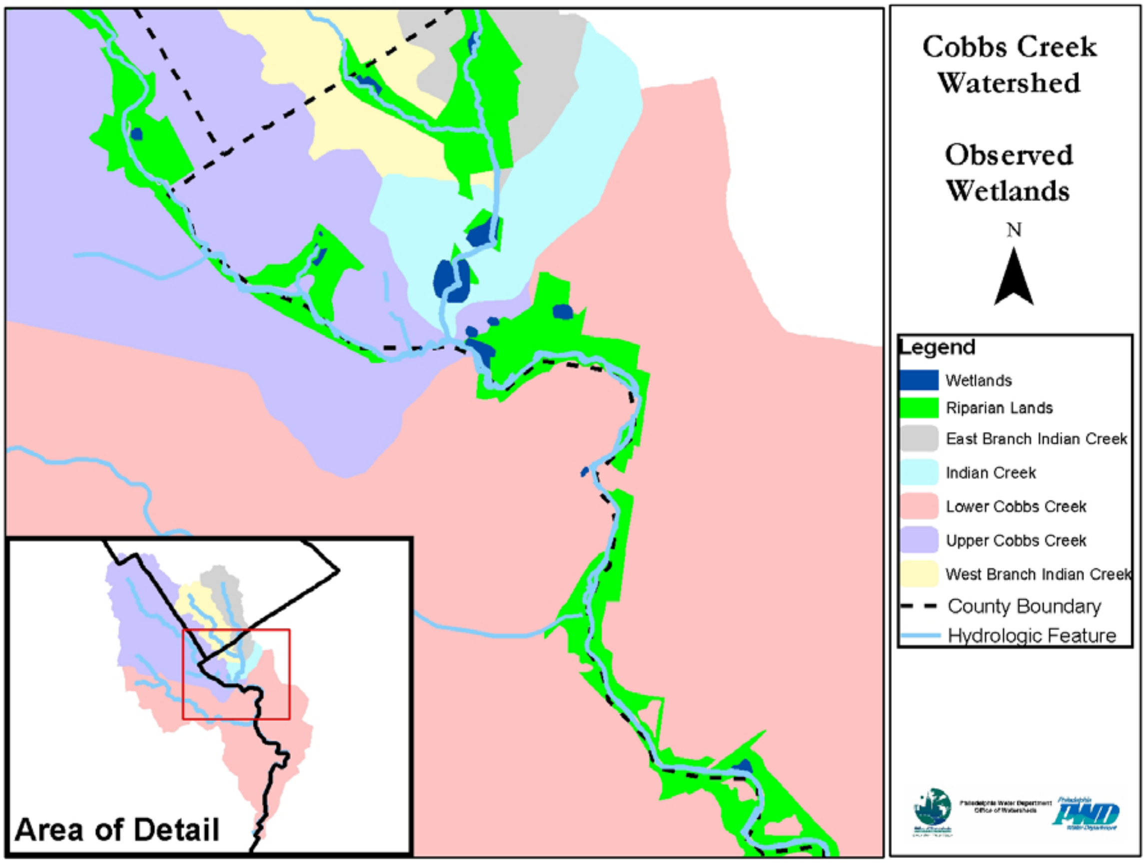


Figure 4-36 Wetlands Identified in the Cobbs Creek Watershed (2002 – 2003)

Table 4-9 Wetland Functional Assessment Results for Cobbs Creek Watershed (based on 45 wetland locations)

Function	Number of Wetlands with Stated Condition
Wildlife Habitat	
Diverse Habitat	12
Moderate	33
Fish Habitat	
Intact Habitat	3
Degraded	7
Lost / Not Present	35
Water Quality Improvement	
Intact Function	12
Degraded	33
Hydrologic Connection to Stream	
Intact Connection	36
Degraded	7
Lost / Not Present	2

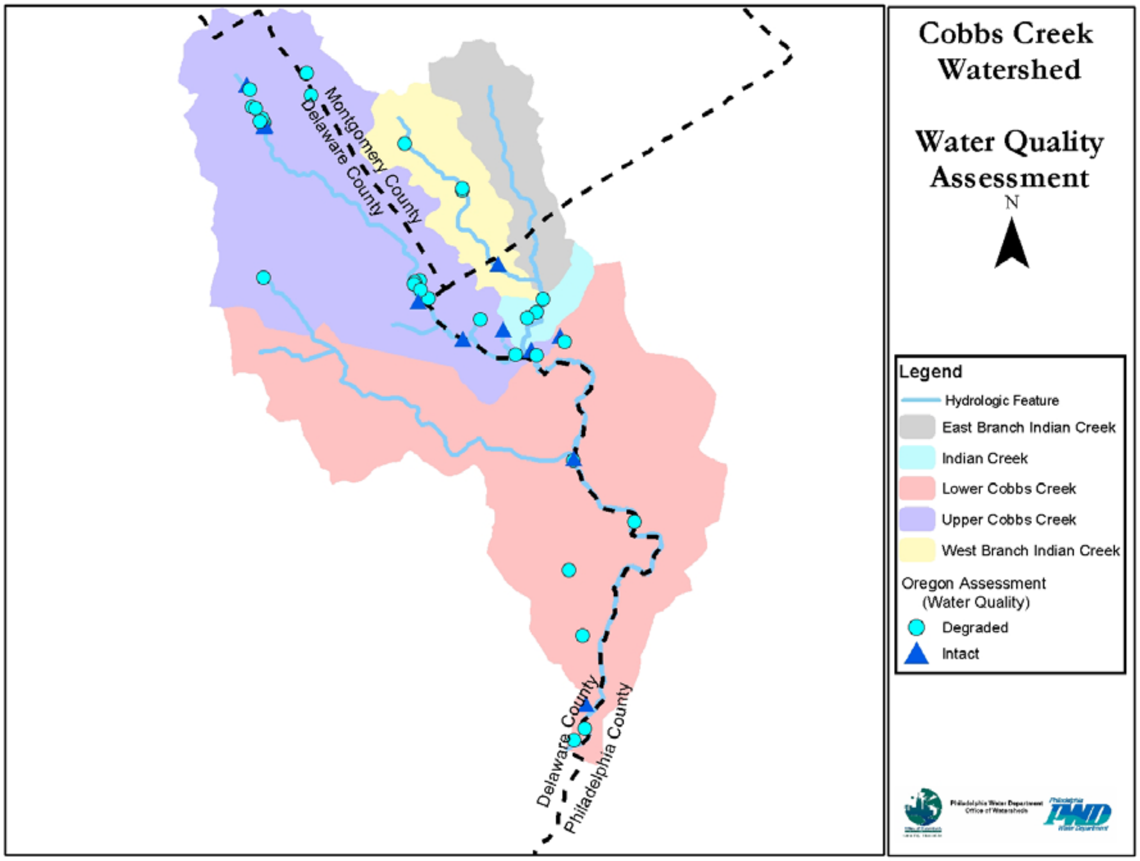


Figure 4-37 Results of Cobbs Creek Wetland Assessments (2002 – 2003)

Indicator 14: Wildlife

Wildlife includes birds, amphibians, and other animals that make their home in the watershed. Quality and diversity of wildlife habitats is also an indicator of watershed quality. Many species have specific habitat requirements. Their presence or absence indicates the health of the habitats. For example, healthy, naturally reproducing amphibian communities indicate the presence appropriate habitats. The red-bellied turtle (Figure 4-38) is one PA listed threatened species found in the watershed.

This indicator measures:

- **Species inventory, identification of any threatened and endangered species**

Figure 4-38 Juvenile Red Bellied Turtle

Where We Were:
There is no historical data available for this indicator.

Where We Are:
A wildlife assessment was completed for Cobbs Creek Park during the "Bio-blitz" in 2001 in which volunteers recorded observed species (Table 4-10). The species of reptiles and amphibians that were found in Cobbs Creek Park were red-backed, northern dusky and two-lined salamanders, snapping and painted turtles, eastern garter, northern water, and brown snakes, and green frogs and bullfrogs. An abundance of several bird species were observed, including Kingbirds, Robins, Catbirds and Chipping Sparrows. No birds or macroinvertebrates that were observed during the Bio-blitz were on the endangered species list. The assessment also determined that Cobbs Creek Park has a low density of deer.

Table 4-10 Species found during 2001 Bio-blitz in Darby-Cobbs Watershed

Birds (72 species)	
Great Blue Heron	Northern Mockingbird
Wood Duck	Brown Thrasher
Mallard Duck	Cedar Waxwing
Cooper's Hawk	European Starling
Red-tailed Hawk	Warbling Vireo
Solitary Sandpiper	Red-eyed Vireo
Spotted Sandpiper	Tennessee Warbler
Rock Dove	Nashville Warbler
Mourning Dove	Northern Parula
Ruby-throated Hummingbird	Yellow Warbler
Chimney Swift	Chestnut-sided Warbler
Red-bellied Woodpecker	Magnolia Warbler
Downy Woodpecker	Black-throated Blue Warbler
Hairy Woodpecker	Yellow-rumped Warbler
Northern Flicker	Black-throated Green Warbler
Eastern Wood-pewee	Blackburnian Warbler
Acadian Flycatcher	Prairie Warbler
Eastern Phoebe	Blackpoll Warbler
Great Crested Flycatcher	Black-and-white Warbler
Eastern Kingbird	American Redstart
Tree Swallow	Ovenbird
Northern Rough-winged Swallow	Northern Waterthrush
Barn Swallow	Mourning Warbler
Blue Jay	Common Yellowthroat
American Crow	Wilson's Warbler
Carolina Chickadee	Canada Warbler
Tufted Titmouse	Scarlet Tanager
White-breasted Nuthatch	Northern Cardinal
Carolina Wren	Indigo Bunting
House Wren	Eastern Towhee
Blue-gray Gnatcatcher	Song Sparrow
Veery	Red-winged Blackbird
Swainson's Thrush	Common Grackle
Wood Thrush	Baltimore Oriole
American Robin	American Goldfinch
Gray Catbird	House Sparrow
Aquatic Macroinvertebrates (12 taxa)	
Mayfly	Sow bugs
Caddisfly	Scuds
Damselfly	Leech
Blackfly	Aquatic Earthworm
Midge	Snails
Cranefly	Crayfish
Reptiles and Amphibians (4 species)	
Bullfrog	Two-lined Salamander
Northern Water Snake	Red-backed Salamander

Indicator 15: Flooding

This indicator measures:

- **Modeled peak flood stage at 3 bridge crossings along lower Cobbs Creek**

Impervious cover and improperly sized or maintained drainage systems in urban watersheds occasionally lead to flooding. Act 167, the Storm Water Management Act of 1978, requires each county in Pennsylvania to prepare and adopt a stormwater management plan for each designated watershed in the county. An official plan provides a mechanism for municipalities to plan for and manage increased runoff associated with possible future development and land use change.

Where We Were:
Frequent, serious flooding has not been a major concern in the Darby-Cobbs watershed. Floodplain mapping studies were conducted by FEMA to establish flood insurance rates for Delaware County in 1993 and for Philadelphia County in 1996. These studies include anecdotal evidence of major flooding during tropical storms. Additional anecdotal evidence is discussed in the Darby Creek River Conservation Plan, prepared by the Darby Creek Valley Association. A number of trouble spots are shown in Figure 4-39, including areas on Cobbs Creek, Naylors Run, Darby and Little Darby Creeks, and Ithan's Run. According to FEMA, flooding at several of these trouble spots may be caused by undersized culverts.

Where We Are:
FEMA studies include stream cross-sections at major road crossings. Figure 4-39 identifies several road crossings where bridge decks are in the 10-year floodplain. As an indicator, 3 cases were chosen where bridge decks along Cobbs Creek Parkway fall within the 10-year floodplain. A simulation was run for a large (3.3 in. total), intense (1.7 in/hr peak) storm on July 21-22, 1988. Table 4-11 indicates that the deck of each bridge was most likely impassable during this storm, which has a return period of about 12 years.

Table 4-11 Peak Flood Stage at 3 Bridges

Trouble Spot	Bridge	Deck Elevation (ft above city datum)	EsrimatedPeak Flood Stage (ft above city datum)
1	Woodland Ave./Main Street (just above 10-yr)	16.4	17.5
3	Cobbs Creek Parkway (below 10-yr)	25.6	27.9
4	Cobbs Creek Parkway (below 10-yr)	25.5	31.1

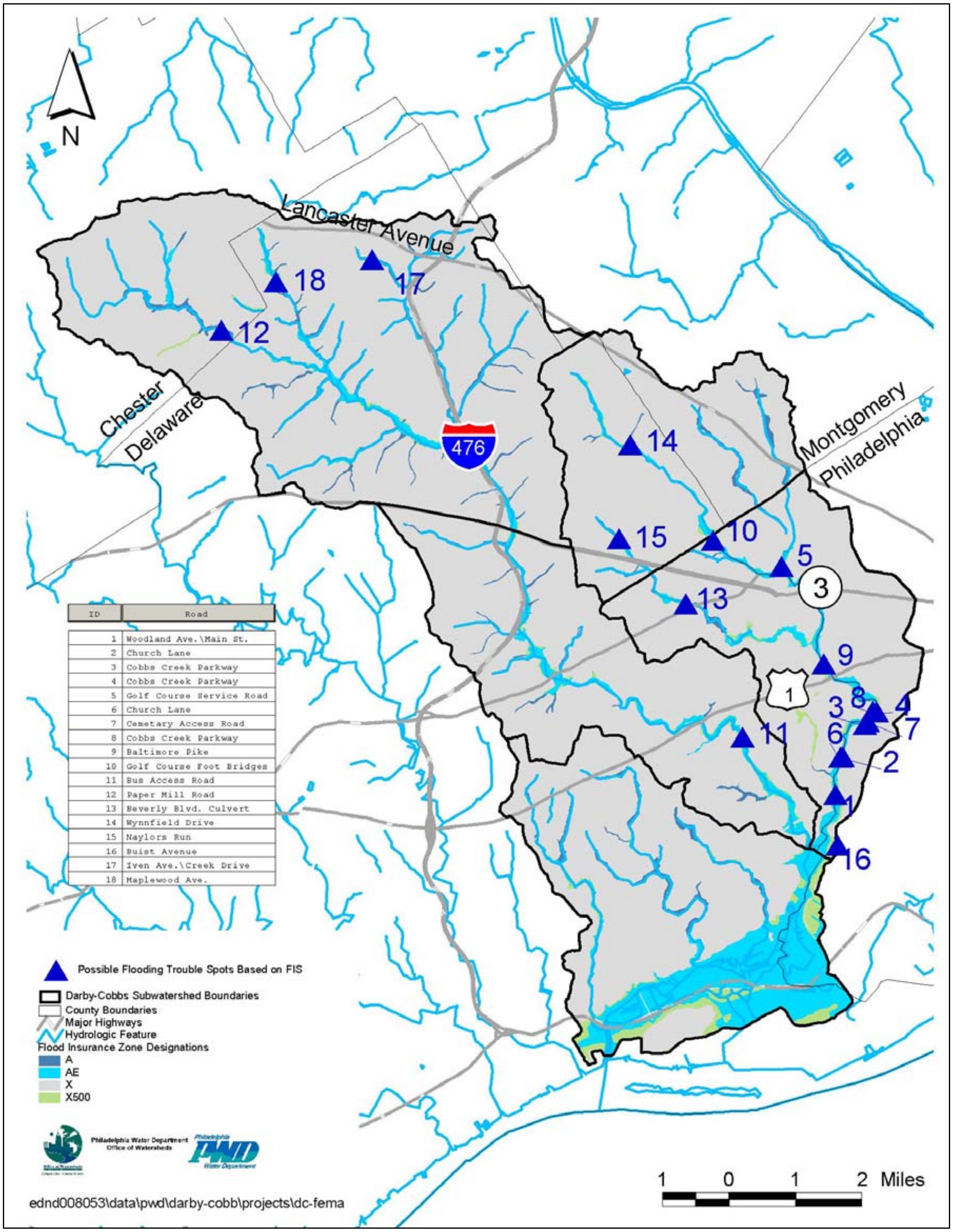


Figure 4-39 Reported / Estimated Flood-prone Areas

Quality of Life

Indicator 16: Public Understanding and Community Stewardship

Because a connection to the natural world and its waterways is less apparent in some communities of the Darby-Cobbs Watershed, the notion of environmental stewardship does not always top the list of daily priorities for many residents. Stewardship, therefore, must be built around the needs of the community as users of the watershed, as well as by making visible the critical ways the health of the watershed is integral to basic quality of life issues. Once this has been established, members of the community can be recruited to take action in protecting their watershed.
Within this context, citizens need to 1) become aware of the meaning of watershed and the watershed in which they live, 2) become informed about the actions they can take to improve watershed health and 3) move from understanding into action.

Stakeholders are those who care with their minds and hearts because they already understand their vital connection to the environmental health of their community. The watershed stakeholders include state and federal regulators, those whose jobs empower them to guard the quality of our rivers and streams. The stakeholders include all of the municipalities, separate entities on paper yet bound together by nature. The stakeholders include all those others – neighborhood groups, religious groups, schools, groups who define themselves as environmental advocates because their personal priorities demand they place their time there.

This indicator measures:

- **Number of responses to surveys**
- **Number of newspaper stories and letters to the editor about watershed-related issues**
- **Changes in membership in the Darby-Cobbs Watershed Partnership, DCVA, Cobbs Creek Community Environmental Education Center, and other current groups**
- **Number of Environmental Action Committees (EACs)**

Where We Were

A historical baseline has not been established for this indicator. Progress will be assessed next time this plan is updated.

Where We Are

A survey of watershed residents was conducted in 2000 in which there were about 342 respondents. Figure 4-40 shows the number of responses received in each municipality. Figure 4-41 shows the actual responses gauging citizen awareness and concern about watershed issues. Of note, a large proportion (47%) of residents live within 4 blocks of a stream, and many enjoy recreational activities along the stream corridor such as nature walks, picnics, and fishing. 57% of respondents indicated that they are concerned about pollution and would not eat fish from Darby or Cobbs Creeks.

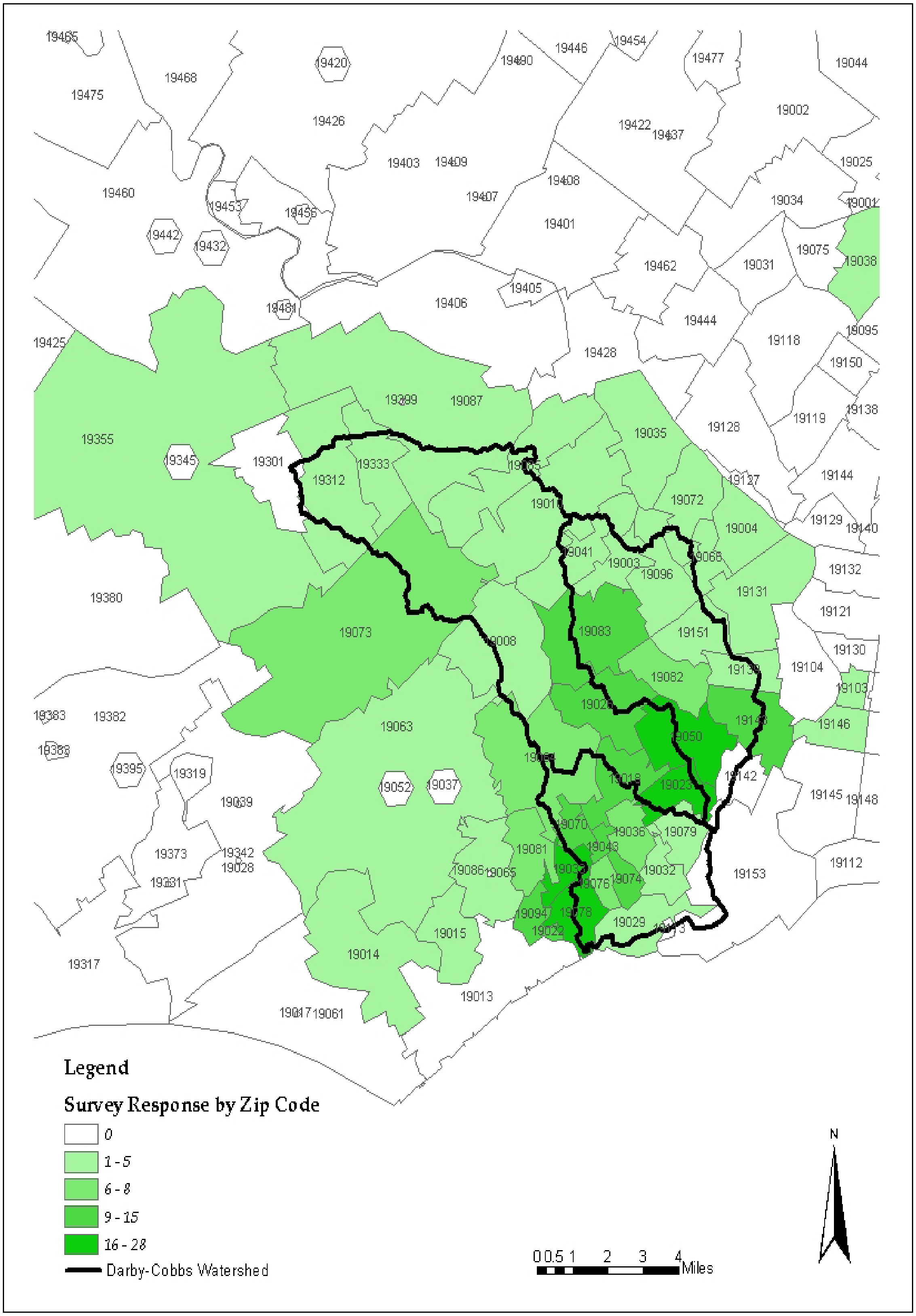
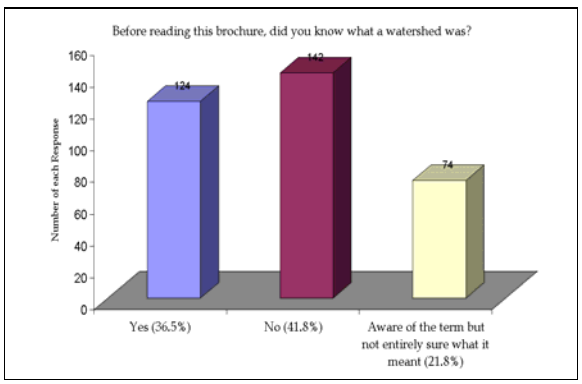
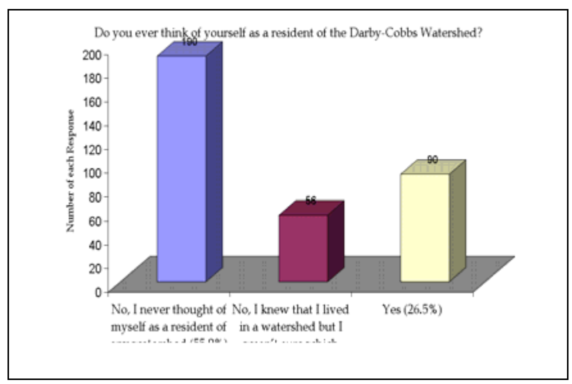


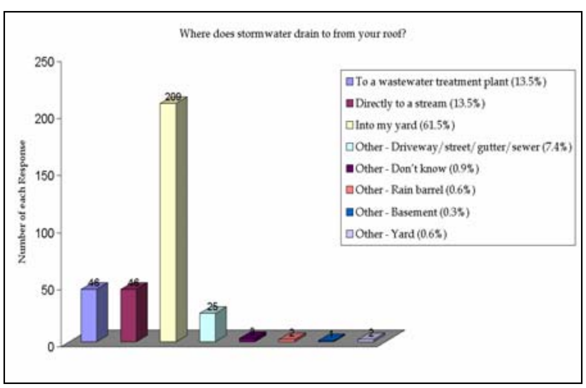
Figure 4-40 Residence Location of Respondents to Darby-Cobbs Watershed Survey

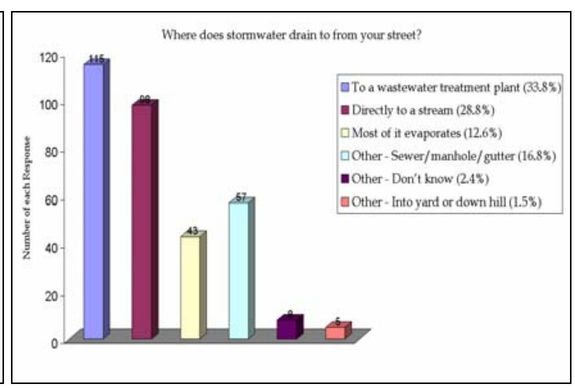
The media greatly influences community perception and may indicate, via public reaction, which events and issues are important to the community. A newspaper clipping survey of articles and letters to the editor in local weekly and daily papers that serve the watershed found nine articles specific to the watershed or the partnership since 2000.

Attendance at meetings held by watershed-related groups is another way to gauge interest among citizens. Eighteen stakeholders consistently attend meetings sponsored by the Partnership, Darby Creek Valley Association (DCVA), Cobbs Creek Community Environmental Education Center (CCCEEC) and other watershed-related forums. Four municipalities in the watershed have municipal appointed Environmental Action Committees (EACs) - Radnor, Marple, Lower Merion, Haverford. Active EACs indicate citizen advocacy for and support of actions needed on the municipal level.









Quality of Life

Indicator 16: Public Understanding and Community Stewardship

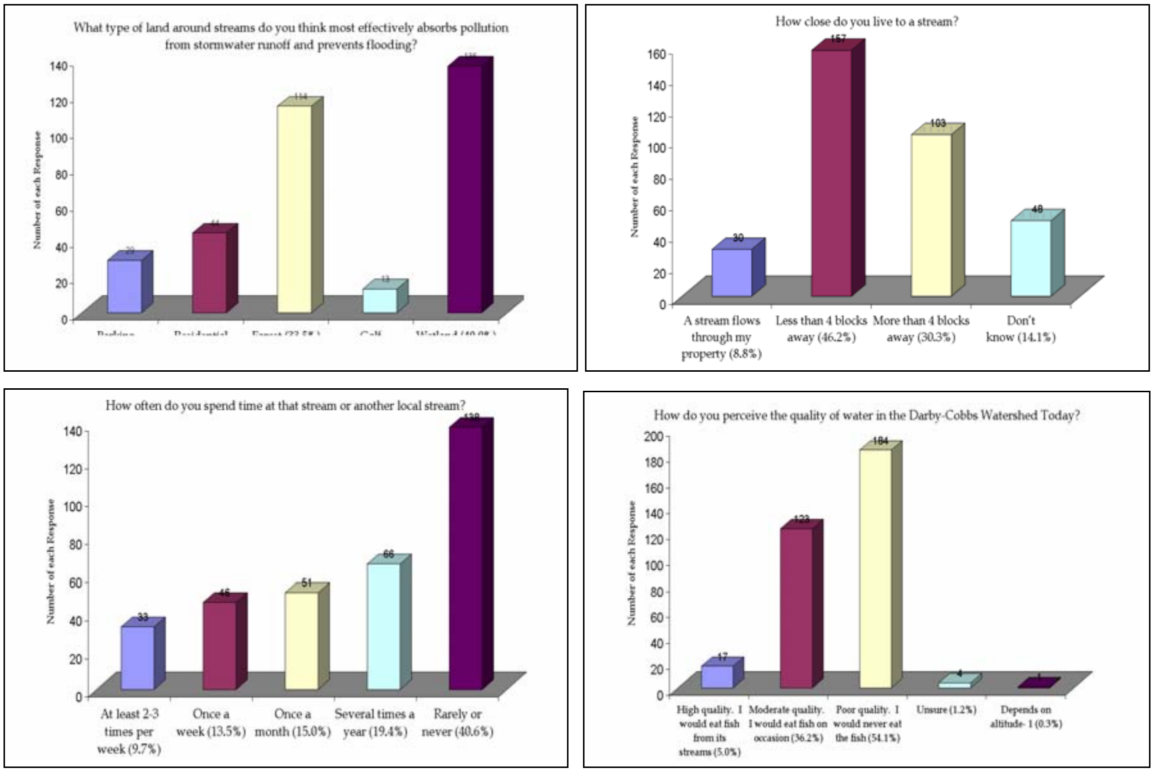


Figure 4-41 Darby - Cobbs Resident Survey Results

Indicator 17: School-Based Education

School aged children of today are the watershed stewards of the future. As such, school based education is an integral component of the long-term health of the watershed.

Figure 4-42 Electrofishing in the Cobbs

School based education takes many forms, from lesson plans within the classroom, to hands-on activities outside of the classroom such as field trips to Cobbs and Darby creeks and nearby nature centers, as well as actual restoration projects. Teacher training programs, developed to assist teachers in bringing watershed concepts to their students, are critical to bringing watershed education to the students, as are partnership with groups like the Cobbs Creek Community Environmental Education Center and the John Heinz Wildlife Refuge at Tinicum. Being engaged in actual restoration projects, either through service learning, after school clubs, or as part of lesson plans, translates lessons into action. There are several ways to measure the success of school based education programs and each depends on the other.

This indicator measures:

- **Number of schools that have environmental or watershed management curricula**
- **Number of teachers trained through the Darby-Cobbs Teacher Training Program**
- **Number of schools participating in programs sponsored by the Cobbs Creek Community Environmental Education Center**

Where We Were

A historical baseline has not been established for this indicator. Progress will be assessed next time this plan is updated.

Where We Are

To date, 11 schools have interactive – incorporating lesson plans with hands on activities - environmental or watershed management curricula, including participation in the Earth Force Program. The schools are Turner Middle School (Phila.), Friends Central (Wynnewood), Nativity BVM (Media), St. Gabriel (Folsom), Pennwood JH, Beverly Hills MS (Phila), Sayre MS (Phila.), St. Cyprian (Phila.), Shaw MS (Phila.), Pepper MS (Phila.), Patterson ES. Forty-eight schools participate in programs sponsored by the Cobbs Creek Community Environmental Education Center.

With the creation of the Darby Cobbs Watershed Partnership, an opportunity arose to incorporate the concepts of an urban watershed environment into school-based curricula to better instruct students in pollution prevention concepts and stormwater runoff quantity issues within their neighborhoods. With the assistance of a Growing Greener grant, the Partnership developed a Darby-Cobbs Watershed Teacher Training program. Twenty teachers from various reaches of the watershed participated in five Saturday workshops, beginning in December of 2000 and ending in May 2001, built around the following modules: watershed management, stormwater management, water quality, ecological restoration, and a workshop session to develop service projects. Each session was taught through a combination of classroom and field experience.

Additionally, the new Academic Standards for Science and Technology and Environment and Ecology became a core requirement of the public school curriculum in January 2002 and testing on these topics commenced for the first time in spring 2003 as part of the PSSA. The standards establish the basic elements of what students should know and be able to accomplish at the end of grades four, seven, 10 and 12. Section 4.1 of these standards is dedicated to watersheds and wetlands. Goals for this topic area are for students to gain knowledge about water cycles, role of watersheds, physical factors, characteristics and functions of wetlands and impacts of watersheds and wetlands. A scope and sequence has been predetermined for each of the aforementioned grades.

Indicator 18: Recreational Use and Aesthetics

People seem to be innately drawn to water and areas of natural beauty. Not surprisingly then, park and recreational areas are often centered on scenic water features, such as lakes or rivers. Indeed, many acres of parkland are already developed along the Darby and Cobbs Creeks. However, many miles of Cobbs Creek are not accessible to the public. If the public has no way to get to a particular stream, it is less likely to be enjoyed. Parks, and the waterways that flow through them, serve many functions, some obvious and others unseen. For instance, parks and waterways are areas of active and passive recreation. Active recreation includes football, baseball, and canoeing, while passive recreation implies areas intended for quiet contemplation or conversation, an essential respite from the concrete and asphalt of the urban world. Natural amenities, when protected and preserved, elevate the quality of life for residents by providing a myriad of recreational, educational and other activities, in addition to enhancing the market value of homes and institutions.

This indicator measures:

- **Stream accessibility score for Cobbs Creek and tributaries**
- **Tons of trash removed from creek and buffer area**

Where We Were

A historical baseline has not been established for this indicator. Progress will be assessed next time this plan is updated.

Where We Are

An accessibility indicator was developed to determine the degree to which a community is able to reach their waterways (Table 4-12 and Figure 4-43). Accessibility was determined on a scale from 0 through 5, with zero representing a particular segment of stream that is inaccessible and 5 representing a completely accessible stream segment. The greater the availability of parking, trails, and public recreational land adjacent to the stream, the higher the accessibility rating. A segment of stream running through a private, industrial, or commercial site was given a rating of 0. A segment of stream running through a public park that has parking and trails leading to the stream was given an accessibility rating of 5. The number of stream miles and the percentage of the total stream miles with each particular accessibility rating were calculated. 1/3 of the waterways within the Cobbs watershed were given a rating of completely accessible. An additional 1/3 of the stream miles were rated as somewhat accessible.

Table 4-12 Accessibility by Stream Miles

Accessibility	Description	Length (Stream Miles)	% Of Stream Miles
0	Not Accessible	0.61	3%
1	Minimally Accessible	5.18	22%
2	Moderately Accessible	1.50	6%
3	Somewhat Accessible	8.06	34%
4	Highly Accessible	0.52	2%
5	Completely Accessible	7.81	33%

Maintenance records indicate that 26 tons of trash and debris have been removed from creeks and riparian buffer areas in Cobbs Creek and its parks between July and December 2003 by the Water Department's Waterways Restoration Team (WRT). The WRT is dedicated to removing large trash and debris – cars, appliances, shopping carts, from our streams in addition to restoring streambanks and streambeds that have been eroded as a result of pipe outfalls. The WRT partners on clean up and restoration efforts with the Fairmount Park Commission, CCCEEC and dedicated volunteers. A common vision is shared by all – to restore the grandeur and beauty of Cobbs Creek for the enjoyment of all residents.

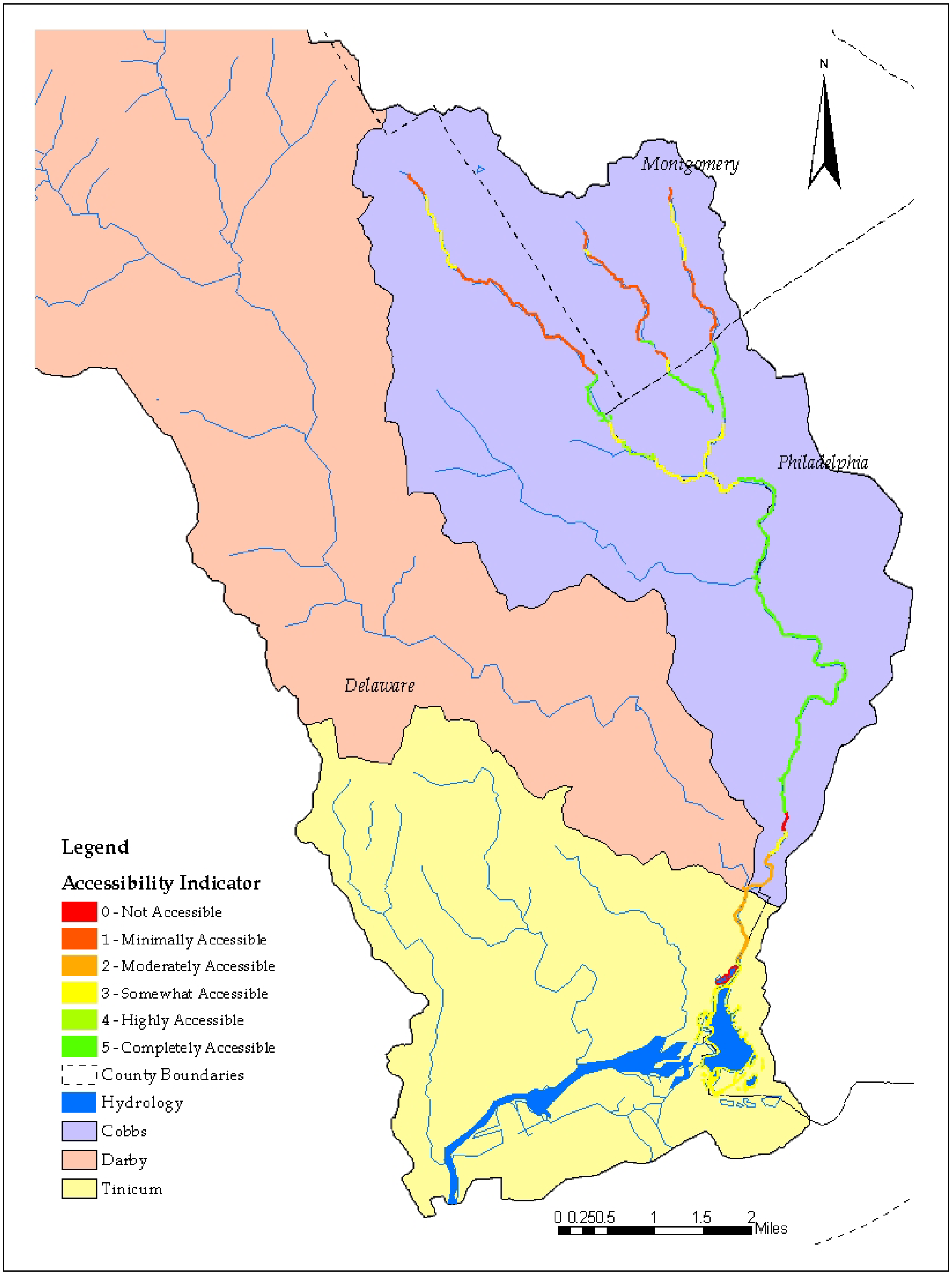


Figure 4-43 Stream Accessibility and Parks in Cobbs Creek Watershed (2003)

Indicator 19: Local Government Stewardship

Local government leadership is essential to ensuring that improvements made under watershed restoration planning are sustainable. Local governments must also support, encourage and complement the stewardship efforts of individuals, environmental groups, and businesses. A major goal is for local governments to work within their regulatory and statutory obligations while actively supporting the stewardship efforts within the watershed. It is also important that local governments implement voluntary actions to restore the watershed. Most importantly, to ensure the success of the watershed management plan, each local government within the watershed must embrace the goals and implementation strategies of the plan. A formal adoption of this plan would multiply its chance for success tremendously.

This indicator measures:

- **Municipalities participating in watershed-related surveys and having up-to-date sewage facilities plans**

Where We Were
A historical baseline has not been established for this indicator. Progress will be assessed next time this plan is updated.

Where We Are
Figure 4-44 shows the municipalities in the Darby-Cobbs watershed. For each municipality, responses have been tabulated (Table 4-13) for several surveys and requests. Sixteen of 44 jurisdictions (including municipalities, townships, boroughs and counties) have signed the Darby-Cobbs Resolution drafted by the Partnership. Five municipalities responded to a survey as part of the Darby Creek River Conservation Plan (RCP), while seven responded to a request letter. Approximately half of municipalities have responded to a survey under the Act 167 Storm Water Planning program. Legally, all municipalities have an Act 537 Plan, a plan that provides for the resolution of existing sewage disposal problems, future sewage disposal needs of new land development and future sewage disposal needs of the municipality. However, some plans are newer and more detailed than others.

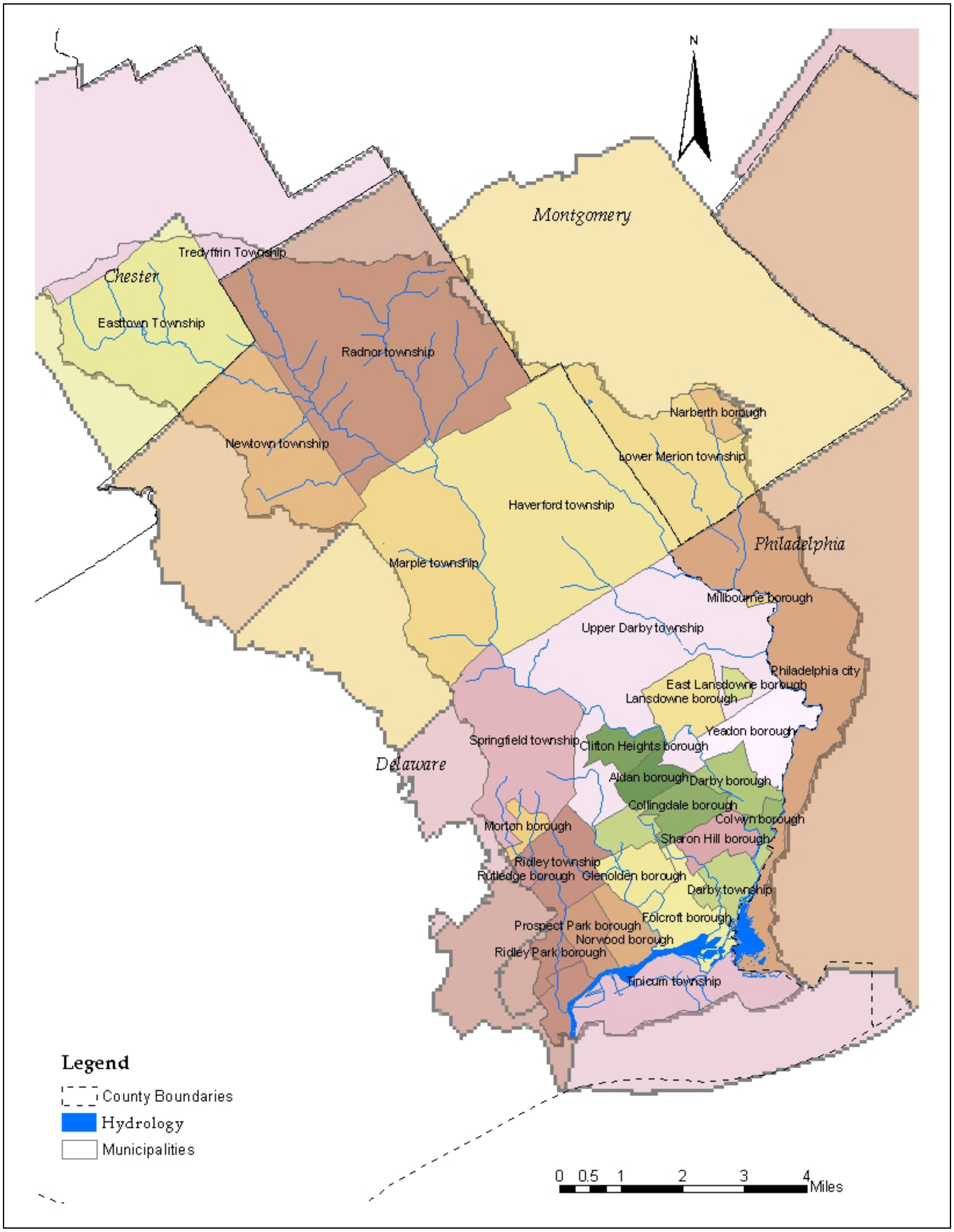


Figure 4-44 Map of Darby-Cobbs Watershed Municipalities and Counties

Table 4-13 Municipalities and Counties signing resolutions and completing surveys

County/Municipality	Resolution	Darby RCP Municipal Survey	Darby RCP Request Letter	Act 537 Municipal Sewage Facilities Plans (# Years Old)	Act 167 Municipal Survey
Chester County	C				50 % of Municipalities have completed. No distinctions as to which ones are available.
Easttown Township	N	N	C	< 5	
Tredyffrin Township	N	N	N	5 > 10	
Delaware County	C				
Aldan Borough	N	N	C	> 20	
Clifton Heights Borough	N	N	N	> 20	
Collingdale Borough	N	N	N	> 20	
Colwyn Borough	C	N	N	> 20	
Darby Borough	N	N	N	> 20	
Darby Township	N	N	N	> 20	
East Lansdowne Borough	C	N	N	> 20	
Folcroft Borough	C	N	N	> 20	
Glenolden Borough	N	N	N	> 20	
Haverford Township	N	C	N	> 20	
Lansdowne Borough	C	N	N	> 20	
Marple Township	C	N	N	< 5	
Millbourne Borough	N	N	N	> 20	
Morton Borough	N	C	N	< 5	
Newtown Township	C	N	N	< 5	
Norwood Borough	N	N	N	< 5	
Prospect Park Borough	N	N	C	< 5	
Radnor Township	C	C	C	> 20	
Ridley Park Borough	N	N	N	< 5	
Ridley Township	C	N	N	< 5	
Rutledge Borough	N	N	N	< 5	
Sharon Hill Borough	C	N	C	> 20	
Tinicum Township	C	N	C	10 > 20	
Upper Darby Township	C	N	C	> 20	
Yeadon Borough	N	N	N	> 20	
Montgomery County	N				
Lower Merion Township	C	N	C	5 > 10	
Narberth Borough	N	N	C	> 20	
Springfield Township	C	C	C	> 20	
Philadelphia	C	C		5 > 10	

Completed	C
Not Completed	N
Not applicable	

Indicator 20: Business and Institutional Stewardship

Awareness is growing regarding the role of businesses and institutions in watershed degradation and restoration. Success of the watershed management plan will require stewardship on the part of stakeholders who represent the diversity of land uses in the watershed, including conservation groups, commercial, industrial, institutional and residential users. The goal of the Partnership is to have a proportional representation of these groups.

This indicator measures:

- **Number of businesses represented at Partnership meetings as a percentage of all citizens and organization present.**

Where We Were

A historical baseline has not been established for this indicator. Progress will be assessed next time this plan is updated.

Where We Are

Figure 4-45 shows the number of representatives of each type of group that have attended Partnership meetings. To date, 6 business representatives have attended, representing 2% of the total.

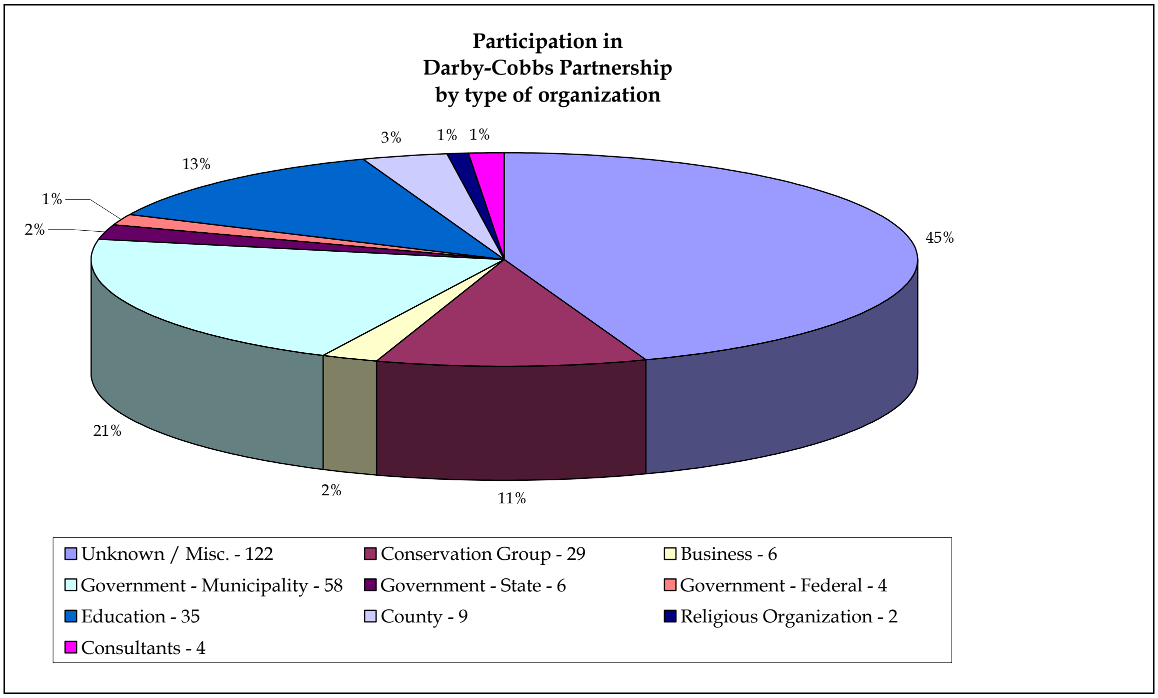


Figure 4-45 Distribution of Partnership Members' Affiliations (2003)

Indicator 21: Cultural and Historic Resources

Waterways have always been cradles of civilization, providing, among many things, a means of travel and rich floodplain soils in which to cultivate crops. Much later, waterways provided power for mills and fueled the beginnings of the industrial revolution. Consequently, historical and cultural resources are often concentrated in and along waterways. These resources enable us to better understand and appreciate different cultures and traditions, to recognize the struggles endured by our ancestors, and to comprehend the technologies of past generations. These cultural and historical resources can also be an invaluable tool to inform our understanding of our present conditions. Cultural and historic resources in the Darby-Cobbs watershed have been tabulated by DCVA in the Darby Creek River Conservation Plan.

This indicator measures:
- **National Register of Historic Places inventory**
- **Number of communities with historical management programs**
- **Number of nonprofit historical/cultural management organizations**

Where We Were
A historical baseline has not been established for this indicator. Progress will be assessed next time this plan is updated.

Where We Are
Figure 4-46 shows the locations of historic sites identified by the RCP planning process. A total of 171 sites were identified. Additionally, the RCP identifies 14 historical societies and commissions at the local level, four at the county level, and three located in Philadelphia. The RCP details many of the historically significant sites and structures.

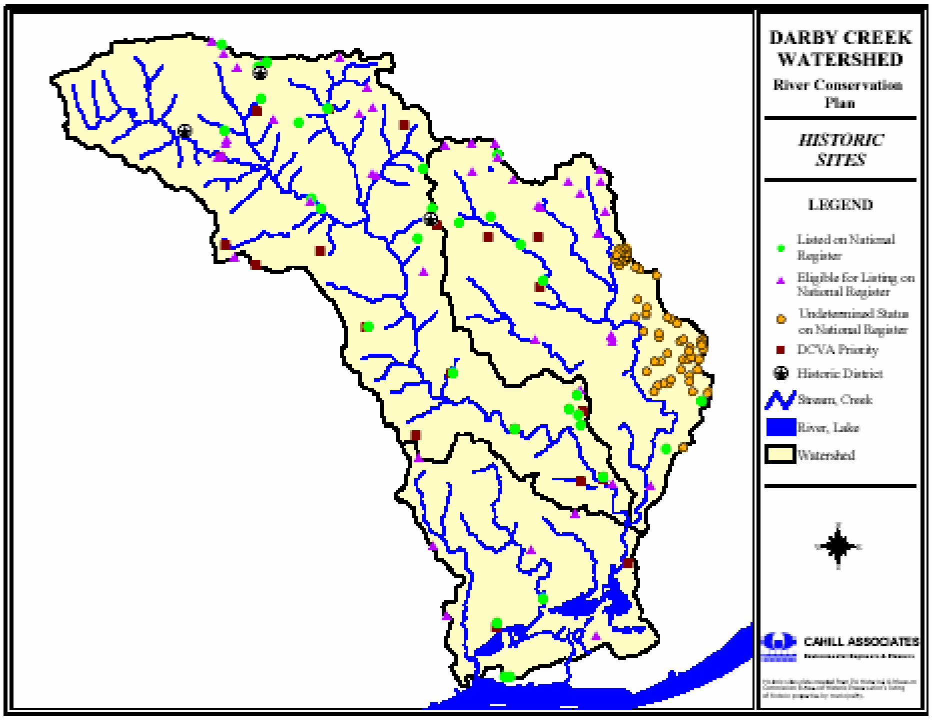


Figure 4-46 Historic Sites Identified in the RCP (2003)

Section 5: Development and Screening of Management Options

5.1 Menu of Options

This section summarizes a comprehensive list of stormwater and watershed management options that the Darby-Cobbs Watershed Partnership thinks may be applicable in the Cobbs watershed. This list serves as the starting point for the screening (Section 5) and evaluation (Section 6) steps that lead to the recommendations contained in the implementation guidance in Section 7. A large amount of detailed information on these options is available from existing sources. Rather than reproducing this information, this section provides references and links to these sources. The options are grouped under the three targets introduced in Section 2:

Target A: Dry Weather Water Quality and Aesthetics

- Regulatory Approaches
- Public Education and Volunteer Programs
- Municipal Measures
- Enhancing Stream Corridor Recreational and Cultural Resources
- Monitoring and Reporting

Target B: Healthy Living Resources

- Channel Stability and Aquatic Habitat Restoration
- Lowland Restoration and Enhancement
- Upland Restoration and Enhancement
- Monitoring and Reporting

Target C: Wet Weather Water Quality and Quantity

- Regulatory Approaches
- Public Education and Volunteer Programs
- Municipal Measures
- Stormwater Management
- Monitoring and Reporting

Target A

Target A is defined for Cobbs Creek as focusing on trash removal and litter prevention, and the elimination of sources of sewage during dry weather. Streams should be aesthetically appealing (look and smell good), accessible to the public, and be an amenity to the community.

Regulatory Approaches

AR1 On-Lot Disposal (Septic System) Management
AR2 Pet Waste, Litter, and Dumping Ordinances

These typical pollution reduction and aesthetic ordinances are already in effect in most locations, and can be effective at controlling diffuse sources of pollutants. They are particularly important in urban watersheds; however, they must be consistently enforced to be effective.

Public Education and Volunteer Programs

AP1 Public Education
AP2 School-Based Education
AP3 Public Participation and Volunteer Programs

Municipal Measures

AM1 Capacity Management Operation and Maintenance (CMOM)
AM2 Inspection and Cleaning of Combined Sewers
AM3 Sanitary Sewer Rehabilitation
AM4 Combined Sewer Rehabilitation
AM5 Illicit Discharge, Detection, and Elimination (IDD&E)
AM6 Stream Cleanup and Maintenance
AM7 Household Hazardous Waste Collection

AO1 Enhancing Stream Corridor Recreational and Cultural Resources

AMR Monitoring and Reporting

AO1 - Enhancing Stream Corridor Recreational and Cultural Resources

Preservation and enhancement of recreational and cultural resources may be integrated into comprehensive watershed management. These resources are part of the link between the human population and natural resources in a watershed. Strategies to provide access to water resources for recreational purposes encourage appreciation for and stewardship of these areas. Strategies to protect water-based historic structures should be implemented to insure that flooding and other impacts are avoided.

AMR - Monitoring and Reporting

Monitoring and reporting under Target A include monitoring of progress toward achievement of objectives (as measured by indicators) and monitoring of implementation of recommended management measures. For example, indicator 18 measures the tons of trash removed from streams and riparian areas (a measure of option implementation) and derives a stream accessibility score for reaches of the Creek (a measure of progress toward an objective).

Target B

Improving the ability of an urban stream to support viable habitat and fish populations focuses primarily on remediating the more obvious impacts of urbanization on the stream. These impacts include loss of riparian habitat, eroding and undercut banks, scoured streambed or excessive sediment deposits, channelized and armored stream sections, and invasive species. The primary tool to address these problems is stream restoration. Restoration focuses on improving channel stability, improving instream and riparian habitat, providing refuge that allows fish to avoid high velocity conditions during storms, and managing land within the stream corridor.

Channel Stability and Aquatic Habitat Restoration

- *BM1* Bed Stabilization and Habitat Restoration
- *BM2* Bank Stabilization and Habitat Restoration
- *BM3* Channel Realignment and Relocation
- *BM4* Plunge Pool Removal
- *BM5* Improvement of Fish Passage

Lowland Restoration and Enhancement

- *BM6* Wetland Creation
- *BM7* Invasive Species Management

Upland Restoration and Enhancement

- *BM8* Biofiltration
- *BM9* Reforestation

- *BMR* Monitoring and Reporting

Many of the stresses faced by aquatic life in urban streams are the result of alternating extremes of high and low flow, and sediment scour and deposition. While stormwater BMPs that promote infiltration do help to reduce these extremes, a recent modeling analysis conducted by PWD indicates that impervious cover would have to be reduced by half or more to have a significant effect. This result indicates that stream restoration measures may be a more feasible means of improving the aquatic habitat in the short term. Modern design techniques may create areas of reduced velocity where aquatic life is protected during high flow. Techniques appropriate to our area are summarized in "Guidelines for Natural Stream Channel Design for Pennsylvania Waterways", by the Alliance for the Chesapeake Bay in March 2003. This publication is available online at http://www.acb-online.org/toolkits.cfm.

The Darby and Cobbs Creeks and their tributaries have numerous low dams that impede fish migration. As part of a stream channel and habitat restoration program, some of these dams may need to be modified or fitted with fish ladders to restore natural migratory patterns.

BMR - Monitoring and Reporting
Monitoring and reporting under Target B includes monitoring of progress toward achievement of objectives (as measured by indicators) and monitoring of implementation of recommended management measures. For example, Indicator 3 measures the channel condition and trend for each reach of the stream. This indicator is both a measure of implementation and a measure of progress toward the goal of reducing streambank and stream channel deposition and scour to protect and restore the natural functions of aquatic habitat and ecosystems, streambanks, and stream channels.

Target C

The third target is to restore water quality to meet fishable and swimmable criteria during wet weather. A comprehensive watershed management approach also must address flooding issues.

Regulatory Approaches

Zoning and Land Use Control

CR1 Requiring Better Site Design in New Development
- Open Space Preservation Plan
- Stream Buffer/Corridor Protection Ordinance
- Wetlands Protection Ordinance
- Steep Slope Ordinance
- Cluster Development Ordinance
- Transfer of Development Rights Ordinance

CR2 Requiring Better Site Design in Redevelopment (may include options in CR1)

CR3 Stormwater and Floodplain Management
CR4 Industrial Stormwater Pollution Prevention
CR5 Construction Stormwater Pollution Prevention
CR6 Post-construction Stormwater Runoff Management
CR7 Pollution Trading
CR8 Use Review and Attainability Analysis
CR9 Watershed-Based Permitting

The regulatory authority for controlling land use is vested in the municipalities through their ability to develop ordinances that regulate zoning and development practices. In areas that are undergoing development pressures, these ordinances are some of the most effective tools for watershed protection. In fully developed, urban watersheds such as the Cobbs Creek watershed, they are less effective, needed primarily to help improve conditions in areas that are re-developing.

A variety of approaches to environmentally responsible land use controls have been developed in recent years, and some are being implemented in the areas adjacent to Philadelphia that are undergoing rapid development. The Delaware Valley Regional Planning Commission (DVRPC) has collected information on these practices and local applications on their web site at http://www.dvrpc.org/planning/protectiontools.htm.

CR3 - Stormwater and Floodplain Management

Ordinances that are important in both developing and developed areas deal directly with the way that stormwater is handled and floodplains are developed or re-developed. Municipal ordinances for stormwater and floodplain management should be consistent with the "Comprehensive Stormwater Management Policy" (Document 392-0300-002) released by PADEP in September 2002. This policy is intended "to more fully integrate post-construction stormwater planning requirements, emphasizing the use of ground water infiltration and volume and rate control best management practices (BMPs), into the existing NPDES permitting programs and the Stormwater Management Act ('Act 167') Planning Program." This policy and a draft model ordinance are available on the PADEP's web site at http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement.htm.

CR4 - Industrial Stormwater Pollution Prevention

- Good Housekeeping
- Preventive Maintenance
- Visual Inspections
- Spill Prevention and Response
- Sediment and Erosion Control
- Employee Training
- Record Keeping and Reporting
- Fueling
- Maintaining Vehicles and Equipment
- Painting Vehicles and Equipment
- Washing Vehicles and Equipment
- Loading and Unloading Materials
- Liquid Storage in Above-Ground Tanks
- Industrial Waste Management and Outside Manufacturing
- Outside Storage of Raw Materials, By-Products, or Finished Products
- Salt Storage
- Flow Diversion
- Exposure Minimization Structures (dikes, drains, etc.)
- Erosion Prevention and Sediment Control
- Infiltration Practices

Detailed guidance on these industrial measures is available in EPA publication 832-R-92-006, "Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices", released in September 1992. Municipalities may choose to adopt more stringent controls at the local level, or may work with state authorities to enforce the existing requirements. These measures are also appropriate for commercial and government operations involved in similar activities. The publication mentioned above is available online at http://www.epa.gov/clariton/clhtml/pubtitleOW.html.

CR5 - Construction Stormwater Pollution Prevention

- Sediment and Erosion Control Practices
- Good Housekeeping
- Waste Disposal
- Minimizing Offsite Vehicle Tracking of Sediments
- Sanitary/Septic Disposal
- Material Management
- Spill Response
- Control of Allowable Non-Stormwater Discharges
- Maintenance and Inspection
- Stormwater Management

Detailed guidance on these measures is available in EPA publication 832-R-92-005, "Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices", released in September 1992. Municipalities may choose to adopt more stringent controls at the local level, or may work with state authorities to enforce the existing requirements. These measures are also appropriate for commercial and government operations involved in similar activities. The publication mentioned above is available online at http://www.epa.gov/clariton/clhtml/pubtitleOW.html.

CR6 - Post-construction Stormwater Runoff Management

Post-construction Stormwater Runoff Management is part of the NPDES Phase 2 stormwater management plan.

CR7 - Pollution Trading

USEPA is exploring market-based measures as a way of reaching targeted overall pollutant load reductions in a watershed. EPA's "Final Water Quality Trading Policy" was released on January 13, 2003, and may be accessed at http://www.epa.gov/owow/watershed/trading/tradingpolicy.html. As this policy is adopted by the states and incorporated in regulations, it may increase incentives for cooperation and coordination between the municipalities and counties that share a watershed.

CR8 - Use Review and Attainability Analysis

USEPA provides procedures for reviewing the applicability and attainability of designated uses. This process may be appropriate for urban watersheds like the Cobbs. EPA document 833-R-01-002, "Coordinating CSO Long-Term Planning with Water Quality Standards Reviews", provides a framework for the process in areas served by combined sewers. This document is available on the EPA web site at http://cfpub.epa.gov/npdes/cso/guidedocs.cfm.

CR9 - Watershed-Based Permitting

A holistic watershed management approach provides a framework for addressing all stressors within a hydrologically defined drainage basin instead of viewing individual sources in isolation. Within a broader watershed management system, the watershed-based permitting approach is a tool that can assist with implementation activities. The utility of this tool relies heavily on a detailed, integrated and inclusive watershed planning process. Watershed planning includes monitoring and assessment activities that generate the data necessary for clear watershed goals to be established and permits to be designed to specifically address the goals. The policy statement and implementation guidance are available on the EPA's web site at http://cfpub.epa.gov/npdes/wqbasedpermitting/wspermitting.cfm

Public Education

CP1 Public Education and Volunteer Programs

Municipal Measures

CM1 Sanitary Sewer Overflow Detection
CM2 Sanitary Sewer Overflow Elimination: Structural Measures
CM3 Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers
CM4 Combined Sewer Overflow (CSO) Control Program
- Nine Minimum Controls
- Long Term CSO Control Plan
- Watershed-Based Planning

CM5 Catch Basin and Storm Inlet Maintenance
CM6 Street Sweeping
CM7 Responsible Landscaping Practices on Public Lands
CM8 Household Hazardous Waste Collection
CM9 Responsible Bridge and Roadway Maintenance

The first three measures above apply primarily to municipalities with separate sanitary sewer systems. The second, reduction of sanitary sewer overflow, is believed to be of critical importance in the Darby-Cobbs watershed. Inspection, cleaning, and when necessary, rehabilitation of aging sanitary sewers may be the single most important pollution reduction measures that should be implemented immediately in this watershed. Reduction of pollutant loads due to stormwater may be of secondary importance if significant loads are being introduced by sanitary sewage.

Structural Stormwater Management Facilities

Detailed information on structural BMPs for stormwater management is available in existing BMP manuals and is not reproduced here. Links to many of these manuals are available in Appendix A of the PADEP's Comprehensive Stormwater Management Policy (see link provided earlier in this document), and three are reproduced below:

Center for Watershed Protection Stormwater Manager's Resource Center
http://www.stormwatercenter.net/

Maryland Stormwater Design Manual
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

New Jersey: Best Management Practices for Control of Nonpoint Source Pollution
http://www.state.nj.us/dep/watershedmgt/bmpmanual.htm

Stormwater Management

Source Control Measures

- *CS1* Reducing Effective Impervious Cover Through Better Site Design
- *CS2* Increasing Urban Tree Canopy
- *CS3* Porous Pavement and Subsurface Storage
- *CS4* Green Rooftops
- *CS5* Capturing Roof Runoff in Rain Barrels or Cisterns

The first measure, reducing effective impervious cover, refers to a variety of measures, including encouraging homeowners to reduce the size of paved areas on their properties. Porous pavement is an alternative to reduction of paved areas. Rooftops represent a large proportion of the impervious area in highly urbanized watersheds such as the Cobbs; constructing rooftop gardens over public and private buildings can be an effective structural measure to reduce urban runoff. This technology is catching on slowly in the United States, but there are some examples in our area.

Rain barrel programs are being sponsored by watershed partnerships in the greater Philadelphia area. Rain barrels are inexpensive but need to be implemented throughout a watershed to be effective as a runoff reduction measure. It is also important that their owners are properly trained and committed to operate and maintain them. Cisterns are similar to rain barrels in function; they also must be drained on a regular basis to provide effective stormwater control.

Tree planting and urban reforestation programs provide hydrologic benefits in addition to quality of life improvements. Leaf surfaces intercept some rainfall that might otherwise fall on impervious surfaces. The rainfall then either evaporates or is conveyed more slowly to the ground along plant stems and trunks.

Municipalities have the opportunity to provide incentives for private landowners to implement these innovative measures through ordinances, tax advantages, or a stormwater fee linked to impervious cover.

Onsite and Regional Stormwater Control Facilities

- *CS6* Maintaining/Retrofitting Existing Stormwater Structures
- *CS7* Modifying Catch Basins to Delay Stormwater Inflow
- *CS8* Retrofit of Existing Sewer Inlets With Dry Wells
- *CS9* Residential Dry Wells, Seepage Trenches, and Water Gardens
- *CS10* Infiltration Basins
- *CS11* Vegetated Swales and Open Channels
- *CS12* Bioretention Basins and Porous Media Filtration
- *CS13* Treatment Wetlands: Onsite and Regional
- *CS14* Dry Detention Basins
- *CS15* Wet Retention Basins
- *CS16* BMPs for Highway Runoff (may include various structural options in this list)

The options above are documented in the state manuals. Most of them may be implemented on the small scale of an individual property. Residential dry wells are an inexpensive way to infiltrate residential roof runoff and provide a benefit distributed over the watershed. Infiltration basins are similar but typically used on a larger scale requiring more land. Porous media filters and bioretention basins are most often used to detain, treat, and infiltrate parking lot runoff. Water gardens are similar to bioretention and can be implemented in backyards or public land such as school grounds. Proper design and maintenance, along with an effective public relations campaign, can alleviate typical concerns about mosquito control and basement flooding.

Retrofit of existing sewer inlets with dry wells is an innovative option that, while expensive, may be attractive in a completely urbanized area with very little land available for traditional BMPs. Using this technology, existing catch basins are retrofitted to provide some measure of storage and infiltration; with full implementation and favorable soil conditions, the resulting outflows may resemble the pre-development condition. The City of Portland, Oregon has implemented this approach and has provided some documentation in its Stormwater Management Manual (http://www.cleanrivers-pdx.org/tech_resources/2002_swmm.htm).

Dry detention and wet retention basins are traditional BMPs that typically provide detention and treatment functions but only limited infiltration. Their design is extensively documented in the state manuals. Constructed wetlands, either on-site or regional, provide similar detention and treatment functions; in addition, they may provide a cooling function and removal of some stormwater through evapotranspiration.

CMR - Monitoring and Reporting

Monitoring and reporting under Target C includes monitoring of progress toward achievement of objectives (as measured by indicators) and monitoring of implementation of recommended management measures. For example, indicator 7 measures the percent of water quality samples where the state fecal coliform standard is met. This indicator is a measure of progress toward the goal of improved water quality in wet weather.

5.2 Screening of Options

The extensive lists of management options described in the previous section were developed to meet each of the goals and objectives established for the Cobbs Creek watershed. Only those options deemed feasible and practical, however, were considered in the final list of management options. To identify these applicable options required a two-step evaluation.

Initial Screening. Some options could be eliminated as impractical for reasons of cost, space required, or other considerations. Options that were already being implemented, were mandated by one of the programs, or were agreed to be vital, were identified for definite implementation. The remaining options had to be screened for applicability to Cobbs Creek. This was done by developing a database and creating every possible combination of options, as described below.

Detailed Evaluation of Structural Options. Structural best management practices for stormwater and combined sewage were subjected to a more rigorous modeling analysis. Effects on runoff volume, overflow volume, peak stream velocity, and pollutant loads were evaluated at various levels of coverage. This is described in section 5.3

Table 5-1 lists the options chosen for each evaluation step.

Table 5-1 Options Chosen for Initial Screening and Detailed Evaluation

Option	Clearly Applicable	Initial Screening	Detailed Model Evaluation
Target A	X		
Target B	X		
Target C			
Regulatory Approaches			
Zoning and Land Use Control			
CR1 Requiring Better Site Design in New Development		X	
CR2 Requiring Better Site Design in Redevelopment	X		
CR3 Stormwater and FloodPlain Management	X		
CR4 Industrial Stormwater Pollution Prevention	X		
CR5 Construction Stormwater Pollution Prevention	X		
CR6 Post-Construction Stormwater Runoff Management	X		
CR7 Pollution Trading		X	
CR8 Use Review and Attainability Analysis		X	
CR9 Watershed Based Permitting	X		
Public Education and Volunteer Programs	X		
CP1 Public Education and Volunteer Programs	X		
Municipal Measures			
CM1 Sanitary Sewer Overflow Detection	X		
CM2 Sanitary Sewer Overflow Elimination: Structural Measures	X		
CM3 Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers	X		
CM4 Combined Sewer Overflow (CSO) Control Program	X*	X*	X*
CM5 Catch Basin and Storm Inlet Maintenance	X		
CM6 Street Sweeping	X		
CM7 Responsible Landscaping Practices on Public Lands	X		
CM8 Household Hazardous Waste Collection	X		
CM9 Responsible Bridge and Roadway Maintenance	X		
CMR Monitoring and Reporting	X		

X*: some sub-options fall within each category shown

Table 5-1 Continued

Option	Clearly Applicable	Initial Screening	Detailed Model Evaluation
Target C			
Stormwater Management			
Source Control Measures			
CS1 Reducing Effective Impervious Cover Through Better Site Design		X	X
CS2 Porous Pavement and Subsurface Storage		X	X
CS3 Green Rooftops		X	X
CS4 Capturing Roof Runoff in Rain Barrels or Cisterns		X	X
CS5 Increasing Urban Tree Canopy	X		
Onsite and Regional Stormwater Control Facilities			
CS6 Maintaining/Retrofitting Existing Stormwater Structures		X	
CS7 Modifying Catch Basins to Delay Stormwater Inflow		X	
CS8 Retrofit of Existing Sewer Inlets With Dry Wells		X	X
CS9 Residential Dry Wells, Seepage Trenches, and Water Gardens		X	X
CS10 Infiltration Basins		X	X
CS11 Vegetated Swales and Open Channels		X	
CS12 Bioretention Basins and Porous Media Filtration		X	X
CS13 Treatment Wetlands: Onsite and Regional		X	X
CS14 Dry Detention Basins		X	X
CS15 Wet Retention Basins		X	X
CS16 BMPs for Highway Runoff		X	

Screening Methodology

Many of the options described above are appropriate to the Cobbs and did not require further evaluation or screening. Others, such as regulatory approaches for areas with new development were eliminated because the potential for new development in the watershed is limited, with the exception of the low-impact design (LID) techniques that can be adapted to redevelopment in urbanized areas. Eventually, the list was consolidated to 21 options that required more sophisticated analysis to test their appropriateness to the Cobbs Creek watershed (Table 5-2). It was decided that a semi-quantitative analysis based on cost-effectiveness would be appropriate, but the analysis should consider not just the cost-effectiveness of the individual option, but also the cost-effectiveness of the options in combination with each other. Thus, an initial screening approach for the 21 options was devised to examine the cost effectiveness of each option for controlling stormwater using an automated database approach.

Table 5-2 Options Chosen for Initial Screening

CR1	Requiring Better Site Design in New Development
CM8	Household Hazardous Waste Collection
CR7	Pollution Trading
CR8	Use Review and Attainability Analysis
CS1	Reducing Effective Impervious Cover through Better Site Design
CS2	Porous Pavement and Subsurface Storage
CS3	Green Rooftops
CS4	Capturing Roof Runoff in Rain Barrels or Cisterns
CM4-1	Increasing Size of Sewer Pipes (1 sub-option of CSO control program)
CM4-2	Structural CSO Storage Facilities (1 sub-option of CSO control program)
CS6	Maintaining/Retrofitting Existing Stormwater Structures
CS8	Retrofitting of Existing Sewer Inlets with Dry Wells
CS7	Modifying Catch Basins to Delay Stormwater Inflow
CS14	Dry Detention Basins
CS15	Wet Retention Basins
CS9	Residential Dry Wells and Seepage Trenches
CS10	Infiltration Basins
CS11	Vegetated Swales and Open Channels
CS12	Bioretention Basins and Porous Media Filtration
CS9	Water Gardens
CS13	Treatment Wetlands: Onsite and Regional

With 21 options under consideration, there are over 1 million ways in which the options can be combined, and it is not readily apparent whether certain combinations are better or worse than others when looking at their ability to meet the planning objectives in a cost-effective manner. Therefore, a computer program was written that worked through each possible combination. The program assigned qualitative cost and effectiveness scores to each option, determined the normalized cost and effectiveness of both individual options and all possible combinations, and tallied a final score as the ratio of effectiveness to cost. In this way, all the combinations were compared to each other in a consistent pattern.

To perform this screening, a cost algorithm was first developed to make an initial, qualitative assessment of the cost of each option. This assessment was taken as the cost of a realistic level of coverage (e.g., fitting 25% of all households with rain barrels may be a realistic goal but fitting 100% is not a realistic goal). A qualitative cost was developed for each option. The cost was given a score of 0 to 3 based on land acquisition, construction, and total salary as shown below.

Criteria for Assigning Initial Cost Classification

Cost	Description
High (3)	significant urban construction involved; or significant land acquisition required
Medium (2)	light construction involved; or field crew needed on a regular basis
Low (1)	non-structural; covered by existing staff salaries

The effectiveness of each option was scored on a similar scale based on the impact it has on short and long term goals as shown below.

Criteria for Assigning Initial Effectiveness Classification

Cost	Description
High (3)	may help meet one or more objectives in short term; instrumental in meeting objectives in long term
Medium (2)	leads to progress in short term, instrumental in meeting objectives in long term
Low (1)	does not lead to progress in short term; leads to limited progress in long term
None (0)	does not apply to a particular goal

Each option was then assigned a single cost-effectiveness score based on the difference or ratio of total effectiveness to total cost. Goal weighting factors were used to balance the relative magnitude of the effectiveness and cost scores. The weighting of these options was discussed in Section 3.

Once each option was assigned a cost effectiveness score they were placed in an alternative scenario with other options. The number of options in each alternative can vary from 1 option to all the options (21). The computer program created all possible combinations of 1 through 21 options, with each combination considered a unique "potential alternative". The following example illustrates the possible alternatives in a simplified case with three goals and three options.

	Effectiveness			Cost
	Goal 1	Goal 2	Goal 3	
Goal Priority	50%	30%	20%	
Option A	2	0	2	1
Option B	0	1	3	2
Option C	0	3	1	3

Possible Alternatives:
A, B, C
AB, AC, BC
ABC

The effectiveness score of an alternative was defined as the sum of option cost-effectiveness scores, weighted by objective priority:

$$E_{ABC} = E_{A1P1} + E_{A2P2} + E_{A3P3} + E_{B1P1} + E_{B2P2} + E_{B3P3} + E_{C1P1} + E_{C2P2} + E_{C3P3}$$

$$C_{ABC} = C_A + C_B + C_C$$

With: E = Effectiveness, C = Cost, and P = Priority. The subscripts denote options and goals; for example, E_{A1} is the effectiveness of option A with respect to goal 1.

Thus, E_{ABC} represents a simple way to measure the effectiveness of the combination of options a, b and c. C_{ABC} is the combined cost of options a, b and c.

The computerized analysis was not intended to provide a definitive answer on which options should or should not be included in the implementation plan. Rather, it was designed to provide insight into options that appear promising, and that appear to combine well with other options. Figure 5-1 shows the results of the cost effectiveness analysis for each option if installed on its own. The normalized scores (0 to 1) represent relative effectiveness at meeting goals (e.g., decreasing stormwater flows, increasing habitat), and cost to build. Cost-effective options are those with a high effectiveness score and a low cost score.

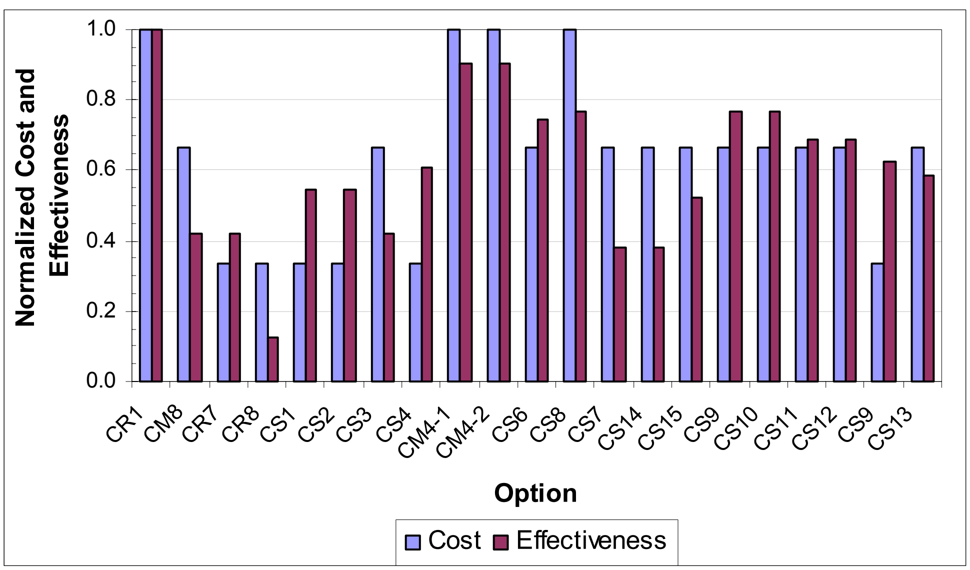


Figure 5-1 Cost–Effectiveness of Individual Options

Figure 5-2 attempts to assess the effectiveness of an option in combination with other options. The bars represent the results of the computerized analysis of all possible option combinations (over one million) by charting the earliest appearance of an option in combination with others. Thus, options 5 (reducing effective impervious cover through better site design) and 6 (porous pavement and subsurface storage) appear early, meaning they had a very high cost-effectiveness score ranking. Option 12 (retrofitting of existing sewer inlets with dry wells) had a low cost-effectiveness score, and made its first appearance only after more than 450 other combinations were rated as superior.

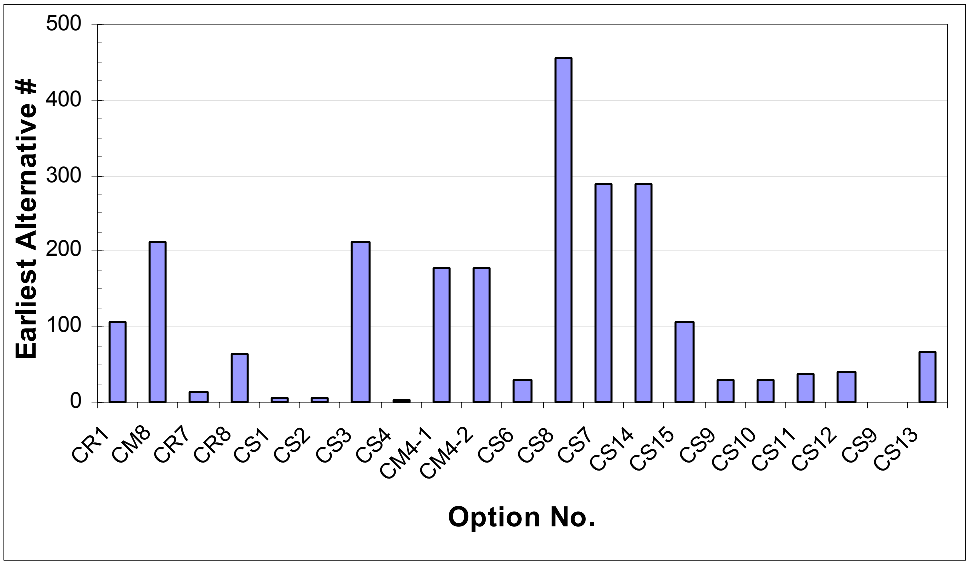


Figure 5-2 Effectiveness of Options in Combination

Table 5-3 summarizes the results of the option screening analysis. Each of the 21 options under consideration for inclusion in the implementation plan is shown in column 1.

Whether or not an option was included in the final set of alternatives was based on how well it did in the cost-effectiveness evaluation. Individually, each option has an effectiveness/cost ratio. How well the option did when combined with other options was judged by how early the option first appeared when results from the more than 1 million possible option combinations were sorted by the effectiveness/cost ratio of the combinations. The first appearance of an option was one way to judge, and its appearance within the 40 highest ranked option combinations was another. Table 5-3 shows the option results with color shading. Green options rated highly, and were likely to be included in the implementation plan. Yellow shaded options were ranked medium, and were possible options for inclusion. The pink highlighted options were the least cost effective options, and were the least likely to be included for implementation.

Table 5-3 Results of Initial Screening

High Score; Medium Score; Low Score

Opt. No.	Option Description	Normalized Cost Score	Normalized Effectiveness Score	Normalized E/C Ratio for Option Alone	First Alternative Appearance
CR1	Requiring Better Site Design in New Development	1.00	1.00	1.00	105
CM8	Household Hazardous Waste Collection	0.67	0.42	0.63	212
CR7	Pollution Trading	0.33	0.42	1.27	13
CR8	Use Review and Attainability Analysis	0.33	0.13	0.38	63
CS1	Reducing Effective Impervious Cover through Better Site Design	0.33	0.55	1.64	4
CS2	Porous Pavement and Subsurface Storage	0.33	0.55	1.64	5
CS3	Green Rooftops	0.67	0.42	0.63	211
CS4	Capturing Roof Runoff in Rain Barrels or Cisterns	0.33	0.61	1.83	2
CM4-1	Increasing Size of Sewer Pipes	1.00	0.91	0.91	178
CM4-2	Structural CSO Storage Facilities	1.00	0.91	0.91	177
CS6	Maintaining/Retrofitting Existing Stormwater Structures	0.67	0.74	1.11	30
CS8	Retrofitting Existing Sewer Inlets with Dry Wells	1.00	0.77	0.77	455
CS7	Modifying Catch Basins to Delay Stormwater Inflow	0.67	0.38	0.57	288
CS14	Dry Detention Basins	0.67	0.38	0.57	289
CS15	Wet Retention Basins	0.67	0.52	0.79	106
CS9	Residential Dry Wells and Seepage Trenches	0.67	0.77	1.15	28
CS10	Infiltration Basins	0.67	0.77	1.15	29
CS11	Vegetated Swales and Open Channels	0.67	0.69	1.03	38
CS12	Bioretention Basins and Porous Media Filtration	0.67	0.69	1.03	39
CS9	Water Gardens	0.33	0.63	1.88	1
CS13	Treatment Wetlands: Onsite and Regional	0.67	0.59	0.88	65

5.3 Modeling Assessment of Structural BMPs

The automated option screening described above was done in a qualitative sense based on the options only, with no direct consideration of their ability to function under the specific circumstances of Cobbs Creek. Those BMPs that were deemed to be generally effective in meeting wet weather or Target C objectives were further assessed using the SWMM model. In this way, the BMPs could be assessed for their cost-effectiveness when implemented in Cobbs Creek. BMPs (or options) that appear to cost-effectively decrease stormwater flows or combined sewer overflows, or significantly reduce pollutant loading during wet weather were subjected to a series of model runs. BMPs were simulated at various levels of implementation within the watershed, and the results graphed. For the assumed level of implementation, the results in terms of pollutant reduction and amount of stormwater treated were then combined with planning level cost estimates, and the options were ranked according to their cost effectiveness. The modeling analysis is documented in more detail in the Comprehensive Characterization Report.

The results are shown in Tables 5-4 through 5-6. Note that the analysis was carried out separately for BMPs placed in CSO areas and in separate storm sewered areas to test the effects of location. There are clear differences in the efficiency of BMPs depending on where they are located. The analysis was also carried out for the cost effectiveness at removal of pollutants using TSS as surrogate for most pollutants, and for cost effectiveness at reducing or treating stormwater quantity reaching the creek. This is important because some BMPs appear to be more efficient at pollutant removal, while others are more efficient at reducing the volume of stormwater reaching the stream. Both are objectives of the watershed management plan.

Table 5-4 shows the estimated cost per gallon of stormwater treated, and the cost per pound of TSS removed for simulations of feasible levels of implementation for each of the types of BMPs under consideration. The results show that there is a wide range of costs, and that costs differ depending on whether a BMP is implemented in a CSO area, or in an area served by separate storm sewers. Table 5-5 shows the relative ability of each of the BMPs to either store stormwater, treat stormwater, or remove TSS, based on simulations of feasible implementation of each of the BMPs in the Cobbs Creek Watershed. Table 5-6 shows the list of options, ranked from most cost-effective to least cost-effective, grouped into highly effective (green), moderately effective (yellow), and least effective (pink) options.

Table 5-4 Cost Analysis Results Using SWMM Model

High Score; Medium Score; Low Score

	WATER QUALITY			WATER QUANTITY		
	TSS Removed			Volume Infiltrated/Evap/Captured		
BMP	Separate ($/lb)	Combined ($/lb)	Watershed ($/lb)	Separate ($/10^3 gal)	Combined ($/10^3 gal)	Watershed ($/10^3 gal)
Treatment Wetlands	0.98	0.43	0.71	2.89	0.38	0.98
Wet Retention Basins	2.94	2.18	2.66	15.02	2.42	5.91
Rain Barrels and Cisterns	13.83	3.68	7.62	9.06	2.50	5.10
Infiltration Basins	3.39	2.51	3.07	17.33	2.79	6.82
Real Time Control	N/A	3.47	N/A	N/A	3.15	N/A
Residential Dry Wells	16.52	8.69	13.05	82.26	8.29	22.62
Bioretention Basins	36.25	15.20	25.73	162.48	13.31	37.71
Dry Wells in Sewer Inlets	1067.59	38.03	118.70	789.61	26.26	82.38
Porous Pavement	92.61	50.46	74.28	63.88	35.23	51.51
Green Rooftops	107.10	50.96	80.81	72.33	35.23	55.17

Table 5-5 Relative Ranks of BMPs for Total Stormwater Storage, Volume of Stormwater Treated, and Simulated Reduction in TSS

BMP Ranking	Potential Storage	Volume Affected	TSS Load Reduction
Highest	Porous Pavement	Infiltration Basins	Inf. Basin
	Infiltration Basins	Wet Retention	Wet Retention
	Wet Retention	Res. Dry Wells	Priv. Dry Wells
	Bioretention	Inlet Dry Wells	Porous Pavement
	Res. Dry Wells	Real Time Control	Real Time Control
	Inlet Dry Wells	Porous Pavement	Green Rooftops
	Green Rooftops	Bioretention	Bioretention
	Wetlands	Green Rooftops	Wetlands
	Rain Barrels	Wetlands	Inlet Dry Wells
Lowest		Rain Barrels	Rain Barrels

Table 5-6 Relative Cost-Effectiveness of Options in Descending Order

High Score; Medium Score; Low Score

WATER QUALITY		WATER QUANTITY	
TSS Removed		Volume Infiltrated/Evaporated/Captured	
Separate	Combined	Separate	Combined
Wetlands	Wetlands	Wetlands	Wetlands
Wet Retention	Wet Retention	Rain Barrels	Wet Retention
Infiltration Basins	Infiltration Basins	Wet Retention	Rain Barrels
Rain Barrels	Real Time Control	Infiltration Basin	Infiltration Basin
Res. Dry Wells	Rain Barrels	Porous Pavement	Real Time Control
Bioretention	Residential Dry Wells	Green Rooftops	Residential Dry Wells
Porous Pavement	Bioretention	Residential Dry Wells	Bioretention
Green Rooftops	Porous Pavement	Sand Filters	Inlet Dry Wells
Inlet Dry Wells	Green Rooftops	Inlet Dry Wells	Green Rooftops
	Inlet Dry Wells		Porous Pavement

The results of the SWMM model BMP simulations support a number of general conclusions about the implementation of BMPs in Cobbs Creek.

- The cost of runoff volume reduction is always higher in separate-sewered than in combined-sewered areas because temporary storage and release results in additional capture at CSO regulator structures. Larger cost differences between CSO and separate storm sewer areas occur where evapotranspiration and/or infiltration are minor components of the BMP (e.g., retrofitting sewer inlets with dry wells, residential dry wells and seepage trenches, bioretention and porous media filters).

- Generally speaking, if pollutant removal is significant for a given BMP, the cost difference between separate and CSO areas is smaller. Examples are porous pavement with subsurface storage, due to significant infiltration, and green rooftops, due to significant ET.

- Traditional BMPs like infiltration basins and wet retention basins can be effective where land is available to build them. These facilities typically have much larger capacities, are regional in nature, and exhibit economies of scale. They are not thought to be practical alternatives for the Cobbs watershed, but they are included for completeness.

- For the combined-sewered areas, real time control (RTC) is among the most competitive options in terms of both volume (5th) and load (4th) reduction. The RTC configuration being considered is highly specific to the Cobbs, and these results may not hold generally for other watersheds.

- In highly urbanized areas, large storage volumes can be achieved only through options such as porous pavement and gravel under parking facilities. Figure 5-3 shows the maximum amount of storage that could be built in the Cobbs watershed given a reasonable level of coverage for each BMP. Subsurface gravel under parking facilities represents over 60% of the storage that could feasibly be built. Bioretention and porous media filters represent the second largest volume at approximately 8%.

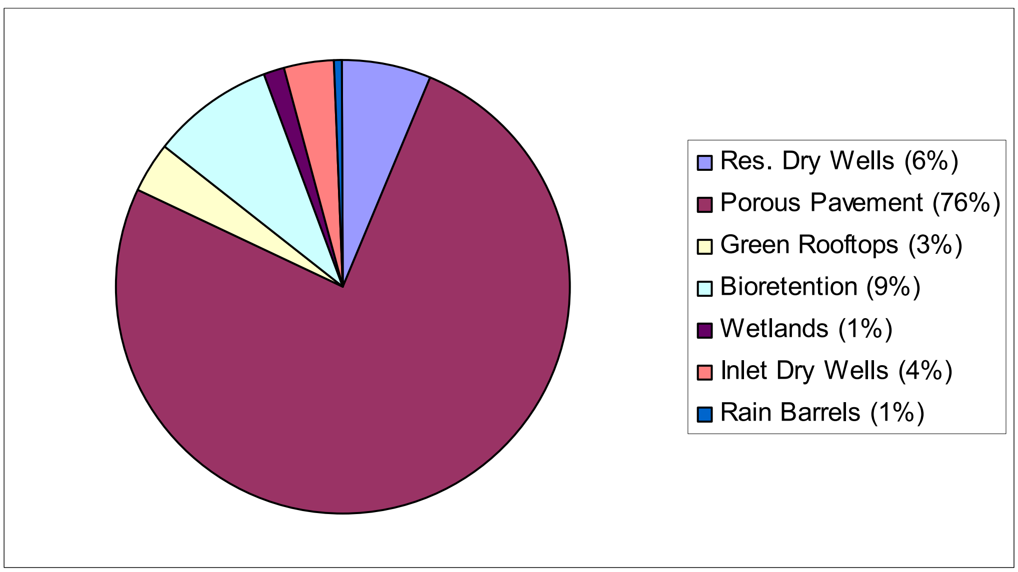


Figure 5-3 Total Storage Volume Feasible for Cobbs Watershed

- Given the urban conditions and soil in the Cobbs, only two of the modeled BMPs are capable of removing large quantities of stormwater (Figure 5-4). If porous pavement covered all parking lots, approximately 12% of stormwater could be removed through infiltration on an annual basis. If green rooftops covered all buildings, approximately 10% of stormwater could be removed through evapotranspiration.

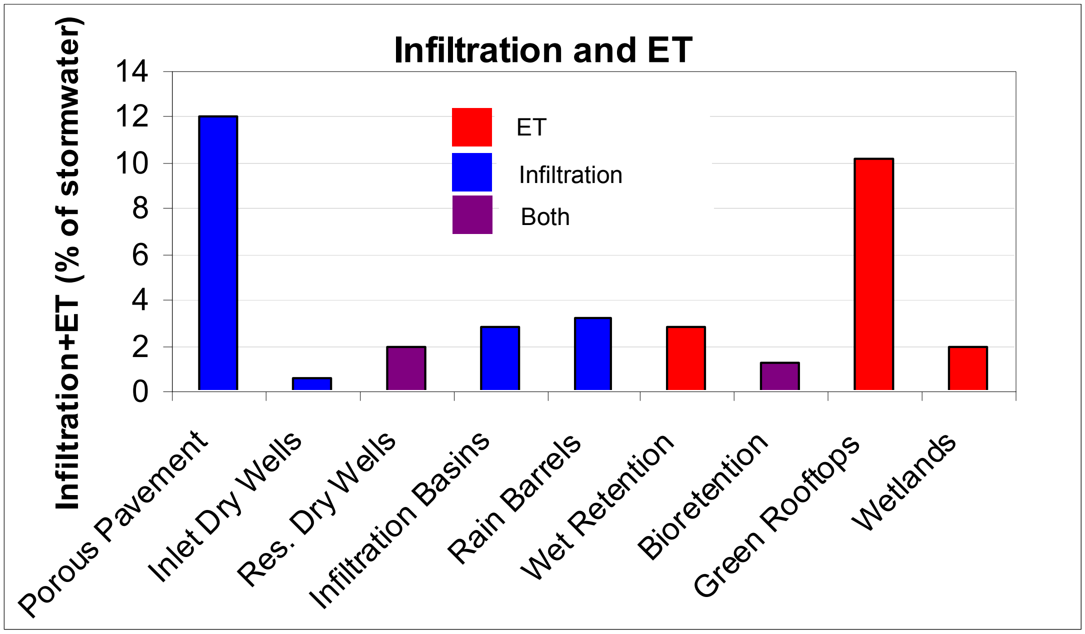


Figure 5-4 Potential Stormwater Volume Removal Given Full Coverage

The cost analysis of alternatives in areas of separate storm sewers shows:

- Wet Retention, wetlands, and infiltration basins are the most cost effective options for TSS removal on a dollar per pound basis. Wetlands and rain barrels are cost effective on a dollar per gallon stormwater treated basis.

- Dry wells in sewer inlets (>$1000/lb), green rooftops and porous pavement (~$100/lb) are particularly expensive for TSS reduction. Dry wells in sewer inlets and bioretention basins are expensive on a per gallon basis for stormwater treatment because of their relatively small area of infiltration.

The cost analysis of alternatives in areas of combined sewers shows:

- Wetlands, wet retention, rain barrels, infiltration basins, real time control, and residential dry wells are all relatively cost effective options on the basis of dollars per pound TSS removed and on the basis of dollars per gallon of stormwater treated.

- Green rooftops and porous pavement (both about $50/lb) are expensive choices either on the basis of TSS removal or on the basis of dollars per gallon stormwater treated.

It is also clear that the most expensive options in combined-sewered areas are more than an order of magnitude lower than the most expensive options in separate-sewered areas. Because hydraulic detention is the most important mechanism in combined-sewered areas, there is less difference in cost-effectiveness between the different types of BMPs.

In combined areas, the regulator structures represent an investment already made in pollution reduction. Thus money spent on stormwater best management practices results in greater load and volume reductions per dollar spent than in separate areas where no stormwater controls are in place. To meet an overall load reduction target in watersheds served by both combined and separate areas, it may be most efficient to focus management measures on the combined areas.

In Section 6, all the results presented above are used to assemble management alternatives that meet watershed goals in a cost-effective manner.

Section 6: Development and Evaluation of Management Alternatives

6.1 Development of Alternatives

BMPs, stream restoration measures, stormwater and CSO management technologies, and public education measures must be combined into coherent, integrated management plan alternatives that address the multiple objectives of the Darby-Cobbs Watershed Partnership. In highly urbanized watersheds, however, it is very difficult to develop appropriate water quality, quantity, and habitat objectives. For Cobbs Creek, PWD's approach is to define three separate sets of objectives or targets, and recommend BMPs and programs to achieve each of the targets. Targets are defined here as groups of objectives that each focus on a different problem related to the urban stream system. They can be thought of as different parts of the overall goal of fishable and swimmable waters through improved water quality, more natural flow patterns, and restored aquatic and riparian habitat.

The three targets of watershed restoration for Cobbs Creek are:

- TARGET A: Dry Weather Water Quality and Aesthetics
- TARGET B: Healthy Living Resources
- TARGET C: Wet Weather Water Quality and Quantity

By defining clear and achievable targets, and designing the alternatives and implementation plan to address the targets simultaneously, the plan will have a much higher likelihood of success. It will also result in realizing some of the objectives within a relatively short time frame, providing positive incentive to the communities and agencies involved in the program to continue and expand their efforts. This approach will also result in more immediate benefits to people living in the watershed than would an approach that attempts to meet all objectives completely in one implementation plan.

6.1.1 Target A: Options for Dry Weather Water Quality and Aesthetics

For Cobbs Creek, the focus of Target A is trash removal, litter prevention, and elimination of sources of sewage during dry weather. Because the options under consideration are aimed at the total elimination of trash and dry weather sources of sewage, no complex analysis was required to help define the program or assess its potential benefits. All options related to this target are included in the implementation plan.

Streams should be aesthetically appealing (e.g., look and smell good), accessible to the public, and be an amenity to the community. Access to and interaction with the stream during dry weather have the highest priority, because dry weather flows occur about 60-65% of the time during the course of a year, and are also the times when the public is most likely to be near or in contact with the streams. The water quality of the stream in dry weather, particularly with respect to bacteria, should be similar to background concentrations in groundwater. Many urban streams rarely meet water quality standards for bacteria, and urban streams often have significant BOD problems, even during baseflow or dry weather conditions.

The following outline shows the list of options recommended for inclusion in the implementation plan to achieve the objectives associated with Target A.

Regulatory Approaches

AR1 On-Lot Disposal (Septic System) Management
AR2 Pet Waste, Litter, and Dumping Ordinances

Public Education and Volunteer Programs

AP1 Public Education*AP2* School-Based Education
AP3 Public Participation and Volunteer Programs

Municipal Measures

AM1 Capacity Management Operation and Maintenance (CMOM)
AM2 Inspection and Cleaning of Combined Sewers
AM3 Sanitary Sewer Rehabilitation
AM4 Combined Sewer Rehabilitation
AM5 Illicit Discharge, Detection, and Elimination (IDD&E)
AM6 Stream Cleanup and Maintenance

AO1 Enhancing Stream Corridor Recreational and Cultural Resources

AMR Monitoring and Reporting

The outline shows that the options relevant to Target A focus on dry weather water quality and visual aesthetics of the stream, primarily removal of trash and elimination of illegal dumping. Also included are a range of regulatory and nonstructural options that address both water quality and quantity concerns. The measures in Table 6-1 may be grouped into three broad categories:

- Measures to Eliminate Sources of Trash and Litter
- Measures to Eliminate Sanitary Waste Inputs in Dry Weather
- Measures to Improve Public Access to Streams

Measures to Eliminate Sanitary Waste Inputs in Dry Weather

Measures to restore water quality during dry weather are fundamental to the plan. Elimination of dry weather sewer discharges due to blockages can be achieved by regularly cleaning and maintaining sewers. Leaking sewers are addressed by rehabilitating broken or leaking sewers, and identifying and correcting cross-connections (sanitary connections to stormwater lines).

In addition to sewage discharges, a program must be implemented to identify and eliminate any other pollutant sources (e.g., point sources or leaking septic tanks) that might be leading to instances of dry weather dissolved oxygen (DO) depression bacteria water quality standard exceedances.

Measures to Eliminate Sources of Trash and Litter

Another aspect of Target A objectives is to improve aesthetics by cleaning up trash and taking measures to reduce littering and illegal dumping. Many stakeholders in area watersheds have indicated that these measures are a primary concern. Options to achieve this include stream cleanup activities and the implementation of a wide range of nonstructural measures to educate the community about the importance of the stream, and about the direct consequences of their actions on the quality of the streams. Example implementation measures include school-based education, establishment of stakeholder and watershed groups, improved street sweeping and litter control, the establishment of municipal “clean stream teams” to clean up trash in the stream, and improved enforcement of existing littering and anti-dumping ordinances.

Measures to Improve Public Access to Streams

A significant portion of Cobbs Creek offers opportunities to improve access and use of the stream for passive recreation through the creation of trails, access points, and improved habitat within the riparian corridor. Areas where access can be improved will be indicated in the implementation plan.

6.1.2 TARGET B: Options for Healthy Living Resources

Improving the ability of an urban stream to support viable habitat and fish populations focuses primarily on the elimination of the more obvious impacts of urbanization on the stream. These include loss of riparian habitat, eroding and undercut banks, scoured streambed or excessive silt deposits, channelized and armored stream sections, trash buildup, and invasive species. The primary tool to accomplish this is stream restoration. Restoration focuses on improving channel stability, improving instream and riparian habitat, providing refuges for fish from high velocity conditions during storms, and managing land within the stream corridor.

Channel Stability and Aquatic Habitat Restoration

- *BM1* Bed Stabilization and Habitat Restoration
- *BM2* Bank Stabilization and Habitat Restoration
- *BM3* Channel Realignment and Relocation
- *BM4* Plunge Pool Removal
- *BM5* Improvement of Fish Passage

Lowland Restoration and Enhancement

- *BM6* Wetland Creation
- *BM7* Invasive Species Management

Upland Restoration and Enhancement

BM8 Biofiltration
BM9 Reforestation

BMR Monitoring and Reporting

Options for stream restoration were developed based on extensive studies carried out in the watershed by PWD in preparation for the Cobbs Creek Watershed Management Plan. Studies included a geomorphologic channel survey (stream assessment) of the entire creek, stormwater modeling, habitat and biological assessments, and modeling of stream velocities along a critical stretch of the creek. Assessment results indicate that the moderately impaired benthic community and pollution tolerant fish assemblages in Cobbs Creek reflect habitat deterioration and episodic water quality degradation throughout the entire watershed. Cobbs Creek watershed is a highly urbanized region where traditional methods of stream bank "reconstruction" and stormwater management have significantly channelized the stream and disconnected it from its historic floodplain, creating a system which is not in dynamic equilibrium (i.e., the amount of erosion and sedimentation is not equal to the amount of sediment transport out of the system). Furthermore, the stream has lost much of its link magnitude (e.g., small first order streams) and wetland systems due to development and increased impervious surfaces. Due to these changes, the stream's hydrologic profile has been altered, decreasing the time to peak flow and increasing peak flow concentration. In doing so, storm events reaching or exceeding bankfull stage are no longer managed by the stream channel and floodplain.

Typical events scour stream banks, fill pools with sediment, and cover riffle structures with sediment at an accelerated rate. As a result, a highly ephemeral (short-lived) system with increased sediment deposition, decreased habitat heterogeneity (e.g. pool-riffle-run systems) and unstable stream banks has been created. These changes have had a deleterious effect on the benthic and ichthyfaunal communities inhabiting Cobbs Creek.

Results of water quality monitoring, habitat assessment, and biological monitoring, suggest the primary impact on the number, health, and diversity of fish species in Cobbs Creek is habitat modification. Restoration efforts, therefore, need to focus on habitat improvement and fishes' ability to avoid high velocity flows during storms. Wetland and streambank restoration/creation projects and stream modeling will be combined with continued biological monitoring to ensure that appropriate procedures are being implemented to increase habitat heterogeneity within the aquatic ecosystem.

The options in Table 6-2 may be further broken into measures necessary used for stabilization of the stream channel, measures for habitat creation, measures to manage infrastructure in restoration areas, and measures to improve fish passage.

Measures for Channel Stabilization

- Bank stabilization, including boulder structures, bioengineering, root wads, plantings, and log and woody structures
- Bed stabilization, including rock/log vanes with grade control, rock/log cross vanes, and naturally occurring boulders and bedrock
- Realignment and relocation of the stream channel, to be used only on severely degraded stream sections

Measures for Habitat Restoration in the Stream and Stream Corridor

- Restoring stream banks, channels, and habitat features
- Restoring riparian (streamside) habitat, including wetlands
- Eliminating deep, poorly mixed pools to improve dissolved oxygen (DO) concentration
- Restoring pools and riffles, healthy banks, and creating safe areas of low flow velocity during storms
- Reforestation, with priority to floodplains, steep slopes, and wetlands
- Invasive species management, needed to increase biodiversity
- Wetland creation, often used in conjunction with stream realignment to improve floodplain areas subject to annual flooding
- Forest preservation

Measures to Manage Infrastructure in the Restoration Area

- Where possible, reducing impervious cover during corridor restoration
- Infrastructure retrofit or relocation of structures within the floodplain or encroaching on the channel
- Road and culvert maintenance

Measures to Improve Fish Passage

- Fish ladders, which allow fish to pass around obstructions
- Modification or removal of dams

A more detailed presentation of the above measures is included in the implementation guidance section (Section 7).

6.1.3 TARGET C: Options for Wet Weather Water Quality and Quantity

Improving water quality and flow conditions during and after storms is the most difficult target to meet in the urban environment. During wet weather, extreme increases in streamflow are common, accompanied by short term changes in water quality. Stormwater generally does not have DO problems, but sampling data indicate that concentrations of metals (such as copper, lead, and zinc) and bacteria do not meet water quality standards during wet weather. These pollutants are introduced by both stormwater and wet weather sewer overflows (CSOs and SSOs).

Target C options also must address flooding issues. Where water quality and quantity problems both exist, options must be identified that address both. Any BMP that increases infiltration or detains flow will help decrease the frequency of damaging floods; however, the size of such structures may need to be increased in areas where flooding is a major concern. Reductions in the frequency of erosive flows and velocities will also help protect the investment in stream restoration made as part of the implementation of Target B options.

Target C must be approached somewhat differently from the first two targets. Full achievement of this target means meeting all water quality standards during wet weather, as well as eliminating all flooding. Full achievement of these goals will be difficult, particularly with regard to wet weather water quality. It is certainly extremely expensive, and would require a long term effort. The only rational approach to full achievement of Target C goals is through stepped implementation with interim targets for reducing wet weather pollutant loads and stormwater flows. During implementation, monitoring must continue to continuously assess the effectiveness of the program. Based on the extensive modeling analysis carried out for Cobbs Creek to date, an initial goal of a 20% reduction in stormwater flows and stormwater/CSO related pollutant loads is challenging but achievable.

It is expected that changes to the approach, and even to the desired results, will occur as measures are implemented and results are monitored. With permits of 5-year duration for most discharge permits, discharge targets and reduction targets must be set and implementation designed in the first 5 years. Implementation for meeting Target C should occur over the next 5 years, with monitoring for effectiveness taking place for 5 years subsequent to implementation. During the last 5-year period, PWD will also work with the regulatory agencies to review water quality standards and determine whether any adjustments to them may be appropriate based on the results of monitoring.

On the Cobbs Creek, data indicate that restoring water quality to meet fishable and swimmable criteria during wet weather primarily means controlling sources of fecal coliform and restoring degraded stream habitat. Because urban streams are subject to extreme changes in flow and very heavy loading of fecal coliform from CSOs and stormwater, options focus on reducing stormwater and CSO overflows by:

- Reducing CSOs from reaching the stream
- Treating or infiltrating stormwater before it reaches the stream
- Implementing floodplain management, planning, and ordinances (e.g., restrict development in the 100-year floodplain)

Options related to Target C are divided into two groups. The first group, listed in the following outline, includes options recommended for full implementation regardless of what alternative is ultimately chosen. These options include a range of ordinances and regulatory measures, public education, measures related to existing municipal infrastructure, selected source controls, and possibilities for pollution trading and use review. The municipal measures focus on the elimination of sanitary sewer overflows and the causes of overflows such as blockages and excessive infiltration. Recommendations for implementing these options are included in Section 7.

Regulatory Approaches

Zoning and Land Use Control

CR2 Requiring Better Site Design in Redevelopment

CR3 Stormwater and Floodplain Management
CR4 Industrial Stormwater Pollution Prevention
CR5 Construction Stormwater Pollution Prevention
CR6 Post-construction Stormwater Runoff Management
CR7 Pollution Trading
CR8 Use Review and Attainability Analysis
CR9 Watershed-Based Permitting

Municipal Measures

CM1 Sanitary Sewer Overflow Detection
CM2 Sanitary Sewer Overflow Elimination: Structural Measures
CM3 Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers
CM4 Combined Sewer Overflow (CSO) Control Program
- Nine Minimum Controls
- Long Term CSO Control Plan
- Watershed-Based Planning

CM5 Catch Basin and Storm Inlet Maintenance
CM6 Street Sweeping
CM7 Responsible Landscaping Practices on Public Lands
CM9 *R*esponsible Bridge and Roadway Maintenance

Stormwater Management

Source Control Measures

CS1 Reducing Effective Impervious Cover Through Better Site Design
CS2 Increasing Urban Tree Canopy
CS3 Porous Pavement and Subsurface Storage
CS4 Green Rooftops
CS5 Capturing Roof Runoff in Rain Barrels or Cisterns

Onsite and Regional Stormwater Control Facilities

CS6 Maintaining/Retrofitting Existing Stormwater Structures
CS8 Retrofit of Existing Sewer Inlets with Dry Wells
CS9 Residential Dry Wells, Seepage Trenches, and Water Gardens
CS12 Bioretention Basins and Porous Media Filtration
CS13 Treatment Wetlands: Onsite and Regional

CMR Monitoring and Reporting

The second group of Target C options includes structural measures designed to achieve specific, measurable discharge and pollutant load reductions. Table 6-1 lists the eight measures, a feasible implementation level for each, and the discharge and pollutant load reductions that are possible with each. Table 6-2 lists six alternatives, or combinations of these eight options that result in approximately a 20% reduction in wet weather flows and loads to the stream system.

Table 6-1 Available Options to Meet Flow and Load Reduction Targets

	Maximum Feasible Implementation	Volume Reduction		Pollutant Reduction
		CSO	Stormwater	
Municipal Measures				
CM4 Combined Sewer Overflow (CSO) Control Program				
• Real Time Control	15 Sites in PWD's SWDD	11%	0%	14%
Structural Stormwater Management Facilities				
Source Control Measures				
CS3 Porous Pavement and Subsurface Storage	50% of parking lots	3%	4%	8%
CS4 Green Rooftops	5% of rooftops	6%	7%	14%
CS5 Capturing Roof Runoff in Rain Barrels or Cisterns	25% of homes	4%	2%	6%
Onsite and Regional Stormwater Control Facilities				
CS8 Retrofit of Existing Sewer Inlets with Dry Wells	100% of inlets	5%	0%	6%
CS9 Residential Dry Wells, Seepage Trenches, Water Gardens	school grounds; 25% of homes	6%	1%	19%
CS12 Bioretention Basins and Porous Media Filtration	50% of parking lots	2%	0%	6%
CS13 Treatment Wetlands: Onsite and Regional	100% of identified potential	5%	1%	12%

Notes:
1. Volume reductions are % of total discharge (sum of CSO and stormwater)
2. "Maximum Feasible" considers technical feasibility and social acceptance, but not cost.

Each alternative is designed to fully meet the goal of 20% reduction in untreated stormwater reaching the stream, and a 20% reduction in pollutant loading through stormwater and/or CSOs. They differ in approach and cost, with each representing a slightly different "design approach".

Table 6-2 Six Alternatives for Meeting 20% Flow and Load Reduction Target

	Unit	Alternative 1	2	3	4	5	6
Municipal Measures							
CM4 Combined Sewer Overflow (CSO) Control Program							
• CSO Storage Tanks	Yes/No	No	Yes	No	No	No	No
• Real Time Control	Yes/No	Yes	No	No	No	No	No
Structural Stormwater Management Facilities							
Source Control Measures							
CS3 Porous Pavement and Subsurface Storage	% of parking lots	0%	0%	0%	0%	50%	25%
CS4 Green Rooftops	% of rooftops	0%	0%	0%	2%	0%	2%
CS5 Capturing Roof Runoff in Rain Barrels or Cisterns	% of homes	25%	25%	25%	25%	0%	20%
Onsite and Regional Stormwater Control Facilities							
CS8 Retrofit of Existing Sewer Inlets with Dry Wells	% of sewer inlets	0%	0%	0%	0%	40%	0%
CS9 Residential Dry Wells, Seepage Trenches, Water Gardens	% of homes	25%	25%	15%	25%	0%	10%
CS12 Bioretention Basins and Porous Media Filtration	% of parking lots	5%	5%	0%	2%	50%	25%
CS13 Treatment Wetlands: Onsite and Regional	% of identified potential	100%	100%	100%	0%	0%	50%

Alternative 1: Real Time Control and Low-Cost Stormwater BMPs

This alternative combines real time control of CSOs within the combined sewered area of the watershed with BMPs that were identified as being cost-effective within the conditions found in Cobbs Creek. Stormwater BMPs are applied only to the areas served by separate storm sewers. The options applied to the separate sewered areas include the use of wetlands for all areas identified as suitable for wetland creation, installation of rain barrels on 25% of all homes, installation of residential dry wells for roof runoff on another 25% of homes, and sand filters or bioretention facilities installed on 5% of the parking lots within the watershed.

Alternative 2: Structural Storage and Low-Cost Stormwater BMPs

This alternative uses large scale retention of combined sewer flows through the use of large CSO tanks. In separate sewered areas, it is assumed that rain barrels are installed on 25% of the households, that 25% of the residences have dry wells to catch roof runoff, and that bioretention basins and/or sand filters are installed in 5% of parking lots.

Alternative 3: Low-Cost Stormwater BMPs throughout Watershed

This alternative uses only stormwater BMPs throughout the watershed; CSOs are addressed by infiltrating and detaining stormwater before it reaches the combined sewer. It includes wetlands at all feasible locations, rain barrels on 25% of all homes, and dry wells on 15% of all homes in the watershed.

Alternative 4: Stormwater BMPs with Focus on Private Property

This alternative uses only stormwater BMPs throughout the watershed. The concept is to examine the effectiveness of stormwater BMPs that are applied primarily to private properties through voluntary or incentive programs. It includes rain barrels on 25% of all homes, dry wells on 25% of all homes, sand filters or bioretention facilities installed on 2% of the parking lots within the watershed and green roofs installed on 2% of all homes in the watershed.

Alternative 5: Stormwater BMPs with Focus on Public Property and Parking

This alternative uses only stormwater BMPs throughout the watershed; however, the focus is primarily on BMPs applied to public lands and facilities. BMPs include bioretention and/or sand filters in 50% of the parking lots in the watershed, porous pavement with storage in 50% of the parking lots, and dry wells replacing 40% of the manholes along both combined and separate sewers throughout the watershed.

Alternative 6: A Mix of Stormwater BMPs

This alternative examines an implementation program that results in a mixture of BMPs that could be applied throughout the watershed. It includes wetland creation on 50% of the feasible locations, rain barrels installed on 20% of all homes, dry wells installed on 10% of the residences to collect roof runoff, sand filters/bioretention on 25% of the parking lots, porous pavement with underground stormwater storage on 25% of the parking lots, and green roofs on 2% of the homes.

6.2 Evaluation of Alternatives

The six alternatives described above are all designed to meet an interim target of 20% reduction in pollutant loading to Cobbs Creek during wet weather. Each represents a different approach to meeting this interim target. All achieve similar reduction in total load, but can have significantly different results when assessed in other ways. For example, costs for each approach are very different, and each approach differs in the degree that it might meet other planning objectives.

Ultimately, Target C options will be implemented within the watershed by a variety of stakeholders (counties, municipalities, watershed groups, State agencies, private businesses, etc.). In order to gain insight into the strengths and weaknesses of the various approaches, the six alternatives were evaluated using a multi-criteria evaluation program called EVAMIX.

6.2.1 Multi-Criteria Evaluation Using EVAMIX

EVAMIX is a matrix-based, multi-criteria evaluation program that makes use of both quantitative criteria (such as cost that are measured with numbers such as millions of dollars), and qualitative criteria (such as implementability, measured only as high, medium, or low) within the same evaluation, regardless of the units of measure. The use of EVAMIX requires the development of a two dimensional matrix consisting of the alternatives to be evaluated (columns) and a set of evaluation criteria (rows). For every combination of alternative and criteria, a score is assigned. Many of the quantitative criteria were scored using model simulation results, while a number of qualitative criteria were scored based on clearly defined definitions and professional judgment.

The other important input to EVAMIX is the selection of weighting factors for each of the criteria. Weights were provided by the Technical Advisory Group, and a separate EVAMIX simulation was run for each set of weights provided.

In summary, the following were used in carrying out the EVAMIX evaluation:

- The six Target C alternatives being evaluated
- A set of clearly defined criteria used to compare the alternatives
- Scores assigned to every alternative for each criterion
- Weighting factors assigned to each criterion. These weights represent the relative importance of each criterion as provided by the stakeholders.

6.2.2 Evaluation Criteria

Eighteen evaluation criteria were developed to assess the ability of the six Target C alternatives to meet planning objectives in a cost effective manner. Each criterion is described below.

Cost

Capital Cost

(quantitative, dollars)

Capital cost includes the cost of constructing best management practices. Cost estimates are based on unit costs (per gallon, per acre, etc.), are planning-level, and do not account for economies of scale or specific local conditions.

Operations and Maintenance (O&M)

(quantitative, 2003 dollars per year)

O&M cost is the annual cost to maintain the set of BMPs over an appropriate design life. A design life of 20 years is assumed if no specific information is available. When a dollar cost for O&M is not readily available in the literature or local experience, O&M is assumed to be a reasonable percentage of construction cost.

Stream Habitat and Aquatic Life

Peak Stream Velocity

(quantitative, % reduction)

This criterion is based on the maximum stream velocity generated in the SWMM model by the one-year synthetic rainfall record used for alternatives modeling. The percent reduction relative to existing conditions is recorded at the following model cross-sections: CC07986, CC13397, CC14215, CC23213, CC26523, CC33332, CC51627, EIC0639, and WIC0252. The number entered into EVAMIX is the average of the six cross-sections.

Groundwater Infiltration and ET

(quantitative, MG)

Infiltration and evapotranspiration that occur due to BMP addition are added throughout the watershed based on model results. Infiltration and evapotranspiration that occur over the land surface, outside of BMPs, are not included.

Stream Channels and Banks

Frequency of Bankfull Flow

(quantitative, years)

This criterion estimates the return interval of bankfull flow under existing conditions for each of the alternatives. Based on the known 50-year record of streamflow, 12 peak flow events with return intervals of 0.05 to 2 years were chosen. These storms were compiled into a synthetic rainfall record and run for each alternative. Frequency of bankfull flow was estimated through a regression of peak streamflow vs. the original return period under existing conditions.

Flooding

Peak Flood Stage (3 criteria for the 3 locations)

(quantitative, peak stage in feet above city datum)

Three cases were chosen where a bridge deck is located in the 10-year floodplain as defined by FEMA. A storm was identified that just inundates the bridge decks under existing conditions. Each alternative was modeled using the storm, and peak stage was recorded.

Reduction in Peak Streamflow

(quantitative, % reduction)

This criterion is based on the maximum streamflow generated in the SWMM model by the one-year synthetic rainfall record used for alternatives modeling. The percent reduction relative to existing conditions is recorded at the following model cross-sections: CC07986, CC13397, CC14215, CC23213, CC26523, CC33332, CC51627, EIC0639, and WIC0252. The number entered into EVAMIX is the average of the six values.

Water Quality and Pollutant Loads

Annual Average Fecal Coliform Load

(quantitative, col/year)

This criterion measures the estimated annual input of fecal coliform to the stream system from all sources. Fecal coliform is intended to act as a surrogate for a range of disease-causing microorganisms.

Annual Average TSS Load

(quantitative, lb/year)

This criterion measures the estimated annual input of total suspended solids to the stream system from all sources. TSS is intended to act as a surrogate for a range of pollutants, including metals such as copper, lead, and zinc.

Stream Corridors

Area of Wetlands Created

(quantitative, acres)

The creation of wetlands is considered a positive result. This criterion estimates created wetlands intended mainly for stormwater and CSO treatment.

Feasibility

Technical Implementability

(Qualitative; High/Medium/Low)

This qualitative criterion uses the following scoring approach.

High	The technologies in the alternative have been widely and successfully applied. Several local contractors will have experience with the technologies.

Medium	The technologies have been successfully applied in other cities or have been successfully demonstrated locally. At least one local contractor will have experience with the technologies. ("Medium" may also be appropriate for an alternative with a mix of technologies classified as "High" and "Low").
Low	The technologies have been applied only in pilot or demonstration programs and only in a few places. It may be impossible to find a local contractor with experience.

Length of Time to Implement

(Qualitative; High/Medium/Low)

This qualitative criterion uses the following scoring approach.

High	The technologies in the alternative can be implemented in 2 years or less.
Medium	The technologies can be implemented in 2 to 5 years, or the alternative contains a mix of "High" and "Low" technologies.
Low	The technologies take more than 5 years to implement.

Feasibility Within the Legal Structure

(Qualitative; High/Low)

This qualitative criterion uses the following scoring approach.

High	Existing laws require or provide an incentive for implementation. For example, measures proposed may overlap with the "six minimum controls" required by NPDES Phase II regulations.
Low	Existing laws do not affect or provide disincentives for different aspects of the plan.

Social/Political Support

(Qualitative; High/Low)

This qualitative criterion uses the following scoring approach.

High	Overall, the measures proposed will be seen as positive by a majority of stakeholders (citizens, local governments, and non-profits).
Medium	The measure has both positive and negative aspects.
Low	Overall, the measures proposed will be seen as negative by a majority of stakeholders (citizens, local governments, and non-profits).

Degree of Construction Disturbance

(Qualitative; High/Medium/Low)

The proposed BMP that causes the most disturbance will control the assignment of this criterion. Low construction disturbance is positive.

High	Construction will require removal of large amounts of pavement (streets, parking lots) and/or construction will significantly affect parking, movement of people and vehicles, and the noise level. Examples include porous pavement and installation of dry wells in sewer inlets.
Medium	Some pavement removal is required. Effects on parking, traffic patterns, and noise are moderate.
Low	Pavement removal is not required or is minimal. Effects on parking, traffic patterns, and noise are minimal. Rain barrels are one example.

Maintenance Required

(Qualitative; High/Medium/Low)

Low maintenance is positive.

High	Existing public programs, staff, and funding will not cover maintenance, or maintenance will be a large burden on private land owners. Or, frequent maintenance is absolutely critical to BMP effectiveness, as with rain barrels.
Medium	Private land owners will be responsible for minor maintenance chores (e.g., minor landscape maintenance for a bioretention basin that would have been a parking island anyway). Public agencies can handle maintenance with existing staff and budget, and/or will dedicate staff time to outreach, workshops, etc.

Low	Maintenance can be performed through existing programs and existing funding. For example, maintenance of RTC will be integrated into current sewer maintenance.

6.2.3 Criteria Weights

A workshop was held with the Technical Advisory Group for Cobbs Creek to obtain stakeholder input on the relative importance of each of the criteria used in the evaluation. Since the implementation plan consists of recommendations to the various potential partners for implementing a variety of BMPs, it was not necessary to reach consensus on the weights or to select one alternative for implementation. In fact, results for every weight set provided by the participating stakeholders were used in the analysis.

Table 6-3 shows the various weight sets used in the evaluation, as well as an average of all the weights. The weights show the range of priorities tested, and indicate that the various weights provide a good measure of the sensitivity of the results to differing opinions on the importance of each criterion.

Table 6-3 Criteria Weights

	Criteria	Average	Stakeholder or Stakeholder Group											
			1	2	3	4	6	7	8	9	10	11	12	13
1	Construction Cost	15.1	20	15	15	25	10	20	3	5	25	30	10	20
2	Operations and Maintenance Cost	10.2	10	10	15	15	10	0	3	15	15	15	10	5
3	Peak Stream Velocity	4.6	9	5	5	1	4	5	1	10	2	10	10	7
4	Groundwater Infiltration	4.7	6	5	5	2	10	0	2	10	3	5	10	3
5	Frequency of Bankfull Flow	7.9	10	10	10	2	14	10	3	10	3	15	5	10
6	Frequency of Flooding	6.9	5	5	5	12	10	10	1	5	10	2	5	8
7	Peak Streamflow	4.3	3	5	5	3	4	0	9	5	5	2	5	2
8	TSS Load	8.4	4	15	5	4	7	30	1	5	5	2	5	6
9	Fecal Coliform Load	6.7	4	10	5	1	7	0	24	5	5	2	5	4
10	Wetland Creation	6.4	6	10	5	1	10	15	5	5	2	2	5	10
11	Technical Implementability	5.1	7	2	5	2	6	10	5	5	5	5	10	5
12	Length of Time to Implement	3.8	3	2	0	6	2	2	10	5	5	5	2	1
13	Feasibility within the Legal Structure	5.2	2	2	10	8	2	3	10	5	5	0	6	1
14	Social/Political Support	6.9	9	2	10	8	2	2	20	5	5	5	10	12
15	Degree of Construction Disturbance	3.8	3	2	0	10	2	3	5	5	5	0	2	6

Table 6-4 EVAMIX Criteria Scores and Result Summary

Criterion	Alternative	5	1	3	6	4	2
	Ave Rank	1.2	1.8	3.2	4.2	4.8	5.8
Capital Cost	$ (million)	36.0	7.1	7.4	19.7	13.8	75.8
Operations and Maintenance Cost	$/yr	5.31E+04	1.05E+05	5.40E+03	2.52E+05	2.25E+05	7.01E+06
Reduction in Peak Velocity	%	1.07	0.29	0.61	1.1	0.69	0.15
Infiltration and ET in BMPs	MG	374	83.2	96.9	211	86.1	83.2
Frequency of Bankfull Flow at Downstream USGS Gauge	Yr	0.39	0.35	0.35	0.35	0.35	0.33
Peak Flood Stage at Cr-Sec 1 (CC-05876)	Ft	17.0	17.3	17.4	17.2	17.4	17.2
Peak Flood Stage at Cr-Sec 2 (CC-13139)	Ft	27.5	27.8	27.9	27.8	27.8	27.7
Peak Flood Stage at Cr-Sec 3 (CC-14540)	Ft	30.7	30.9	31.0	30.8	31.0	30.9
Reduction in Peak Streamflow	%	5.1	2.2	1.4	3.8	1.3	2.8
Annual Average Fecal Coliform Load	#/yr	1.10E+16	7.78E+15	1.14E+16	1.15E+16	1.16E+16	9.32E+15
Annual Average TSS Load	lb/yr	2.65E+06	2.57E+06	2.72E+06	2.80E+06	2.75E+06	2.60E+06
Area of Treatment Wetland Created	Ac	50	25	50	25	50	25
Technical Implementability	L/M/H	H	H	H	M	M	H
Length of Time to Implement	L/M/H	H	L	L	M	M	M
Feasibility Within the Legal Structure	L/H	L	H	L	L	L	H
Social-political support	L/M/H	H	M	L	M	L	L
Degree of Construction Disturbance	L/M/H	H	L	L	M	L	M
Maintenance Required	L/M/H	L	L	M	M	M	H

6.3 Evaluation Results

Table 6-5 shows the scores assigned to each alternative and the units the scores represent across all criteria. The first row of the table shows the alternatives in order of their ranks, from most desirable to least desirable. The second row indicates the average rank that the alternative achieved using all of the weight sets provided by the stakeholders. In general, the results were consistent.

- **Highly Ranked:** Alternative 5 was ranked as the best for 10 of the thirteen stakeholder weight sets, and was ranked 2^{nd} on three of the weight sets. Alternative 1 ranked 1^{st} on three of the weight sets, and 2^{nd} on all the others. These two were clearly the highest ranked alternatives, as evidenced by their average rankings.

- **Moderately Ranked:** Alternative 3 was either ranked as the 3^{rd} best or 4^{th} best alternative for all weight sets. Alternative 6 was very sensitive to the selected weight set, and was ranked anywhere for 3^{rd} best to 6^{th} best.

- **Lowest Ranked:** Alternative 4 ranked anywhere from 4^{th} best to 6^{th}, and was one of the less highly ranked alternatives. Alternative 2 was clearly the worst alternative, scoring 5^{th} best for two weight sets, and 6^{th} best (last) on all the others.

Table 6-8 shows the alternatives in order of preference, highest to lowest. The table presents a summary of the strengths and weaknesses of each of the alternatives.

Table 6-5 Alternative Evaluation Summary

Target C: Wet Weather Alternatives	Avg. Rank	Strengths	Weaknesses	Comments
Alt. 5: Stormwater BMPs: Focus on Public Property/Parking - bioretention in 50% of parking lots - porous pavement in 50% of parking lots - dry wells in 40% of sewer inlets	1.23	Reductions in peak flow and peak velocities; significant recharge through porous pavement; favorable political/social climate	Relatively expensive; difficult to implement, with a long period of time to full implementation	Overall best ranked (first or second best using all weights). Indicates that main strength comes through high implementation of porous pavement
Alt.1 Real Time Control and Low-Cost Stormwater BMPs - RTC in combined areas - all feasible wetlands in separate-sewered areas - rain barrels on 25% of homes (sep. areas) - dry wells for 25% of homes (sep. areas) - bioretention in 5% of parking lots (sep. areas)	1.77	Lowest capital cost due to use of Real Time Control option; full implementation is relatively rapid; implementation relatively easy with low construction disturbance	Relatively little recharge; relatively low reduction in peak flow and peak velocity; relatively low fecal coliform/TSS removal; low implementation of wetland option	Overall, 2nd ranked alternative. Main strength comes from cost and ease of implementation. Use of private-based alternatives with limited treatment or storage means poorer ranking in water quality aspects.
Alt. 3: Low-Cost Stormwater BMPs throughout Watershed - all feasible wetlands - rain barrels on 25% of homes - dry wells for 15% of homes	3.23	Generally low cost (capital and O&M together); easy to implement; short time frame for implementation; minimal construction disturbance; full realization of wetland potential	Poor infiltration; poor peak flood and velocity reductions; weak political/social support	Mid-ranked alternative. Reliance on private sector solutions (dry wells, rain barrels) is low cost, but requires significant cooperation from citizens, thus harder to implement.
Alt. 6: A Mix of Stormwater BMPs - half of feasible wetlands - rain barrels on 20% of homes - dry wells for 10% of homes - bioretention in 25% of parking lots - porous pavement in 25% of parking lots - green roofs on 2% of buildings	4.15	Mid-range cost; good peak flow and velocity reduction; excellent reduction in TSS and fecal coliform	Relatively high O&M and capital costs; moderate to low feasibility; limited use of wetlands	BMP mixture, which would be done for practicality and to provide a variety of BMP approaches, results only in a moderately effective solution.

Alt. 4: Stormwater BMPs Focusing on Private Property - rain barrels on 25% of homes - dry wells for 25% of homes - green roofs on 2% of buildings	4.77	Full use of wetlands; limited construction disturbance	Poor reduction in peak flows, flooding, and peak velocity; poor infiltration; moderate to high cost; focus on private property implementation makes it harder to achieve full implementation	Relatively poorly ranked alternative across all weight sets
Alt 2: Structural Storage and Low-Cost Stormwater BMPs - tank storage for combined sewage - all feasible wetlands (separate-sewered areas) - rain barrels on 25% of homes (sep. areas) - dry wells for 25% of homes (sep. areas) - bioretention in 5% of parking lots (sep. areas)	5.85	Technically feasible; easy to implement within regulatory structure	Extremely high cost; fairly limited effect on peak stream flow and peak velocity; relatively poor reduction in fecal coliform and TSS	Ranked as poorest of the alternatives. Main drawbacks are high cost and limited water quality benefit.

6.4 General Conclusions

The alternatives analysis presented above is not meant to yield an exact scenario for implementation. Rather, the computerized option screening results, the extensive modeling of BMPs, and the evaluation of the alternatives for Target C were all designed to help with developing a cost-effective approach to management of the Cobbs Creek watershed. Each analysis yielded additional insight into approaches that are most applicable to the specific conditions found in the watershed. The general conclusions resulting from the various computer analyses are presented here. These conclusions form the basis for the recommended implementation plan provided in section 7.

The primary conclusion is that *no single approach can achieve all the goals and objectives. The use of Targets with associated management approaches and schedules is considered the most practical and efficient way to achieve the planning objectives.*

Target A and Target B have specific measures that must be implemented, and full achievement of the targets is envisioned. For Target C, no single option or BMP is sufficient, and none are clearly superior to all others. This indicates that flexibility, "seeing what works where, and adjusting", is probably the best approach to implementation. A mixed approach (not having a plan to implement certain BMPs as a primary approach), however, appears to lead to only moderately successful alternatives.

Some general conclusions are:

- Alternatives that rely on the use of public property provide more ability to control implementation than those that rely on private property.

- Private property BMPs (rain barrels, residential dry wells) can be effective and low cost, if reasonable levels of implementation and regular maintenance can be achieved.

- Porous pavement and parking lot options are extremely effective at meeting Target C objectives for infiltration.

- Real time control is an attractive option for the CSO areas of Cobbs Creek because it is effective and low cost.

- Structural controls such as large retention tanks for CSO control are a poor choice in terms of cost-effectiveness and effectiveness at restoring lost resources.

- Placing BMPs in CSO areas tends to maximize their effectiveness when compared to the same BMP in a separate sewered area. This is shown by the lower cost-per-gallon of stormwater treated in CSO areas.

- Use of wetlands for stormwater treatment is both effective and relatively inexpensive.

- Regional basins (infiltration, wet retention) can be cost-effective but are probably not feasible on a large scale in the Cobbs Creek watershed due to space constraints.

- There are larger differences in cost-effectiveness when considering implementation in CSO areas vs. implementation in separate-sewered areas when ET and/or infiltration are minor components of the BMP (e.g., dry wells in sewer inlets, residential dry wells, sand filters). These low ET/infiltration BMPs are more effective when placed in CSO areas rather than in separate sewered areas.

- Because there is generally a greater load and volume reduction per dollar spent in CSO areas, pollution trading options may be an interesting implementation approach to consider.

Section 7: Implementation Guidelines

This section presents the plan for implementation of those water management options that were identified by the Darby-Cobbs Watershed Partnership as best meeting the planning goals and objectives under the site specific conditions of Cobbs Creek. Following extensive screening and evaluation, only those options that are cost-effective and feasible under the specific conditions found in the Cobbs Creek watershed are included in the implementation plan. The section starts with summary tables of the recommended options, organized by the level of government or agency responsible for carrying out the recommendation under current regulations. More detailed information on each recommended option is then presented for each of the three targets.

Summary Tables

The summary section first presents the options in tables. A separate table was made presenting recommended actions for PADEP, Montgomery County, Philadelphia, watershed municipalities, and other stakeholders. Tables indicate which options are the responsibility of that agency or level of government for each of the three targets. In the following sections, more detailed information about recommended options is presented, organized in groups under each of three water management targets. Each option is first presented in a summary table format (what, who, where, and when), followed by text and figures that further describe the option and the implementation approach being recommended.

PADEP Actions

Action	Where	When
Industrial Stormwater Pollution Prevention	Industrial sites	Short-term
Construction Stormwater Pollution Prevention	Construction sites	Short-term
Pollution Trading	To be determined	Long-term
Use Review and Attainability Analysis	To be determined	Short-term
Stewardship/Advocacy of Watershed Management Plan	Watershed-wide	Short-term
Watershed-Based Permitting	Watershed-wide	Medium-term
Monitoring and Reporting	Watershed-wide	Ongoing

Philadelphia Actions

Action	Where	When
Pet Waste, Litter, and Dumping Ordinances	Watershed-wide	Short-term
Public Education	Watershed-wide	Short-term
School-Based Education	All schools	Short-term
Public Participation and Volunteer Programs	Watershed-wide	Short-term
Inspection and Cleaning of Combined Sewers	Watershed-wide	Short-term
Combined Sewer Rehabilitation	Combined-Sewered Areas	Medium-term
Stream Cleanup and Maintenance	Cobbs Creek within or along City boundary	Short-term
Enhancing Stream Corridor Recreational and Cultural Resources	Along the stream corridor	Medium-term
Bed Stabilization and Habitat Restoration	Cobbs Creek 40%, West Indian Creek 44%	Short-term
Bank Stabilization and Habitat Restoration	Middle section of Cobbs Creek	Short-term
Channel Realignment and Relocation	Cobbs Creek, East and West Indian Creek	Short-term
Plunge Pool Removal	CSO and stormwater outfalls	Short-term
Improvement of Fish Passage	Woodland Avenue dam	Short-term
Wetland Creation	Riparian corridor	Short-term
Invasive Species Management	Riparian corridor	Short-term
Reforestation	Riparian corridor	Short-term
Requiring Better Site Design in Redevelopment	Watershed-wide	Short-term
Stormwater and Floodplain Management	Watershed-wide	Short-term
Post-Construction Stormwater Runoff Management	Municipalities required to do Phase II permit	Short-term
Sanitary Sewer Overflow Detection	Separate-Sewered Areas	Short-term
Sanitary Sewer Overflow Elimination: Structural Measures	Separate-Sewered Areas	Medium-term
CSO Control Program	Philadelphia combined sewer system	Short-term
Catch Basin and Storm Inlet Maintenance	All inlets	Short-term
Street Sweeping (Philadelphia Streets Department)	Streets and Parking Lots	Short-term
Responsible Landscaping on Public lands	Green space	Short-term
Responsible Bridge and Roadway Maintenance	Roadways and bridges	Short-term
Reducing Effective Impervious Cover through Better Site Design	Watershed-wide	Long-term
Increasing Urban Tree Canopy	Watershed-wide	Medium-term
Porous Pavement and Subsurface Storage	Parking lots watershed-wide	Long-term
Green Rooftops	Appropriate public buildings chosen by PWD	Medium-term
Capturing Roof Runoff in Rain Barrels or Cisterns	Homes where dry wells are not feasible	Medium-term
Maintaining/Retrofitting Existing Stormwater Structures	Watershed-wide	Short-term
Retrofitting Existing Sewer Inlets with Dry Wells	Inlets in combined-sewered areas	Long-term
Residential Dry Wells, Seepage Trenches, and Water Gardens	Homes and schools watershed-wide	Long-term
Bioretention Basins and Porous Media Filtration	Watershed-wide	Long-term
Treatment Wetlands: Onsite and Regional	Riparian corridor	Medium-term
Monitoring and Reporting	Watershed-wide	Ongoing

Delaware and Montgomery County Municipality Actions

Action	Where	When
On-Lot Disposal (Septic System) Management	All areas with septic systems	Short-term
Pet Waste, Litter, and Dumping Ordinances	Watershed-wide	Short-term
Public Education	All Cobbs Creek municipalities	Short-term
School-Based Education	All schools	Short-term
Public Participation and Volunteer Programs	All Cobbs Creek municipalities	Short-term
Capacity Management Operation and Maintenance	Separate-Sewered Areas	Short-term
Inspection and Cleaning of Sanitary Sewers	Separate and Combined Sewered Areas	Short-term
Sanitary Sewer Rehabilitation	Separate-Sewered Areas	Medium-term
Illicit Discharge, Detection, and Elimination (IDD&E)	All areas with a storm or combined sewer.	Short-term
Stream Cleanup and Maintenance	Cobbs Creek within or along City boundary	Short-term
Enhancing Stream Corridor Recreational and Cultural Resources	Along the stream corridor	Medium-term
Bed Stabilization and Habitat Restoration	Cobbs Creek 40%, West Indian Creek 44%	Short-term
Bank Stabilization and Habitat Restoration	Middle section of Cobbs Creek	Short-term
Channel Realignment and Relocation	Cobbs Creek, East and West Indian Creek	Short-term
Plunge Pool Removal	CSO and stormwater outfalls	Short-term
Improvement of Fish Passage	Woodland Avenue dam	Short-term
Wetland Creation	Riparian corridor	Short-term
Invasive Species Management	Riparian corridor	Short-term
Reforestation	Riparian corridor	Short-term
Requiring Better Site Design in Redevelopment	Watershed-wide	Short-term
Stormwater and Floodplain Management	Watershed-wide	Short-term
Post-Construction Stormwater Runoff Management	Municipalities required to do Phase II permit	Short-term
Sanitary Sewer Overflow Detection	All areas with separate sewers	Ongoing program
Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers	Separate-Sewered Areas	Medium-term
Catch Basin and Storm Inlet Maintenance	All inlets	Ongoing program
Street Sweeping	Streets and Parking Lots	Short-term
Responsible Landscaping on Public lands	Green space	Short-term
Responsible Bridge and Roadway Maintenance	Roadways and bridges	Short-term
Reducing Effective Impervious Cover through Better Site Design	Watershed-wide	Long-term
Increasing Urban Tree Canopy	Watershed-wide	Medium-term
Porous Pavement and Subsurface Storage	Parking lots watershed-wide	Long-term
Capturing Roof Runoff in Rain Barrels or Cisterns	Homes where dry wells are not feasible	Medium-term
Maintaining/Retrofitting Existing Stormwater Structures	Watershed-wide	Short-term
Residential Dry Wells, Seepage Trenches, and Water Gardens	Homes and schools watershed-wide	Long-term
Bioretention Basins and Porous Media Filtration	Watershed-wide	Long-term
Treatment Wetlands: Onsite and Regional	Riparian corridor	Medium-term
Monitoring and Reporting	Watershed-wide	Ongoing

7.1 Target A: Dry Weather Water Quality and Aesthetics

Regulatory Approaches

AR1 On-Lot Disposal (Septic System) Management
AR2 Pet Waste, Litter, and Dumping Ordinances

Public Education and Volunteer Programs

AP1 Public Education
AP2 School-Based Education
AP3 Public Participation and Volunteer Programs

Municipal Measures

AM1 Capacity Management Operation and Maintenance (CMOM)
AM2 Inspection and Cleaning of Combined Sewers
AM3 Sanitary Sewer Rehabilitation
AM4 Combined Sewer Rehabilitation
AM5 Illicit Discharge, Detection, and Elimination (IDD&E)
AM6 Stream Cleanup and Maintenance

AO1 Enhancing Stream Corridor Recreational and Cultural Resources

AMR Monitoring and Reporting

7.1.1 Regulatory Approaches

On-Lot Disposal (Septic System) Management (AR1) Related goals: 5, 6 Related Indicators: 7, 11, 19, 20			
What	Who	Where	When
Septic tank management program required as part of the municipality's Official Act 537 Sewage Facilities Plan	Municipalities through state certified Sewage Enforcement Officers (SEO) • All Act 537 plans are outdated and should be updated with exception of Lower Merion Township	All areas with septic systems; See Table 7-1	Within next 5 years;

Septic tank management programs are presently required of all Pennsylvania municipalities as part of their Official Act 537 Sewage Facilities Plans. Keeping these plans up to date, including provisions related to operation and maintenance of on-lot sewage disposal systems (OLDS) is an important means of controlling the release of pathogens and nutrients within the watershed.

The Pennsylvania Sewage Facilities Act (Act 537) requires that all Commonwealth municipalities develop and implement comprehensive official plans that provide for resolution of existing sewage disposal problems, provide for future sewage disposal needs of new land development, and provide for future municipal sewage disposal needs (See Section 1). When a municipality adopts a plan, the plan is submitted for review and approval by the Pennsylvania Department of Environmental Protection (PADEP). By regulation, the planning process is not final until an Act 537 Plan has been approved by PADEP. Municipalities are required to revise (unless they are exempt from revising) the "Official Plan" if a new land development project is proposed or if unanticipated conditions or circumstances arise, making the base plan inadequate. There are two basic types of plan changes. "Plan revisions" resulting from new land development are completed using "planning modules" that are specific to individual projects. An "update revision" is used by municipalities to make broad changes to their Official Plan.

Act 537 planning has been a municipal requirement since July 1, 1967. Legally, all municipalities have an Act 537 Plan; however, some plans are newer and more detailed than others. A list of municipalities within the Cobbs Creek Watershed indicating the age and status of their Act 537 Plans is presented in Table 7-1 below. Note that all municipalities have outdated plans, with the possible exception of Lower Merion Township and the City of Philadelphia. Municipalities are shown in Figure 7-1.

Table 7-1 Act 537 Plans in Cobbs Creek Watershed

Municipality	County	Plan Approval Date	Status
Colwyn Borough	Delaware	1/1/1972	> 20 years; update in progress
Darby Borough	Delaware	1/1/1972	> 20 years; update in progress
East Lansdowne Borough	Delaware	1/1/1972	> 20 years; update in progress
Haverford Township	Delaware	1/1/1972	> 20 years; update in progress
Lansdowne Borough	Delaware	1/1/1972	> 20 years; update in progress
Lower Merion Township	Montgomery	6/16/1998	Plan between 5 and 10 years old
Millbourne Borough	Delaware	1/1/1972	> 20 years; update in progress
Narberth Borough	Montgomery	1/1/1973	> 20 years
Philadelphia	Philadelphia	11/10/1993	Plan between 5 and 10 years old
Radnor Township	Delaware	1/1/1974	> 20 years; update in progress
Upper Darby Township	Delaware	3/1/1975	> 20 years; update in progress
Yeadon Borough	Delaware	1/1/1972	> 20 years; update in progress

Figure 7-1 Cobbs Watershed Municipalities

Relevant Provisions of Act 537

- All municipalities must develop and implement an official sewage plan that addresses their present and future sewage disposal needs. Local agencies are required to employ both primary and alternate Sewage Enforcement Officers (SEO) responsible for overseeing the daily operation of that agency's OLDS permitting program.
- Local agencies, through their SEO, approve or deny permits for construction of on-lot sewage disposal systems prior to system installation. The SEO is responsible for conducting soil profile testing, percolation testing, OLDS design review, and approving or denying OLDS permit applications.
- Local agencies, through their SEO, must manage the permitting program for individual on-lot disposal systems and community on-lot systems with design flows of 10,000 gallons-per-day or less.
- Municipalities are required to assure the proper operation and maintenance of sewage facilities within their borders.

Municipalities should maintain information on the location, type and operational status of existing sewage facilities, as well as results of sanitary surveys. This information, however, is often incomplete. Septic tank data were included in the U.S. census through 1990, but were believed to be inaccurate and were not included in the 2000 census. County health departments may have information, and assessments have been attempted through voluntary questionnaires submitted by municipalities. These tasks have proven to be difficult but can be completed through perseverance.

Implementation of a Comprehensive Septic Tank Management Program

Each municipality shown in the above table should update its Act 537 plan in the coming 5-year period.

Table 7-2 below presents 1990 census sanitary survey results along with the area within the Cobbs Creek Watershed for Delaware County Municipalities. Implementation of septic system management programs should be actively pursued in municipalities that have a large estimated number of septic systems and a high percentage of their total area within the watershed: Haverford Township, Upper Darby Township, and Yeadon Borough.

Table 7-2 Septic System Data from 1990 Census

Municipality	Area (Acres)	Area in Watershed (Acres)	Percent of Area in Watershed (Acres)	Housing Units with Public Sewer	Housing Units with Septic Systems	Total Housing Units Occupied
Colwyn borough	164	96	58.60%	970	0	924
Darby borough	522	140	26.80%	4027	8	3709
East Lansdowne borough	132	132	100.00%	999	0	961
Haverford township	6406	3873	60.50%	17942	250	17727
Lansdowne borough	753	111	14.70%	5092	11	4917
Lower Merion township	15265	2375	15.60%			
Millbourne borough	44	44	100.00%	405	4	379
Narberth borough	316	268	84.90%			
Philadelphia city	91287	3562	3.90%			
Radnor township	8811	32	0.40%	9568	1013	9838
Upper Darby township	4824	2700	56.00%	33925	137	32746
Yeadon borough	1032	910	88.20%	1973	40	4794

The implementation of comprehensive septic tank management programs in those three municipalities ideally will be consistently designed to provide degrees of protection based on an assessment of the environmental sensitivity of the area.

The EPA has recently issued Voluntary National Guidelines for Management of Onsite and Clustered Wastewater Treatment Systems (EPA 832-B-03-001), covering all aspects of a comprehensive program, from design, inspection, and enforcement to public education and long-term planning. This document presents several different management models to choose from; division of responsibility and ownership between private land owners and public agencies varies between the different models. Municipalities should select that approach which best suits their conditions.

The Five Management Models

- Management Model 1 - "Homeowner Awareness" specifies appropriate program elements and activities where treatment systems are owned and operated by individual property owners in areas of low environmental sensitivity. This program is adequate where treatment technologies are limited to conventional systems that require little owner attention. To help ensure that timely maintenance is performed, the regulatory authority mails maintenance reminders to owners at appropriate intervals.
- Management Model 2 - "Maintenance Contracts" specifies program elements and activities where more complex designs are employed to enhance the capacity of conventional systems to accept and treat wastewater. Because of treatment complexity, contracts with qualified technicians are needed to ensure proper and timely maintenance.
- Management Model 3 - "Operating Permits" specifies program elements and activities where sustained performance of treatment systems is critical to protect public health and water quality. Limited-term operating permits are issued to the owner and are renewable for another term if the owner demonstrates that the system is in compliance with the terms and conditions of the permit. Performance-based designs may be incorporated into programs with management controls at this level.
- Management Model 4 - "Responsible Management Entity (RME) Operation and Maintenance" specifies program elements and activities where frequent and highly reliable operation and maintenance of decentralized systems is required to ensure water resource protection in sensitive environments. Under this model, the operating permit is issued to an RME instead of the property owner to provide the needed assurance that the appropriate maintenance is performed.
- Management Model 5 - "RME Ownership" specifies that program elements and activities for treatment systems are owned, operated, and maintained by the RME, which removes the property owner from responsibility for the system. This program is analogous to central sewerage and provides the greatest assurance of system performance in the most sensitive of environments.

Pet Waste, Litter, and Dumping Ordinances (AR2) Related goals: 5, 6, 8, 9 Related Indicators: 7, 8, 9, 10, 11, 16, 17, 18, 19, 20			
What	Who	Where	When
Adopt and enforce ordinance to require the removal of pet waste by the animal's owner within the municipality; Adopt and enforce ordinance to prohibit littering and dumping within the municipality.	See Table 7-3 (may not identify all municipalities with ordinance)	Entire Watershed	within 5 years; update as needed

Some municipalities in the Cobbs Creek watershed have adopted an ordinance to address removal of pet waste by the animal's owner and an ordinance that prohibits littering and dumping. These ordinances tend to be similar in scope but vary in penalties. Table 7-3 shows the municipalities in the watershed that are known to have adopted pet waste and littering ordinances.

Table 7-3 Pet Waste and Littering Ordinances in the Cobbs Creek Watershed

Municipality	Pet Waste Ordinance	Littering and Dumping Ordinance
Colwyn Borough		
Darby Borough		
East Lansdowne Borough**		
Haverford Township	X	X
Lansdowne Borough	X	X
Lower Merion Township		X
Millbourne Borough		
Narberth Borough		
Philadelphia		
Radnor Township	X	
Upper Darby Township		
Yeadon Borough		

*** Note: Ordinances for East Lansdowne Borough were not reviewed for this analysis.*

Source: www.ordinance.com, Delaware Valley Regional Planning Commission

Municipalities currently without ordinances are strongly encouraged to adopt them within the next two years. As an example of possible ordinance language, the following excerpts from Haverford Township's pet waste ordinance and Lansdowne Borough's Littering and Dumping Ordinance appear below.

Pet Waste Ordinance	Littering and Dumping Ordinance
Haverford Township All excrement from animal(s) on the owner's property will be the responsibility of the owner of the offending animal to abate, and the owner shall clean the area of excrement on a daily basis. It shall be the duty of the owner of any animal to pick up and remove in its entirety any excrement from said animal from all public and private property. Excrement must not be deposited in a street or at a curbside, but must be removed from the area completely.	Lansdowne Borough The practice of throwing or dumping any discarded matter of any kind in or on any private or public property, vacant or occupied within the Borough of Lansdowne is prohibited. The practice of storing or depositing abandoned or junked vehicles, machinery, etc., in or on any public or private property, vacant or occupied is prohibited. The use or ownership of any unsafe or dangerous building or structure upon any public or private property, vacant or occupied, is prohibited. Driving or permitting the use of a motor vehicle that deposits its contents or other debris on any road within the Borough of Lansdowne is prohibited.

While pet waste and littering ordinances are enacted primarily for aesthetic purposes, reduction of pathogens and debris in stormwater, and thus in Cobbs Creek, can be reduced through their enforcement. Municipalities can assist residents in abiding by ordinances by placing trash cans in areas with higher pedestrian traffic. Plastic bags should be provided with trash cans in areas heavily used by dog owners. Homeowners' associations should also be asked to notify residents of these ordinances and to provide trash cans and plastic bags in those neighborhoods as well.

7.1.2 Public Education and Volunteer Programs

Public Education (AP1) Related Goals: 7, 8, 9, 10 Related Indicators: 16, 17, 18, 19, 20, 21			
What	Who	Where	When
Public Education Plan Educational Program Implementation	Municipalities on the Phase II List (see Table 7-4)	All municipalities in the Cobbs Creek Watershed	Short-term: first 5 years coinciding with the stormwater permit (See Table 7-5)

Public education about watershed management is an integral part of the watershed implementation plan. It is designed to educate citizens on the importance of the watershed to the community, and on ways that individual behavior can impact water quality and the riparian and aquatic environment associated with Cobbs Creek. In accordance with the Cobbs Creek Plan's stated purpose of integrating various existing programs, and to avoid duplication of effort, the recommended implementation plan follows the Stormwater Management Program Protocol ("Protocol") to meet the six Minimum Control Measures required of municipal permittees under Phase II NPDES Stormwater Regulations (found at 40 CFR §§ 122.26 – 123.35). In this way, implementation of these public education measures by municipalities will satisfy federal NPDES permit requirements for municipal separate storm sewer systems ("MS4s"), described in detail at 40 CFR §122.34.

Table 7-4 lists the municipalities that should work together with the City of Philadelphia on Public Education about watershed management issues. Assuming that a single, watershed-wide public education campaign focusing on all three targets (A, B, and C) can be implemented, PWD should, at a minimum, work with Haverford Township, Upper Darby Township, and Lower Merion Township to cover most of the watershed.

Table 7-4 Cobbs Creek Municipalities on Phase I or II Stormwater List

Municipality	County	% of Muni. Area Drained by Watershed	% of Watershed within Muni.
Colwyn Borough	Delaware	55%	1%
Darby Borough	Delaware	17%	1%
E. Lansdowne Borough	Delaware	100%	1%
Haverford Twshp.	Delaware	59%	26%
Lansdowne Borough	Delaware	9%	<1%
Millbourne Borough	Delaware	100%	<1%
Radnor Twshp.	Delaware	1%	<1%
Upper Darby Twshp.	Delaware	50%	18%
Yeadon Borough	Delaware	85%	6%
Lower Merion Twshp.	Montgomery	18%	19%
Narberth Borough	Montgomery	92%	2%
City of Philadelphia	Philadelphia	4%	26%

Public Education Plan

PWD and the primary watershed municipalities should jointly develop a public education plan. The public education plan must target homeowners, business owners, and developers, focusing on connections between their actions, stormwater runoff, and water quality. By the end of Year 1, cooperating municipalities should have a comprehensive plan in place that will help tap into the target audiences' existing communication channels to inform them about improving stormwater quality. During the following permit years, municipalities should monitor the effectiveness of the plan, and update it to ensure information about the target audiences is accurate.

PADEP has made available a template for a public education plan, available on the PADEP website, www.dep.state.pa.us, directLINK "stormwater". The plan should include an approach to collecting information on the three target audience categories. Municipalities should create a comprehensive inventory of the newsletters, newspapers, web sites, meetings, magazines, organizations, associations, etc. used by the target audiences. Cooperation of the municipalities under the Cobbs Creek Watershed Plan in gathering this information should help eliminate redundancy of effort. During the remaining years of the stormwater permit, municipalities are responsible for ensuring that information in the public education plan is accurate and current.

In addition to the PADEP mandated information, other information relevant to watershed management should be included on topics such as:

- Improper Disposal to Storm Drains
- Automobile Maintenance
- Car Washing
- Animal Waste Collection
- Restorative Redevelopment: Public Education Aspects

Public Education Implementation

Once the public education plan is developed, it must be implemented. This means distributing educational materials provided by PADEP that contain messages related to watershed (and stormwater) management. Municipalities can find educational materials needed to implement the educational program on the PADEP website, www.dep.state.pa.us, directLINK "stormwater."

To fulfill NPDES stormwater permit requirements, municipalities should implement two phases of educational outreach. During the first stage, the focus is on raising the awareness of target audiences. In the second stage, municipalities should aim to educate the target audiences about the problems and potential solutions. PADEP presents requirements in the stormwater permit for the "what" and "when" of this minimum measure component, but it does not specify the "how." Municipalities should use their Public Education Plan to determine the most effective means of getting educational materials into the hands of target audiences. Any additional educational activities should show compliance with this Minimum Control Measure. This includes educational activities by watershed groups, and certainly should make use of the existing Cobbs Creek Partnership activities.

In Year 1, municipalities are required to start raising target audience awareness. Raising awareness can be accomplished by use of PADEP materials. PADEP has made available copies of the pamphlet entitled, "When It Rains, It Drains" (available on the PADEP website, www.dep.state.pa.us, directLINK "stormwater)." This document addresses the issue of pollution related to stormwater runoff and activities that citizens can use to improve stormwater quality. It also provides an overview of a typical stormwater management program. Using the information on distribution channels in the Public Education Plan, municipalities should disseminate these pamphlets to all the target audience categories in the community.

In Year 2, municipalities should begin to educate all the target audiences. This includes distributing fact sheets to developers about their responsibilities under the state and federal stormwater regulations. To meet this requirement, municipalities should distribute the Fact Sheets prepared by PADEP, and run a stormwater ad in local newspapers.

In addition to targeting developers, municipalities may distribute posters to schools, community organizations and institutions, and businesses. Topics such as responsible vehicle maintenance, household hazardous waste disposal, and pet waste management are important to stormwater management. PADEP has developed a series of posters that convey messages about these topics.

Another useful measure is storm drain stenciling. While not required by the Protocol, any stenciling done by outside organizations may contribute to meeting permit requirements for this Minimum Control Measure.

Public education directors should check any links to PADEP's stormwater website and update the links if necessary.

In Years 3-5, the implementation continues. This consists mainly of continuing with distribution of posters and fact sheets, and running additional ads in local newspapers.

The schedule for developing and implementing the plan to meet Phase II stormwater requirements is shown in Table 7-5 below.

Table 7-5 Schedule for Implementation of the Public Education Program

PERMIT YEAR	**Education Plan**	**Educational Program**
Year 1	Determine Target Audience Develop Public Education Plan Raise Target Audience Awareness	• Disseminate materials to all target audiences using appropriate distribution channels • Newspaper advertisement • Other components of Plan
Years 2-5	Implement the plan Revise Plan as needed	• Disseminate materials to all target audiences using appropriate distribution channels • Newspaper advertisement • Other components of Plan

Source: PADEP MS4 Stormwater Management Program Protocol, 2003

School-Based Education (AP2) Related Goals: 8, 9 Related Indicators: 17, 18, 21			
What	Who	Where	When
Implement PA Environmental Education Curriculum; engage schoolchildren and watershed protection through resources such as Cobbs Creek Community Environmental Education Center and the John Heinz Wildlife Refuge at Tinicum.	School districts, supported by municipal governments and non-profits	All schools	Short-term (within 5 years)

Besides requirements found in the MS4 Stormwater Management Program Protocol, another important aspect of public education is to reach children through school curricula.

School-based watershed education takes many forms, from lesson plans within the classroom, to hands-on activities outside of the classroom such as field trips to Cobbs and Darby creeks and nearby nature centers, as well conducting actual restoration projects. Teacher training programs, developed to assist teachers in bringing watershed concepts to their students, are critical, as are partnerships with groups like the Cobbs Creek Community Environmental Education Center Inc, and the John Heinz Wildlife Refuge at Tinicum. Being engaged in actual restoration projects, whether through service learning, after school clubs, or as part of lesson plans translates lessons into action.

Sources for lesson plans include the following:

- Incorporate the Pennsylvania Environmental Education Curriculum developed by PADEP into middle school curricula. This curriculum introduces concepts in watersheds, wetlands, stormwater, drinking water, and water and air pollution.

- Use local examples of watershed protection and restoration to enhance the program. The Cobbs Creek Community Environmental Education Center works with schools to provide watershed-based educational opportunities, including the Environmental Scholars Program, Tree Survey Project, Urban Watershed Program, Environmental Clubs, Learning Grove / Trail Development Project, Park Management Program, and Teacher Training Program.

Public Participation and Volunteer Programs (AP3) Related Goals: 4, 6, 7, 8, 9, 10 Related Indicators: 15, 10, 11, 12, 13, 14, 16, 17, 18, 21			
What	Who	Where	When
Public Participation Volunteer Monitoring and Storm Drain Stenciling	Municipalities	All municipalities in the Cobbs Creek Watershed	First 5 years coinciding with the stormwater permit.

Public participation is another facet of implementation that must follow the Stormwater Management Program Protocol ("Protocol") to meet the six Minimum Control Measures required of municipal permittees under the Phase II NPDES Stormwater Regulations (found at 40 CFR §§ 122.26 – 123.35). The public must participate in issues related to municipal actions to address stormwater impacts on water quality. This includes new planning initiatives, changes to ordinances and other local regulations. This requirement overlaps the public participation aspects of the watershed management plan, and suggests that a unified and coordinated approach between municipalities would be efficient. All municipalities in the watershed (listed in Table 7-4) are required to have a public participation program.

Prior to adoption of any ordinance required under the PADEP Stormwater Protocol, municipalities must provide adequate public notice and opportunities for public review and input, and hold hearings to obtain public feedback. This can be done in conjunction with normal public sessions of the municipal governing body. The notice must be published in a local newspaper of general circulation. Involving citizen groups, watershed organizations and businesses as much as possible will obtain broad support for stormwater management efforts. The current Steering Committee for the Cobbs Creek Watershed Plan is an obvious example of such inclusion, and can help municipalities to meet this requirement.

Although the actual public participation requirements can be met by following guidelines for Act 167 planning, it is recommended that municipalities do more than the minimum. Some options for additional public participation are listed below.

- Develop a Public Involvement and Participation Plan: by the end of Year 1, a municipality may want to have a comprehensive plan in place that will guide your efforts to recruit volunteers and obtain participation at public meetings. This could be part of the Public Education Plan discussed above.

- Produce strategies for recruiting participation from six categories of stakeholders: municipal employees, homeowners, businesses, schools, watershed associations and other volunteer groups and developers.

- Develop a comprehensive stakeholder mailing list.

- Conduct Public Meetings: PADEP suggests using a general stormwater public meeting to kick-off public education and participation efforts. This has already been done for the Cobbs Partnership and Steering Committee, and municipalities are encouraged to make use of this. Invite representatives from all six stakeholder categories. It is important that all stakeholder interests have the opportunity to participate. Meeting agendas should include, but not be limited to, the overview presentation on the watershed management and stormwater program and time for questions from the audience.

An important aspect of public participation is the establishment of volunteer programs. There are many types of volunteer programs that can help manage stormwater and improve a community's water quality. The goal of the volunteer program is to obtain and sustain volunteer support that will aid watershed management efforts. To reach this goal, it is important to develop a program that reflects stakeholders' concerns and interests. Examples of volunteer programs are:

Volunteer Monitoring Program

Municipalities should determine which type of assessment the program will undertake and develop a study design using the manual entitled *Designing Your Monitoring Program: A Technical Handbook for Community-Based Monitoring in Pennsylvania* as the basis for planning and implementing your monitoring program (PADEP, 2001).

Storm Drain Stenciling Program

Municipalities should establish procedures for storm drain stenciling and organize volunteers to carry out the program. PADEP has provided resource materials in a References and Resources CD-ROM on developing and implementing a storm drain stenciling program.

Stream Cleanup and Restoration Activities

Citizen participation in stream cleanups is a good way to get the community involved in keeping the streams free of trash and debris. Stream cleanups can be coordinated with PWD's Waterways Restoration Unit. Other participatory activities can include support of riparian plantings during stream restoration activities.

7.1.3 Municipal Measures

Capacity Management Operation and Maintenance (CMOM) (AM1) Related Goals: 1, 5, 6 Related Indicators: 7, 9, 11			
What	Who	Where	When
Program to manage and maintain sewer systems; plans in place to track SSOs and overflow response plan.	Separate Sewered Municipalities	Separate Sanitary Sewer Areas	Medium term: 5+ years

CMOM programs are recommended for all areas with separate sanitary sewer systems and are an important component of Target A because they help prevent dry weather discharges. Recommendations in this section cover both the dry and wet weather aspects of the program; recommendations that are specific to SSO abatement are included here for completeness and are referred to under Target C. The recommendations in this section are adapted from the "Consensus Recommendation of the SSO Federal Advisory Subcommittee" published in October 1999.

(1) General Standards

- Properly manage, operate and maintain, at all times, all parts of collection system. Perform maintenance and inspections using techniques similar to those recommended for combined sewers in option AM2.
- Provide adequate capacity to convey base flows and peak flows for all parts of the collection system.
- Take all feasible steps to stop, and mitigate the impact of, sanitary sewer overflows in portions of the collection system.
- Provide notification to parties with a reasonable potential for exposure to pollutants associated with the overflow event.
- Develop a written summary of the CMOM program and make it, and the audit under section (5), available to any member of the public upon request.

(2) Management Program

Develop a capacity, management, operation and maintenance (CMOM) program to comply with the above general standards. If any element of this section is not appropriate or applicable for the CMOM program in question, it does not need to address the element, but a written summary must explain why that element is not applicable.

The management program should consist of the following six components.

1. Goals
The program must identify in detail the major goals of the CMOM program consistent with the general standards identified above.

2. Organization
A) Identify administrative and maintenance positions responsible for implementing measures in the CMOM program, including lines of authority by organization chart or similar document; and (B) establish the chain of communication for reporting SSOs from receipt of a complaint or other information to the person responsible for reporting to the NPDES authority.

3. Legal Authority
Include legal authority, through sewer use ordinances, service agreements or other legally binding documents, to:
(A) Control infiltration and connections from inflow sources;
(B) Require that sewers and connections be properly designed and constructed;
(C) Ensure proper installation, testing, and inspection of new and rehabilitated sewers (such as new or rehabilitated collector sewers and new or rehabilitated service laterals);
(D) Address flows from satellite municipal collection systems; and
(E) Implement the general and specific prohibitions of the national pretreatment program that you are subject to under 40 CFR 403.5.

4. Measures and Activities
The CMOM program must address the elements listed below that are appropriate and applicable to the sewer system and identify the person or position in the organization responsible for each element.
(A) Maintenance of facilities
(B) Maintenance of a map of the collection system
(C) Management of information and use of timely, relevant information to establish and prioritize appropriate CMOM activities, and to identify and illustrate trends in overflows.
(D) Routine preventive operation and maintenance activities
(E) Assessment of the current capacity of the collection system and treatment facilities
(F) Identification and prioritization of structural deficiencies and identification and implementation of short-term and long term rehabilitation actions to address each deficiency
(G) Appropriate training on a regular basis.
(H) Equipment and replacement parts inventories including identification of critical replacement parts.

5. Design and Performance Provisions
(A) Requirements and standards for the installation of new sewers, pumps and other appurtenances; and rehabilitation and repair projects.

(B) Procedures and specifications for inspecting and testing the installation of new sewers, pumps, and other appurtenances and for rehabilitation and repair projects.

6. Monitoring, Measurement and Program Modifications
Monitor the implementation and, where appropriate, measure the effectiveness of each element of the CMOM program. Program elements must be updated as appropriate based on monitoring or performance evaluations. The summary of the CMOM program should be modified as appropriate to keep it updated and accurate.

(3) Overflow Response Plan:

An overflow response plan should be developed and implemented that identifies measures to protect public health and the environment including, but not limited to, mechanisms to:

(i) ensure that all overflows are made aware of (to the greatest extent possible);

(ii) ensure that overflows are appropriately responded to, including ensuring that reports of overflows are immediately dispatched to appropriate personnel for investigation and appropriate response;

(iii) ensure appropriate reporting pursuant to 40 CFR 122.42(e).

(iv) ensure appropriate notification to the public, health agencies, and other impacted entities (e.g. water suppliers) pursuant to 40 CFR 122.42(h). The CMOM plan should identify the public health and other officials who will receive immediate notification.

(v) ensure that appropriate personnel are aware of and follow the plan and are appropriately trained; and

(vi) provide emergency operations.

(4) System Evaluation and Capacity assurance plan:

A plan should be prepared and implemented for system evaluation and capacity assurance if peak flow conditions are contributing to an SSO discharge unless either (1) already taken steps to correct the hydraulic deficiency or (2) the discharge meets the criteria of 122.42(g)(2). At a minimum the plan must include:

(i) **Evaluation**: Steps to evaluate those portions of the collection system which are experiencing or contributing to an SSO discharge caused by hydraulic deficiency or to noncompliance at a treatment plant. The evaluation should provide estimates of peak flows (including flows from SSOs that escape from the system) associated with conditions similar to those causing overflow events, provide estimates of the capacity of key system components, identify hydraulic deficiencies, including components of the system with limiting capacity and identify the major sources that contribute to the peak flows associated with overflow events.

(ii) **Capacity Enhancement Measures**: Establish short and long term actions to address each hydraulic deficiency including prioritization, alternative analysis, and a schedule.

(iii) **Plan updates**: The plan should be updated to describe any significant change in proposed actions and/or implementation schedule. The plan should also be updated to reflect available information on the performance of measures that have been implemented.

(5) CMOM Program Audits

As part of the NPDES permit application, an audit should be conducted, appropriate to the size of the system and the number of overflows, and a report submitted of such audit, evaluating the CMOM program and its compliance with this subsection, including its deficiencies and steps to respond to them.

(6) Communications

The permittee should communicate on a regular basis with various interested parties on the implementation and performance of its CMOM program. The communication system should allow interested parties to provide input to the permittee as the CMOM program is developed and implemented.

Inspection and Cleaning of Combined Sewers (AM2) Related Goals: 6, 7, 10 Related Indicators: 11, 19			
What	Who	Where	When
inspection activities routine maintenance, monitoring activities	PWD	Combined Sewered Areas (see Figure 7-2)	First 5 years coinciding with the stormwater permit.

Maintenance of sewers includes activities required to keep the system functioning as it was originally designed and constructed. Any reinvestment in the system, including routine maintenance, capital improvements for repair or rehabilitation, inspection activities, and monitoring activities are generally classified as maintenance.

An inspection program is vital to proper maintenance of a wastewater collection system. Without inspections, a maintenance program is difficult to design, since problems cannot be solved if they are not identified. Sewer inspections identify problems such as blocked, broken, or cracked pipes; tree roots growing into the sewer; sections of pipe that settle or shift so that pipe joints no longer match; and sediment and other material building up and causing pipes to break or collapse. The elements of an inspection program include flow monitoring, manhole inspections, smoke/dye testing, closed circuit television inspection, and private sector inspections. Private sector building inspection activities include inspection of area drains, downspouts, cleanouts, sump discharges and other private sector inflow sources into the system.

In addition to inspection, routine maintenance must also include sewer cleaning, root removal/treatment, cleaning of mainline stoppages, cleaning of house service stoppages, and inspections and servicing of pump stations.

PWD is responsible for implementation of this option in the combined sewer areas of the Cobbs Creek watershed, but municipalities with separate sewers should have similar permanent and active sewer maintenance programs in place under CMOM (see AM1). Figure 7-2 shows the areas where sanitary sewers and combined sewers exist. All municipalities in the watershed are responsible for sewer maintenance.

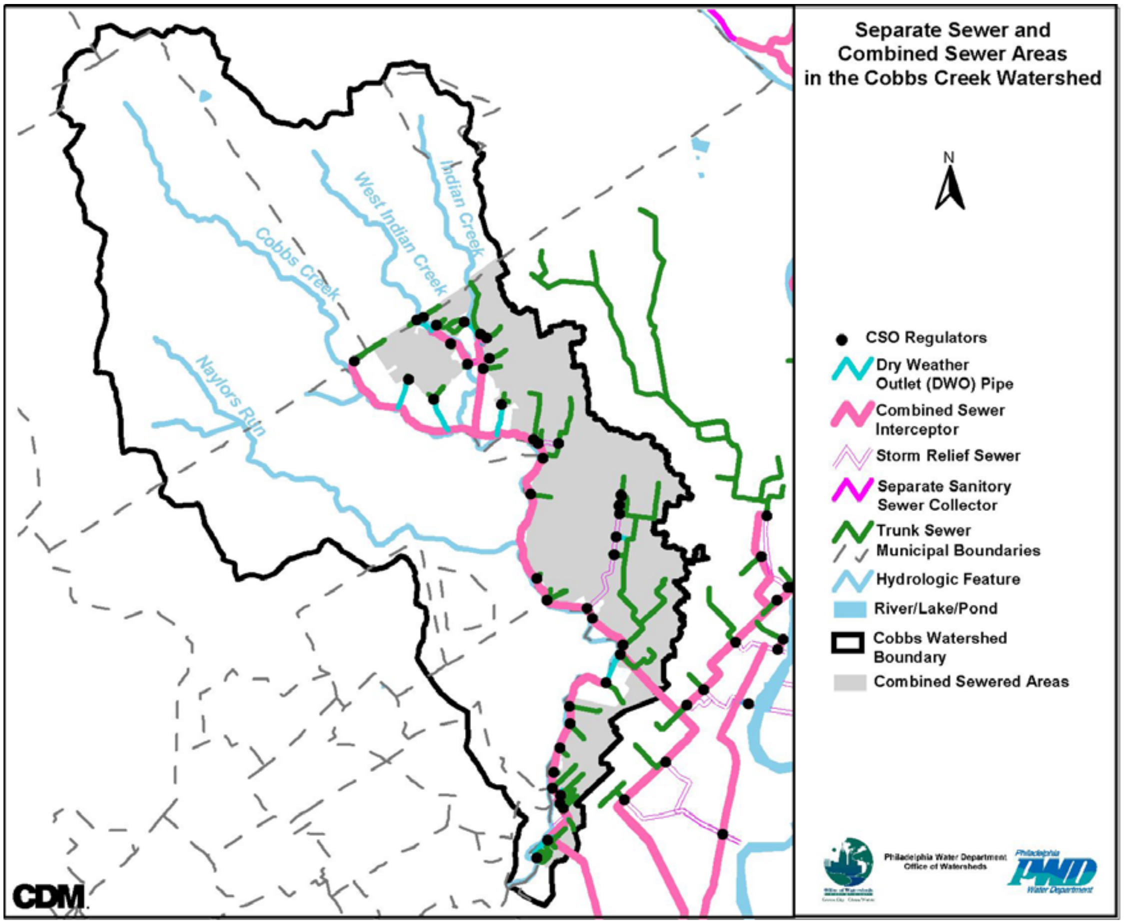


Figure 7-2 Separate Sewer and Combined Sewer Areas in Cobbs Creek

PWD has combined sewer maintenance responsibilities in the Cobbs Creek watershed. CSO regulations (the Nine Minimum Controls discussed in Section 1) have required that PWD carry out improved sewer maintenance. Some of the activities PWD is carrying out include the review and improvement of on-going operation and maintenance programs, and comprehensive inspection and monitoring programs to characterize and report overflows and other conditions in the combined sewer system.

Sanitary Sewer Rehabilitation (AM3) Related Goals:5, 6 Related Indicators:7, 11			
What	Who	Where	When
Perform major repairs or replacement on sections of sewer determined to be in poor condition.	All municipalities with separate sanitary sewer systems	All municipalities with separate sanitary sewer systems	Medium Term

The CMOM and sewer inspection programs discussed in previous sections may identify sections of sewer that are in poor condition and in need of major repair or replacement. This section is adapted from fact sheets provided on the EPA web site: http://www.epa.gov/owm/mtb/rehabl.pdf.

Under the traditional method of sewer relief, a replacement or additional parallel sewer line is constructed by digging along the entire length of the existing pipeline. While these traditional methods of sewer rehabilitation require unearthing and replacing the deficient pipe (the dig-and-replace method), trenchless methods of rehabilitation use the existing pipe as a host for a new pipe or liner. Trenchless sewer rehabilitation techniques offer a method of correcting pipe deficiencies that requires less restoration and causes less disturbance and environmental degradation than the traditional dig and-replace method.

Trenchless Sewer Rehabilitation Methods:

- Pipe Bursting, or In-Line Expansion
- Sliplining
- Cured-In-Place Pipe
- Modified Cross Section Liner

These alternative techniques must be fully understood before they are applied. These four sewer rehabilitation methods are described further in the following sections.

Pipe Bursting or In-Line Expansion

Pipe bursting, or in-line expansion, is a method by which the existing pipe is forced outward and opened by a bursting tool. The Pipebursting™ method, patented by the British Gas Company in 1980, was successfully applied by the gas pipelines industry before its applicability was identified by other underground utility agencies. Over the last two decades, other methods of in-line expansion have been patented as well. During in-line expansion, the existing pipe is used as a guide for inserting the expansion head (part of the bursting tool). The expansion head, typically pulled by a cable rod and winch, increases the area available for the new pipe by pushing the existing pipe radially outward until it cracks. The bursting device pulls the new pipeline behind itself.

Sliplining

Sliplining is a well-established method of trenchless rehabilitation. During the sliplining process, a new liner of smaller diameter is placed inside the existing pipe. The annular space, or area between the existing pipe and the new pipe, is typically grouted to prevent leaks and to provide structural integrity.

Cured-In-Place Pipe

During the cured-in-place pipe (CIPP) renewal process, a flexible fabric liner, coated with a thermosetting resin, is inserted into the existing pipeline and cured to form a new liner. The liner is typically inserted into the existing pipe through an existing manhole. The fabric tube holds the resin in place until the tube is inserted in the pipe and ready to be cured. Commonly manufactured resins include unsaturated polyester, vinyl ester.

Modified Cross Section Lining

The modified cross section lining methods include deformed and reformed methods, sewagelining™, and rolldown. These methods either modify the pipe's cross sectional profile or reduce its cross sectional area so that the liner can be extruded through the existing pipe. The liner is subsequently expanded to conform to the existing pipe's size. Another method of obtaining a close fit between the new lining and existing pipe is to temporarily compress the new liner before it is drawn through the existing pipeline. The sewagelining™ and rolldown processes use chemical and mechanical means, respectively, to reduce the cross-sectional area of the new liner.

External Sewer Rehabilitation Methods (adapted from EPA/600/R-01/034)

External rehabilitation methods are performed from the above ground surface by excavating adjacent to the pipe, or the external region of the pipe is treated from inside the pipe through the wall. Some of the methods used include:

External Point Repairs
Chemical Grouting (Acrylamide Base Gel, Acrylic Base Gel)
Cement Grouting (Cement, Microfine Cement, Compaction)

Internal Sewer Rehabilitation Methods
The basic internal sewer rehabilitation methods include:

Chemical Grouting

Internal grouting is the most commonly used method for sealing leaking joints in structurally sound sewer pipes. Chemical grouts do not stop leaks by filling cracks; they are forced through cracks and joints, and gel with surrounding soil, forming a waterproof collar around leaking pipes. This method is accomplished by sealing off an area with a "packer," air testing the segment, and pressure injecting a chemical grout for all segments which fail the air test. The three major types of chemical grout are: Acrylic, Acrylate, and Urethane.

Continuous Pipe

Insertion of a continuous pipe through the existing pipe (Polyethylene and Polypropylene)

Segmental

Short segments of new pipe are assembled to form a continuous line, and forced into the host pipe. Generally, this method is used on larger sized pipe and forced into the host pipe. (Polyethylene, Polyvinyl Chloride, Reinforced Plastic Mortar, Fiberglass Reinforced Plastic, Ductile Iron, Steel)

Fold and Form Pipe

This is similar to sliplining, except that the liner pipe is deformed in some manner to aid insertion into the existing pipe. Depending on the specific manufacturer, the liner pipe may be made of PVC or HDPE. One method of deforming the liner is to fold it into a "U" shape before insertion into the existing pipe. The pipe is then returned to its original circular shape using heated air or water, or using a rounded shaping device or mandrel. Ideally, there will be no void between the existing pipe and the liner pipe after expansion of the liner pipe with the shaping device. For the "U" shape liner, the resulting pipe liner is seamless and jointless.

Spiral Wound Pipe

This involves winding strips of PVC in a helical pattern to form a continuous liner on the inside of the existing pipe. The liner is then strengthened and supported with grout that is injected into the annular void between the existing pipe and the liner. A modified spiral method is also available that winds the liner pipe into a smaller diameter than the existing pipe, and then by slippage of the seams, the liner expands outward.

Combined Sewer Rehabilitation (AM4) Related Goals: 5, 6, 9, 10 Related Indicators: 7, 8, 9, 10, 11, 19, 20			
What	Who	Where	When
Perform major repairs or replacement on sections of sewer determined to be in poor condition.	PWD	Combined-Sewered Areas	Medium Term

Rehabilitation of combined sewers is conceptually similar to rehabilitation of separate sanitary sewers. Refer to option AM3 for information on specific techniques.

Illicit Discharge, Detection, and Elimination (IDD&E) (AM5) Related Goals: 5, 6, 8, 9, 10 Related Indicators: 7, 8, 9, 10, 11, 16, 19, 20			
What	Who	Where	When
IDD&E Program in conformance with Phase II Stormwater Permits and the LTCP for PWD.	All Municipalities required to do Phase II permit (see Table 7-4) PWD in CSO Areas	All areas with a storm sewer or combined sewer. See Figure 7-2	Five year program associated with stormwater permit. (See Table 7-7)

In accordance with the Cobbs Creek Plan's stated purpose of integrating various existing programs, and to avoid duplication of effort, the recommended implementation plan follows the Stormwater Management Program Protocol ("Protocol") to meets the six minimum control measures required of municipal permittees under the Phase II NPDES Stormwater Regulations (found at 40 CFR §§ 122.26 – 123.35). One of the six minimum controls is an IDD&E program. The IDD&E program can be summarized as consisting of the following steps:

- Develop map of municipal separate storm sewer system outfalls and receiving water bodies
- Prohibit illicit discharges via PADEP-approved ordinance
- Implement an IDD&E Program that includes 1) field screening program and procedures and 2) elimination of illicit discharges
- Conduct public awareness and reporting program (see under Public Education above)

A similar approach to controlling dry weather flows is being followed by PWD under the Long Term Control Plan (LTCP) for CSOs.

Each step is explained in more detail below.

Develop an Outfall Map

The federal regulations define an outfall as "a point source as defined by 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the United States". A "point source" is defined as "any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft from which pollutants are or may be discharged."

Many of the outfalls along Cobbs Creek have already been located under the studies performed for the Cobbs Creek Watershed Management Plan. Municipalities should work with PWD to develop a consistent set of outfall maps that meet the specific requirements of the Phase II program.

Illicit Discharge Ordinance

A Model Ordinance is available from PADEP and should be used as is. PADEP discourages changes to the model ordinance, because it has been prepared to meet the MS4 permit requirements. However, some municipalities already have good stormwater ordinances. Municipalities who do not wish to enact the model ordinance in its entirety must get approval from PADEP to ensure that the MS4 permit requirements are met.

The model ordinance must be enacted in the first year of the permit term, except where a municipality commits to a multi-municipal, watershed-based program following this Protocol, in which case the schedule is delayed one year. Subsequent to completion of the Act 167 Plan (or Plan Update), the ordinance must be modified to reflect Plan requirements. Regardless of the timing of the Act 167 Plan (or Plan Update) an ordinance must be enacted within the first two years of the permit term for all municipalities in Cobbs Creek.

IDD&E Program

Following PADEP protocol, the IDD&E Program must consist of the following three elements, which must be implemented according to the schedule shown below.

- Conduct Field Screening
- Identify Source of Illicit Discharges
- Develop and Implement a Strategy to Remove or Correct Illicit Discharges.

Field Screening

Field screening is necessary to identify source(s) of actual illicit discharges. Field screening must start in Year 2 of the permit. PADEP provides a checklist that must be used when conducting field screening. Every outfall in priority areas must be screened two times a year. This activity can be accomplished concurrently with other existing field activities, such as regularly scheduled fire hydrant inspections, road repairs, landscaping activities, other field work conducted during county preparation of the Act 167 stormwater plan, etc.

Using a PADEP supplied Checklist, the staff designated to conduct field screening collect visual data. The screening should be conducted at least 72 hours since the last precipitation event, and at least 48 hours should pass between the first screening at a particular outfall and the second screening at that outfall. If someone conducting the field screening discovers a dry-weather flow, they (or another designated individual with the proper training) must collect a sample of that flow for analysis. Such a discovery triggers the requirements under the other two program elements:

- Identify Source of Illicit Discharges
- Remove or Correct Illicit Discharges

Identify the Source of Illicit Discharges

The following IDD&E Program elements only apply if a dry-weather flow is identified during field screening activities in Years 2, 3, 4, and/or 5. For each illicit discharge that is identified during field screening, the following program elements must be carried out.

- Collect and analyze samples of the dry-weather flow.

If field inspectors identify a dry-weather flow at an outfall during field screening, they should take two grab samples of the flow and analyze the samples for the characteristics and pollutants listed in the Table 7-6 below.

Table 7-6 Dry-Weather Flow Sampling Analysis Requirements

Characteristic/Pollutant	Method
Color	Visual observation
Odor	Visual observation
Turbidity	Visual observation
Sheen/scum	Visual observation
PH	In-field analysis
Total chlorine	In-field analysis
Total copper	In-field analysis
Total phenol	In-field analysis
Detergents/surfactants	In-field analysis
Flow	In-field measurement
Bacteria	Laboratory analysis

- Identify the source of the discharge.

The data obtained from visual, in-field, and laboratory analysis will provide the information necessary to determine the source of the dry-weather flow or floatables. Based on the pollutants contained in the sample, it should be possible to determine if the source is from illegal dumping in a storm drain, a cross-connection, or a leak in a pipe. Potential sources of the dry-weather flow can be located by tracing the flow upstream using storm drain maps and by inspecting upgradient manholes and storm drains. If need be, a more focused test to pinpoint the source can be tried, such as dye testing, smoke testing, and television camera inspection.

Remove or Correct the Illicit Discharge

Once the source has been identified, municipalities need to determine if it is a case of improper dumping or if a property owner has an improper physical connection to the storm sewer system. This will help to select the most appropriate method for correcting or removing the discharge. If it is a case of improper dumping, the only recourse may be to conduct intensified education of residents living in and traveling through that area. If it is a case of an improper physical connection, the appropriate action can be taken to correct the discharge. A plan of action to eliminate elicit connections might include plugging discharge points or disconnecting and reconnecting lines.

If a violation is found, the property owner should be notified of the violation and given a timeframe for removal of the source. After that time has passed, the outfall can be screened to identify the dry weather discharge. The property should be visited a final time to confirm that the property owner removed or corrected the source. The results of all discussions, tests, and screenings should be documented for follow-up purposes. Progress evaluation of the municipal IDD&E program will depend on the ability to tabulate the number of illicit connections corrected and the status of those in the process of being corrected.

All municipalities within Cobbs Creek that have a sanitary sewer system are required to carry out this program. Table 7-4 lists the municipalities, and Figure 7-1 shows the location of the sewered areas.

The PADEP protocol has laid out a very specific time table for completion of this program by the municipalities. The timing is shown in Table 7-7 below.

Table 7-7 Implementation Schedule for IDE&E Program

PERMIT YEAR	***IMPLEMENTATION SCHEDULE PERMIT REQUIREMENTS AND MEASURABLE GOALS***			
	Mapping	**Ordinance**	**Program**	**Education**
Year 2	· Establish priority areas for 25% of system	Implement and enforce	· Screen Priority Areas · Take corrective actions to remove illicit discharges (as needed)	· Distribute educational material (see Public Education and Outreach Minimum Measure)
Years 3-5	· Establish priority areas for 25% of system	Implement and enforce	· Screen Priority Areas · Take corrective actions to remove illicit discharges (as needed)	· Distribute educational material (see Public Education and Outreach Minimum Measure)

Stream Cleanup and Maintenance (AM6) Related Goals: 2, 4, 6, 8, 9 Related Indicators: 3, 4, 5, 6, 10, 11, 15, 16, 17, 19, 20			
What	Who	Where	When
Remove litter and heavy debris. Maintain habitat improvements (fish ladders, FGM, elimination of plunge pools).	PWD Waterways Restoration Unit; Fairmount Park volunteers and other volunteer groups	Portions of Cobbs Creek and tributaries within or along the City boundary; areas outside the City maintained by volunteers only	Begin within 5 years; monthly maintenance schedule to be determined

Keeping streams free of trash is a continuous activity. NLREEP volunteers alone have removed over 2,000 bags of trash from the stream corridor since 1998. Public education should help in reducing trash and debris reaching the streams, however, PWD and municipalities need to put into place a permanent maintenance schedule. PWD has implemented a permanent Waterways Restoration Unit. This team periodically removes trash and large debris from Cobbs Creek on a rotating schedule. For reaches of stream within the City or along the City boundary, the team will focus on removal of litter and heavy debris, and maintenance of in-stream aquatic habitat improvement projects including fish ladders, fluvial geomorphologic restoration projects, and elimination of outfall plunge pools. For reaches of stream outside the City, municipalities should organize periodic stream cleanups using volunteer groups.

Municipalities that have the greatest length of stream within their boundaries include Haverford Township, Upper Darby Township, and Lower Merion Township.

Enhancing Stream Corridor Recreational and Cultural Resources (AO1) Related Goals: 7, 8, 9 Related Indicators: 16, 17, 18, 19, 20, 21			
What	Who	Where	When
Establish and improve trails and greenways using measures recommended in the Darby RCP and the Fairmount Park Trails Master Plan. Protect historic sites listed in the Darby RCP.	Outside Philadelphia: partnership of Department of Conservation and Natural Resources (DCNR), county planning departments, and municipalities. Inside Philadelphia: Fairmount Park Commission.	See Figures 7-3 and 7-4.	Medium term: 5-15 years

Part of Target A addresses the accessibility of Cobbs Creek. Once dry weather water quality and aesthetics have been improved, the recreational value of the Creek will be enhanced, and better accessibility becomes important. A stream accessibility analysis (Section 4, Indicator 18) indicated that much of the headwaters of the Cobbs are inaccessible. The recommended actions focus primarily on improving access to public lands where recreational potential is greatest.

Outside the City of Philadelphia, implementation of the Upper Cobbs Creek Area Greenway is recommended in the Darby Creek Watershed River Conservation Plan. Most of the proposed greenway extension lies in Haverford Township (Figure 7-3). The main recommendations from the RCP are:

- Link existing Fairmount Park green areas northward to Haverford College
- Link the Cobbs greenway to the Darby Creek main-stem through the Merion Golf Club and Haverford State Hospital Site.

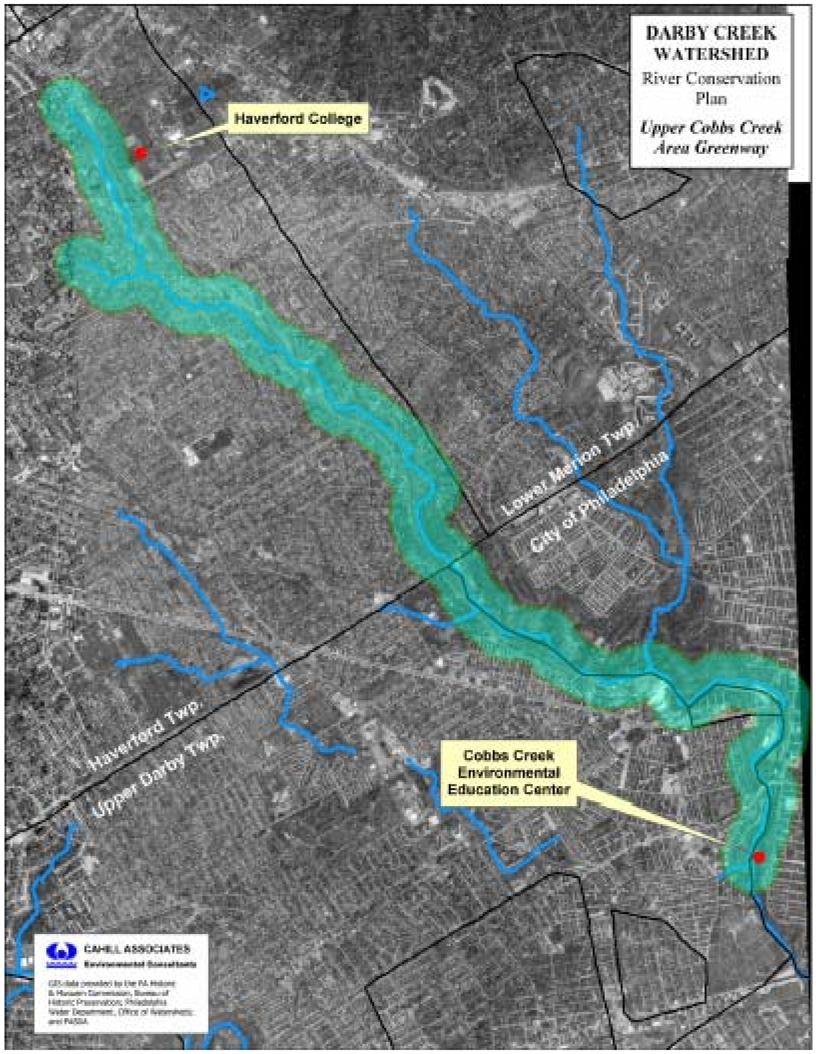


Figure 7-3 Upper Cobbs Creek Area Greenway (Source: Darby RCP)

Fairmount Park's Natural Lands Restoration and Trails Master Plan contains specific recommendations for creating and enhancing trails in the Cobbs section of the Park. These are shown in Table 7-8 and in Figure 7-4.

Table 7-8 Fairmount Park Trails Master Plan Recommendations for Cobbs Creek
■ Provide maximum support and development of positive volunteer educational and restoration efforts already in place. ■ Eliminate redundant and problematic trails that are contributing to the ecological decline of the natural areas. ■ Increase perceived safety by providing better trail sight lines and perimeter lighting. ■ Create well-defined trail heads that have good transit and regional connections. ■ Provide access points/gateways to adjacent neighborhoods. ■ Provide interpretive and educational opportunities for the diverse ecological and cultural settings of the park. ■ Provide for adequate parking and controlled access to the trails to eliminate/reduce likelihood of trails as entrance points for motorized vehicles (particularly ATV's and abandoned autos). ■ Provide maintenance strategies and restoration solutions for eroded and degraded trails that will continue to be used.

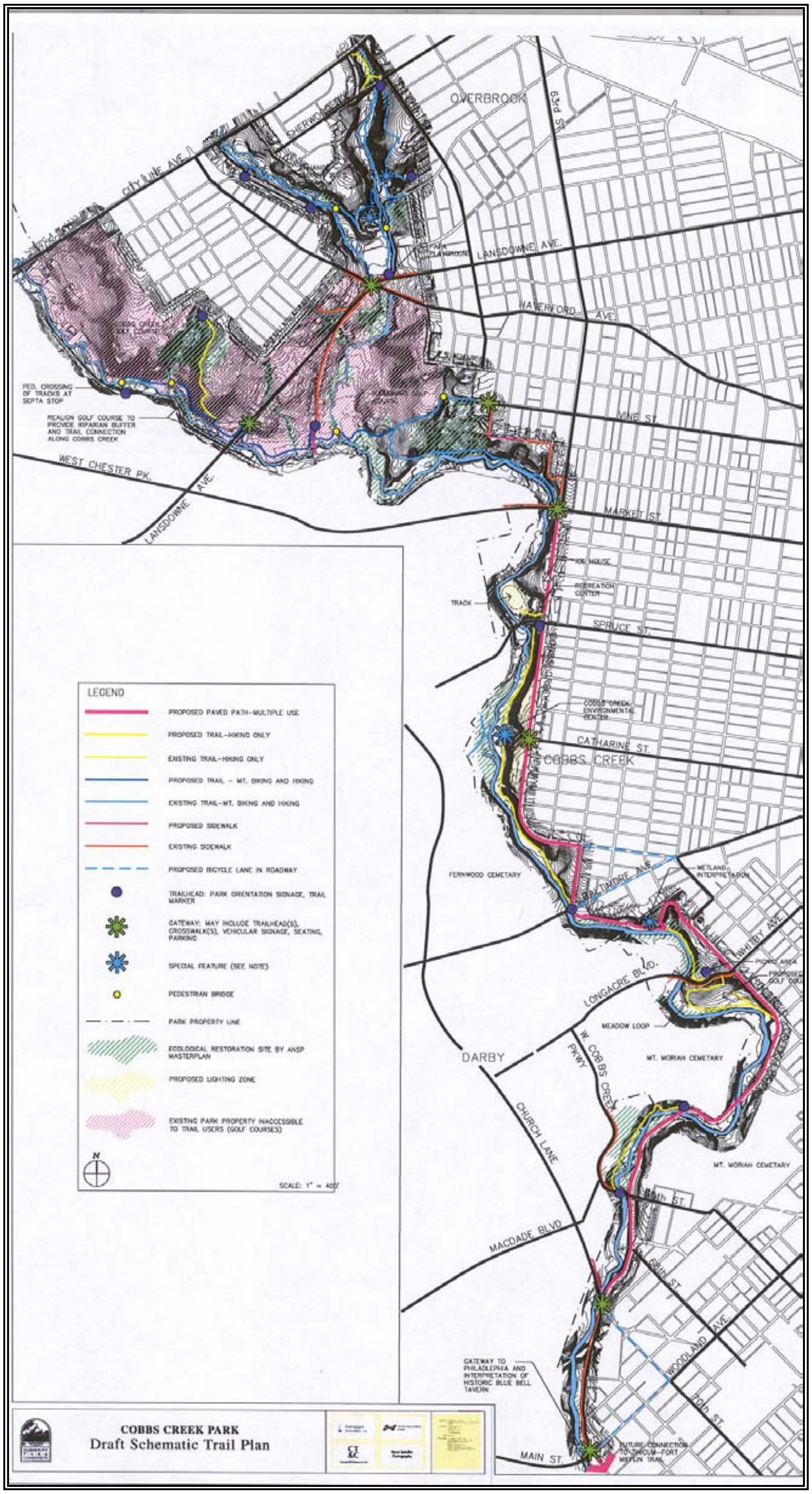


Figure 7-4 Cobbs Creek Schematic Trail Plan (from www.nlreep.org)

7.2 Target B: Healthy Living Resources

Stream and Riparian Corridor Improvement

The Cobbs Creek Watershed Management Plan proposes a comprehensive stream and riparian corridor restoration strategy. Given the historic degradation of the water quality and ecology of Cobbs Creek and its tributaries from urbanization, an interdependent set of corridor improvement actions are recommended. The actions - ranging from conservation of existing open spaces, to stream stabilization actions, to creation of new wetlands and biofiltration areas – together constitute a fully integrated riparian corridor improvement strategy that provides new habitat and water quality improvement. In the Philadelphia portion of the riparian corridor, this approach is intended to complement and expand the Fairmount Park Commission's Natural Lands Restoration and Environmental Education Program (NLREEP).

These riparian corridor improvement actions, when implemented simultaneously, will result in improvements that span the waterway and riparian corridor, from the developed properties along one bank to the developed properties along the opposing bank. Thus, riparian corridor actions improve the ecology of the Cobbs Creek landscape and optimize the ways in which the limited remaining open space can help improve water quality. The long-term benefits of an integrated riparian strategy significantly outweigh the short-term construction disturbances that are needed to implement the Cobbs Creek riparian corridor improvements.

The riparian corridor is defined here as the land area that borders a stream and which directly affects and is affected by the water quality. The riparian corridor typically includes floodplains, shorelines, wetlands, and riparian forest. For the purposes of the Cobbs Creek riparian corridor improvement strategy, the riparian area also includes the stream channel. Thus, the full undeveloped land and waterway area between the existing land development that surrounds the corridor will be considered for ecological improvement and for biofiltration functions that will improve water quality. Listed below are the options recommended for implementation across the corridor, from the lowest point in the landscape (the stream channel) to the highest (upland forest).

Channel Stability and Aquatic Habitat Restoration

- *BM1* Bed Stabilization and Habitat Restoration
- *BM2* Bank Stabilization and Habitat Restoration
- *BM3* Channel Realignment and Relocation
- *BM4* Plunge Pool Removal
- *BM5* Improvement of Fish Passage

Lowland Restoration and Enhancement

- *BM6* Wetland Creation
- *BM7* Invasive Species Management

Upland Restoration and Enhancement

BM8 Biofiltration

BM9 Reforestation

BMR Monitoring and Reporting

Timeline. The most effective approach to riparian corridor improvement is to perform all the proposed streambed, streambank, wetland, and riparian upland improvements simultaneously along a reach, or stream section. When one section is completed, work shifts downstream, section by section, for the length of the Cobbs Creek corridor. Implementing one set of corridor actions, for example, bed stabilization, without complementary actions, such as bank stabilization, will result in only limited success, because the aquatic and streamside land environments must function interactively to provide optimal stability. For this reason, the riparian corridor improvement strategy is both a short-term and long-term plan. Restoration activities in sections of the Creek that are in greatest need of improvement should be implemented early (targeting stream sections that are causing or contributing to water quality or ecological impairment first). For the Cobbs Creek corridor, it is anticipated that significant improvements in water quality and ecology can be realized by addressing high priority locations early in the planning cycle, with lower priority sections receiving riparian corridor improvement later in the cycle (Figure 7-5 and Table 7-9). It is important to note that the next step in implementing the riparian corridor improvement strategy is to develop a corridor improvement facilities plan, under which integrated designs are prepared for the full range of corridor improvements (e.g., bed and bank stabilization, and wetland creation and enhancement). Also included in this facilities plan are recommended solutions to problems created by channel obstructions such as bridge abutments.

Aside from land management strategies, restoration efforts are generally recommended for implementation beginning in headwater reaches and continuing downstream to avoid undermining any previous efforts. However, restoration projects for the East and West Indian Creeks may occur simultaneously with ongoing efforts upstream of the confluence of East Indian Creek and Cobbs Creek.

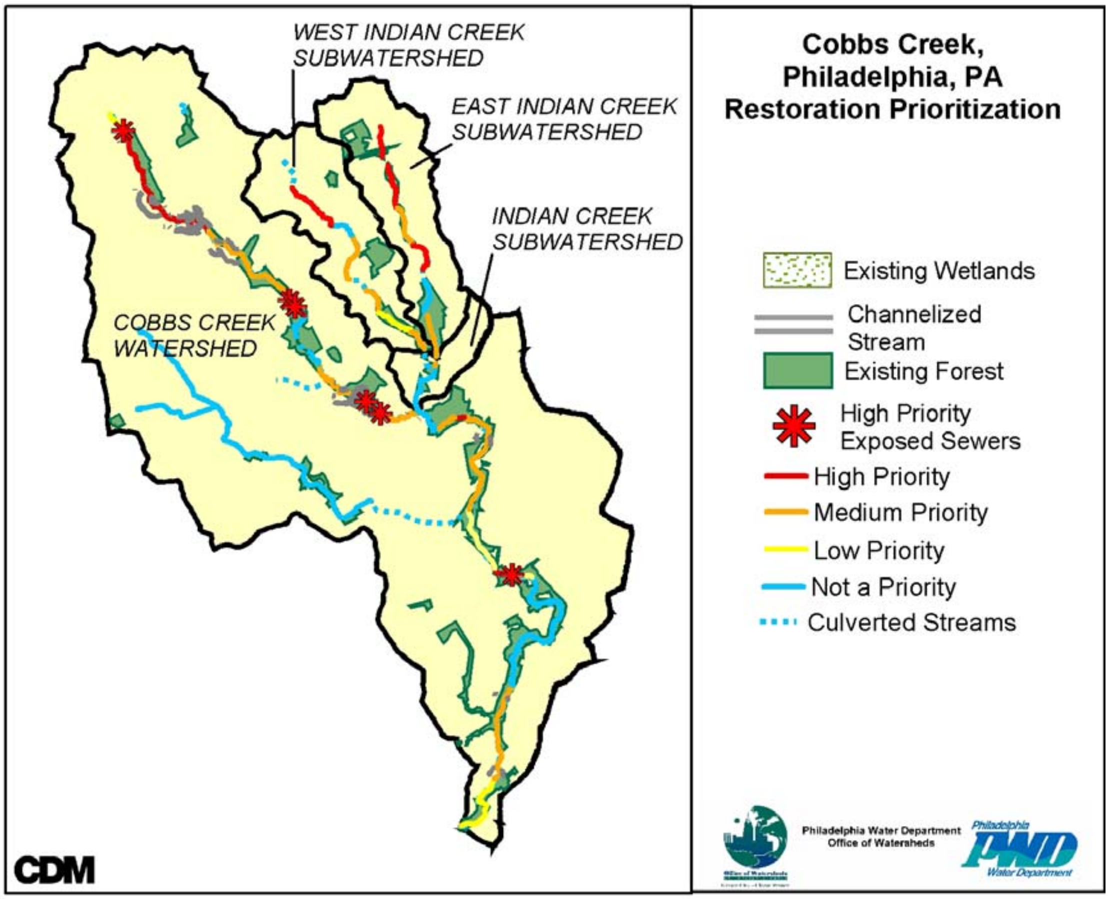


Figure 7-5 Cobbs Creek Watershed Restoration Prioritizations

Table 7-9 Total Miles of Stream by Stream Restoration Priorities

Subwatershed	Priority	Length (miles)
Cobbs	Not a Priority	5.53
Cobbs	Low Priority	3.87
Cobbs	Medium Priority	10.53
Cobbs	High Priority	4.82
East Indian Creek	Not a Priority	1.94
East Indian Creek	Low Priority	0
East Indian Creek	Medium Priority	1.96
East Indian Creek	High Priority	2.37
West Indian Creek	Not a Priority	0.55
West Indian Creek	Low Priority	0.96
West Indian Creek	Medium Priority	2.48
West Indian Creek	High Priority	1.25

7.2.1 Channel Stability and Aquatic Habitat Restoration

The Cobbs Creek watershed is strongly influenced by existing land use and anthropogenic channel changes. Cobbs, East Indian, and West Indian Creeks are all adjusting to increased flows and velocities that have resulted from extremely large amounts of impervious surface and the presence of structures associated with utilities. Changes to channel platform, pattern, and geometry will continue to occur. Cumulative impacts seen today and those that are expected to occur throughout the watershed are bed and bank erosion, channel over-widening, channel down-cutting, the lack or overabundance of sediment, less or no connection to the floodplain, and increased dominance by invasive species. Reach ranking results show that the Cobbs Creek subwatershed is the least stable, followed by West Indian and then East Indian Creeks. Headwater reaches in each subwatershed are more degraded than reaches nearer to the confluences with Cobbs Creek and Darby Creek. Final reach ranks also suggest that land use adversely impacts habitat to a greater degree than it impacts channel stability, while infrastructure is the opposite.

Overall, based on existing conditions, the Cobbs Creek subwatershed contains the greatest amount of degraded channel and has the highest restoration priority. Reaches assigned the highest restoration priority within this subwatershed are those that are severely degraded and/or continue to degrade. In all cases, the highest priority reaches contain infrastructure. Utilities present within these reaches that are of most concern consist of exposed sewer pipes and dams. Reaches both upstream and downstream of these utilities sometimes were included in the prioritization because they are being impacted by these structures or because expected future restoration/retrofit designs may require additional channel length. Multiple consecutive reaches that yielded high final ranking scores, generally those that were greater than the average stability score for the subwatershed, were also assigned a high restoration priority. The least amount of restoration is recommended for the downstream portion of Cobbs Creek.

Results of the reach ranking for the East Indian Creek subwatershed reveal that the downstream portion of the creek is more stable than the upstream portion. Degradation and corresponding higher geometry scores within the upstream portion of the creek can be attributed to a far greater number of disturbances to the channel by landowners. Disturbances such as landscaping, fountains, footbridges, etc. occur less frequently as the East Indian Creek flows downstream. Additionally, as the East Indian Creek flows downstream, land use transitions to less concentrated single family residential development and/or commercial businesses. This change in land use correlates with the width of riparian buffer present and is reflected in the reach habitat scores for the downstream portion of the East Indian Creek. The downstream portion of the East Indian Creek contains the lowest priority reaches, or the most stable reaches, in the entire Cobbs Creek watershed.

Results of the West Indian Creek ranking revealed similar results to those of East Indian Creek. Land use trends for both subwatersheds are alike in that the headwaters are primarily single family residential areas where a large amount of channel disturbances have occurred. Reach ranking reveals that the middle section of the creek are the least stable and show the least amount of natural habitat. West Indian Creek headwater reaches, although some reach ranks suggest this portion of the channel is more stable, are considered the least stable due to anthropogenic changes. Approximately 30% of the total linear feet of channel within this subwatershed have been altered. It follows that the most stable portions of West Indian Creek are the three downstream most reaches, where the riparian corridor is widest and the fewest channel disturbances are present.

Bed Stabilization and Habitat Restoration (BM1) Related Goals: 3 Related Indicators: 3, 4			
What	Who	Where	When
Design structures that provide grade control while diverting flow away from the channel banks. Bed stabilization measures include rock/log vanes with grade control, rock/log cross vanes, and using naturally occurring boulders and bedrock. Incorporate habitat improvements along with the stabilization measures.	Municipalities bordering streams recommended for restoration.	Cobbs Creek (40%) and West Indian Creek (44%) were identified as the areas with the highest percentage of actively degrading creek beds. (See Figure 7-5)	Begin within 5 years; complete restoration program within 10-15 years; monthly maintenance schedule to be determined

Bed conditions in stream channels subjected to urbanized flow often do not support a healthy aquatic ecosystem. High-velocity urbanized flows result in downcutting and widening of the bed over time, and deposition of fine sediments disrupts macroinvertebrate communities that are critical links in the aquatic food chain. Loss of pool and riffle sequences deprives fish of the variety of habitats they need to feed, spawn, and seek shelter from high flows. These channel changes tend to begin downstream and migrate their way upstream over a period of time.

Bed stabilization is recommended for those reaches that are currently degrading through incising or downcutting. Bed stabilization measures include rock/log vanes with grade control, rock/log cross vanes, and using naturally occurring boulders and bedrock. These measures reduce erosion by diverting high flows away from banks and by controlling the grade (slope) of the bed. They also stop downcutting from migrating upstream and restore habitat features that lead to healthy macroinvertebrate and fish communities. Detailed design plans are recommended for those stretches shown in Figure 7-6.

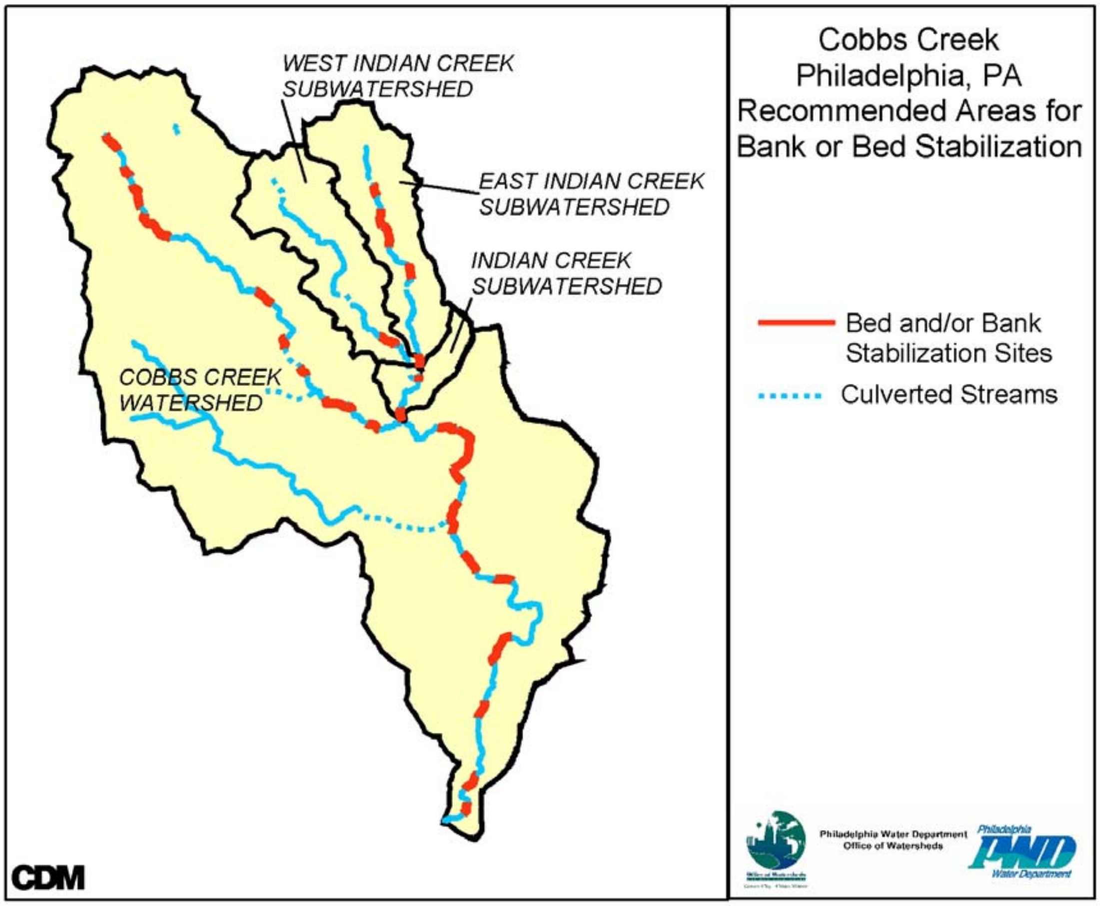


Figure 7-6 Recommended Areas for Bank and/or Bed Stabilization

Bank Stabilization and Habitat Restoration (BM2) Related Goals: 3, 4, 7, 8 Related Indicators: 3, 4, 12, 13, 15, 16, 19			
What	Who	Where	When
Bank stabilization design that may consist of boulder bank and boulder toe stabilization, bioengineering, root wads, plantings, and log and woody structures.	PWD; Fairmount Park NLREEP Municipalities bordering streams recommended for restoration. Municipalities bordering streams recommended for restoration.	Mid-sections of Cobbs Creek are the least stable, highest priority, bank stabilization areas. Channel banks rated as moderate or high should be evaluated further for site specific bank stabilization measures. These methods are best suited to small, local areas of bank erosion in East and West Indian Creek headwaters where discharges are the lowest. (See Figure 7-5)	begin 0-5 years; monthly maintenance schedule to be determined

The fine sediment that is deposited in the beds of many urban streams is often the result of bank erosion upstream. In addition to downcutting the stream bed, high-velocity urban flows result in steep, sometimes vertical banks that disconnect the stream from its historical floodplain. Using natural stabilization measures on banks also provide fish habitat and areas of reduced velocity during storms. A properly restored bank prevents further erosion, reconnects the stream to its floodplain (wetlands and riparian forest as appropriate), and provides fish habitat. It also may remove a hazardous and unsightly condition caused by a collapsing bank.

Bank stabilization measures can vary from small plantings to the installation of boulder walls, based on the severity of the erosion and whether it is localized or continues for some distance along a bank. Boulder structures are used in smaller channels that are eroding and over-widening to the point where property is, or is expected, to be lost. More natural bank stabilization methods such as bioengineering, root wads, plantings, logs, and woody structures are appropriate in areas where the bankfull width is limited and significant additional channel changes are not expected (future increases in the rate of erosion, sediment supply, tree fall, channel widening, and channel migration are not expected). These measures enhance aquatic habitat in addition to providing stabilization. Since 1998, NLREEP has repaired approximately 1020 feet of unstable banks and beds in Cobbs Creek Park, primarily along tributaries to the main stem. Figure 7-5 identifies the 5.9 miles of highest priority where additional stabilization will be recommended within 5 years. The most appropriate measures for each reach will be determined in the detailed design stage.

Channel Realignment and Relocation (BM3) Related Goals: 3, 7 Related Indicators: 3, 4, 12, 13			
What	Who	Where	When
Realignment and relocation for portions of creek channel. Daylighting recommended for two channel sections.	PWD Municipalities bordering streams recommended for restoration.	Five portions of Cobbs Creek, four portions of East Indian Creek and two portions of West Indian Creek that are potential stream realignment and relocation areas. Daylighting: downstream most portion of West Indian Creek and a section upstream of City Line Avenue. (See Figure 7-7)	begin 0-5 years; monthly maintenance schedule to be determined

In the most severely degraded reaches of Cobbs Creek, stabilization of the existing bed and banks may not be possible, or migration of the stream channel may threaten valuable infrastructure. In these areas, realignment and relocation of the stream channel may be necessary. This measure increases stability by creating a new channel along a path that is natural for the stream to follow. The design of bed and bank structures is not constrained by existing conditions. In some cases, the existing channel makes an ideal site for a riparian wetland. Channel realignment and relocation is commonly implemented for portions of a channel rather than for an entire length of channel due to construction and maintenance costs, and the amount of disturbance that occurs to existing natural habitat. Stream channel realignment and relocation is best suited to consecutive severely degraded reaches. Potential realignment and relocation sites totaling 8.0 miles of stream are shown on Figure 7-7.

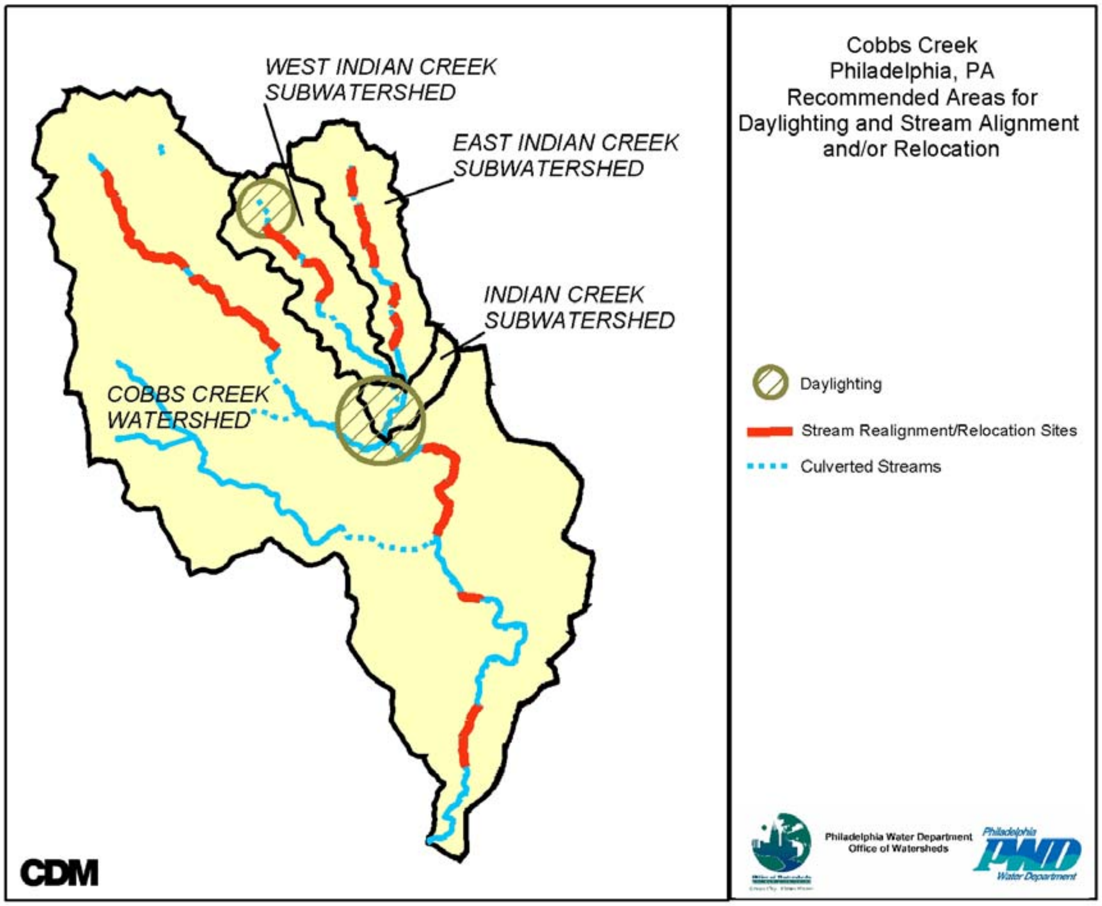


Figure 7-7 Recommended Areas for Stream Realignment and/or Relocation

Plunge Pool Removal (BM4) Related Goals: 3, 4, 9 Related Indicators: 3, 15, 19, 20			
What	Who	Where	When
Remove plunge pools below stormwater and CSO outfalls.	PWD Municipalities bordering streams recommended for restoration.	Outfalls shown in Figure 7-8	begin 0-5 years; monthly maintenance schedule to be determined

When stormwater and combined sewer outfalls discharge directly to the stream channel, they may create deep, poorly mixed pools. Both types of outfalls discharge along the length of the Cobbs and its tributaries (Figure 7-8). Because these pools are typically near the bank and not in the main flow, they can become poorly mixed during low flow. These pools often have increased odors and reduce the aesthetic quality of the stream. DO Biological activity in the sediment and water column can reduce dissolved oxygen to low levels, and this low-DO water can be flushed out and affect downstream areas during wet weather. The depression of DO is a function of both pollutant loads from the outfalls and in stream baseflow, and the physical condition of the channel. When DO is in an acceptable range in the well-mixed portion of the channel but not in nearby plunge pools, elimination of the plunge pools can be expected to eliminate the water quality condition that might affect the aquatic ecosystem.

When possible, outfalls can discharge further up the bank into a wetland or biofiltration area; these areas provide detention, evaporation, cooling, and treatment of pollutant loads in addition to protecting the integrity of the stream channel. Opportunities for creation of these areas will be discussed later in this section. Where the only place for an outfall to discharge is directly into the stream channel, the area may be protected using appropriate bed and bank stabilization features as discussed in previous sections.

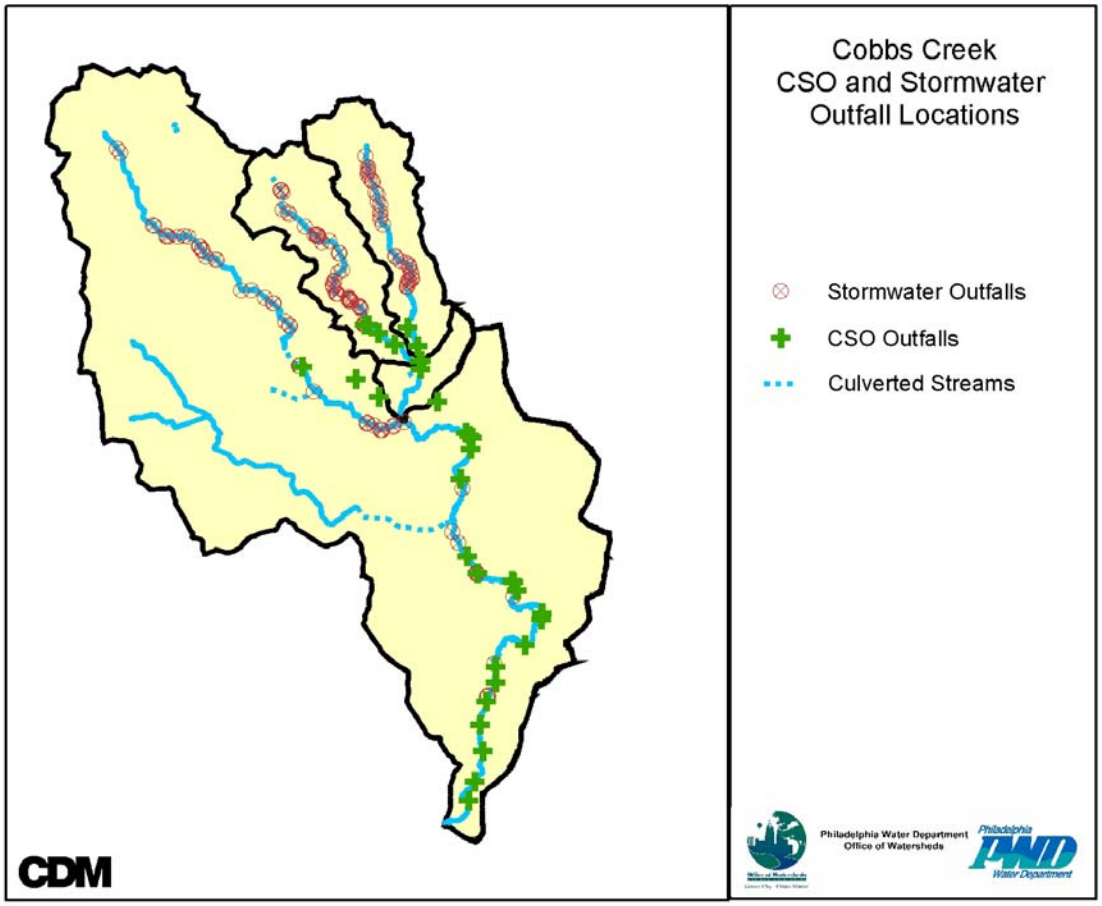


Figure 7-8 Stormwater and CSO Outfalls

Improvement of Fish Passage (BM5) Related Goals: 2, 8, 9, 10 Related Indicators: 3, 5, 6, 16, 19, 20, 21			
What	Who	Where	When
Undertake a detailed study to recommend dam removal, modification, or installation of a fish ladder.	PWD; Fairmount Park NLREEP	Woodland Avenue dam (See Figure 7-9).	Short-term (within 5 years)

For the Cobbs Creek, the State designated aquatic life uses for the non-tidal portion of the creek are Warm Water Fishes (WWF) and Migratory Fishes (MF). The designated recreational water uses also include boating, when surface water flow or impoundment conditions allow; fishing, for recreation and or consumption; water contact sports; and esthetics, for a clean setting to recreational pursuits.

Target A options are designed to ensure that water quality in Cobbs Creek is supportive of fish, and the channel improvements discussed in Target B create suitable aquatic habitat features. In addition to fish that live exclusively in fresh water, creation and enhancement of fish habitat along the Cobbs channel will create an environment suitable for migratory and semi-migratory fish. These anadromous species, such as American shad, spend portions of their life cycles in salt water and portions in fresh water. Currently, a dam at Woodland Avenue excludes migratory fish from most of Cobbs Creek. Historically, migratory fish ranged upstream to just below the current site of Cobbs Creek golf course, where a natural rock ledge (today a low dam) restricts further migration (Figure 7-9). NLREEP has identified ecological benefits to removing the Woodland Ave. dam (Natural Lands Restoration Master Plan); however, the dam is a historic structure and its removal or modification reqires further study. The effects of this dam on the stream channel and upstream sediment will be considered as part of detailed fluvial geomorphological restoration design for the stream corridor.

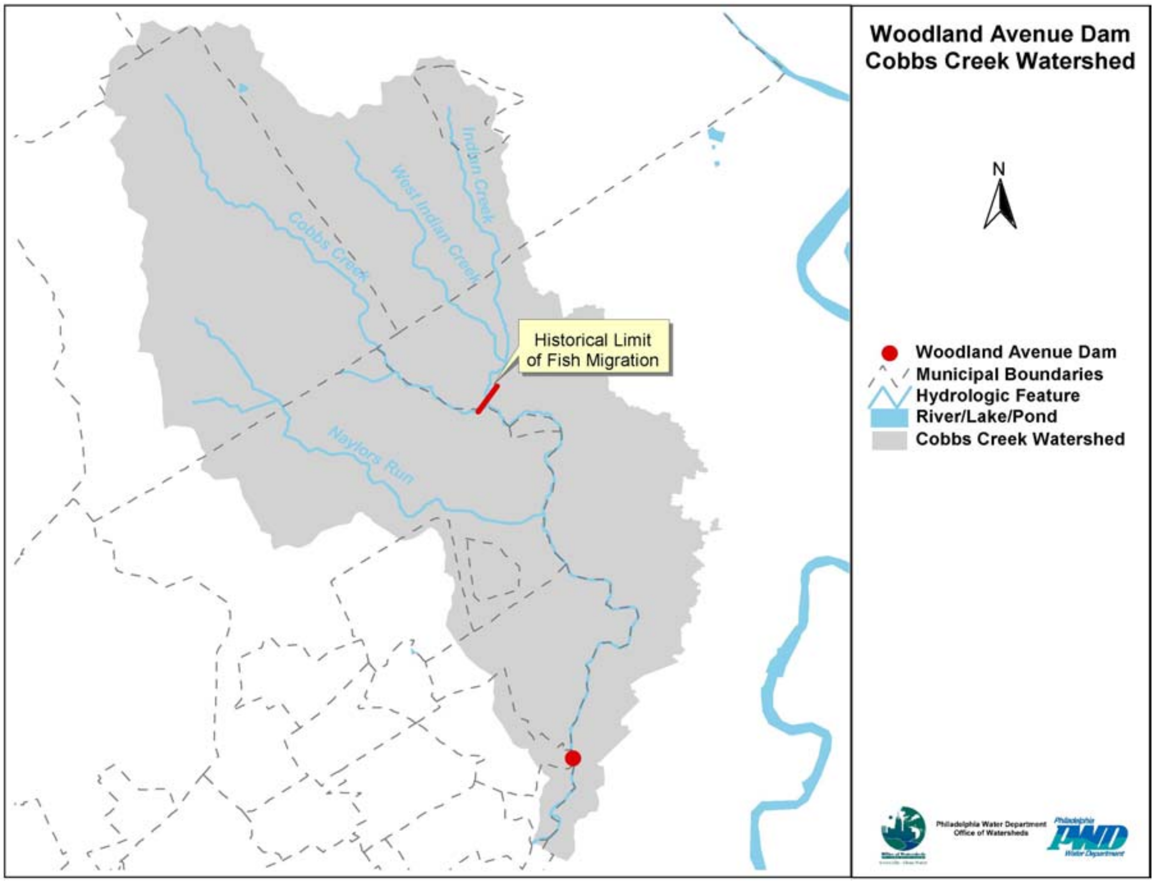


Figure 7-9 Woodland Avenue Dam

7.2.2 Lowland Restoration and Enhancement

One major riparian corridor improvement action, from both an ecological and water quality improvement perspective, is creation and enhancement of wetlands along Cobbs Creek. NLREEP has completed several wetland creation and enhancement projects in Cobbs Creek Park since 1998, including a constructed stormwater treatment wetland at the confluence of Cobbs Creek and Naylors Run. The Cobbs and Indian Creek subwatersheds were field surveyed in 2002/2003 to assess additional wetland creation and improvement opportunities. Existing wetlands were evaluated for their ability to perform important wetland functions (e.g., flood flow alteration, water quality improvement, and habitat). Existing wetlands were then assessed to determine if they were degraded and might be enhanced. Finally, locations where new wetlands could be created were identified. New wetland creation opportunities were classified into two groups:

- Wetlands immediately adjacent to the waterway and which would receive flood flows frequently during the year (< one year storm), and,
- Pocket wetlands that can be created using check dams that are higher in the landscape and that would receive stormwater flows from adjacent subwatershed areas, but would receive flood flows only from major storm

events.

Wetlands Enhancement. Along the Cobbs and Indian Creek subwatersheds, 45 existing wetland areas were identified during the field investigation, and each was evaluated for wetland enhancement potential. Almost one-third of the wetlands exhibited high enhancement potential (Table 7-10), because they had a direct hydrologic relationship with the stream yet showed degraded conditions at present. Half of the wetland areas showed moderate enhancement potential, because their hydrologic relationship with the waterway had been partially compromised or they exhibited somewhat degraded conditions. The potential enhancement sites are designated on Figure 7-10; the site numbers correspond to those in the Comprehensive Watershed Characterization Report (soon to be available on the Partnership website).

Table 7-10 Wetland Enhancement Potential

Wetland Enhancement Potential	
Enhancement Rating	*Wetland Areas*
High	13
Moderate	27
Low	5

In general, priority will be given to wetland creation and enhancement over reforestation of uplands because of the greater water quality benefits provided by wetlands.

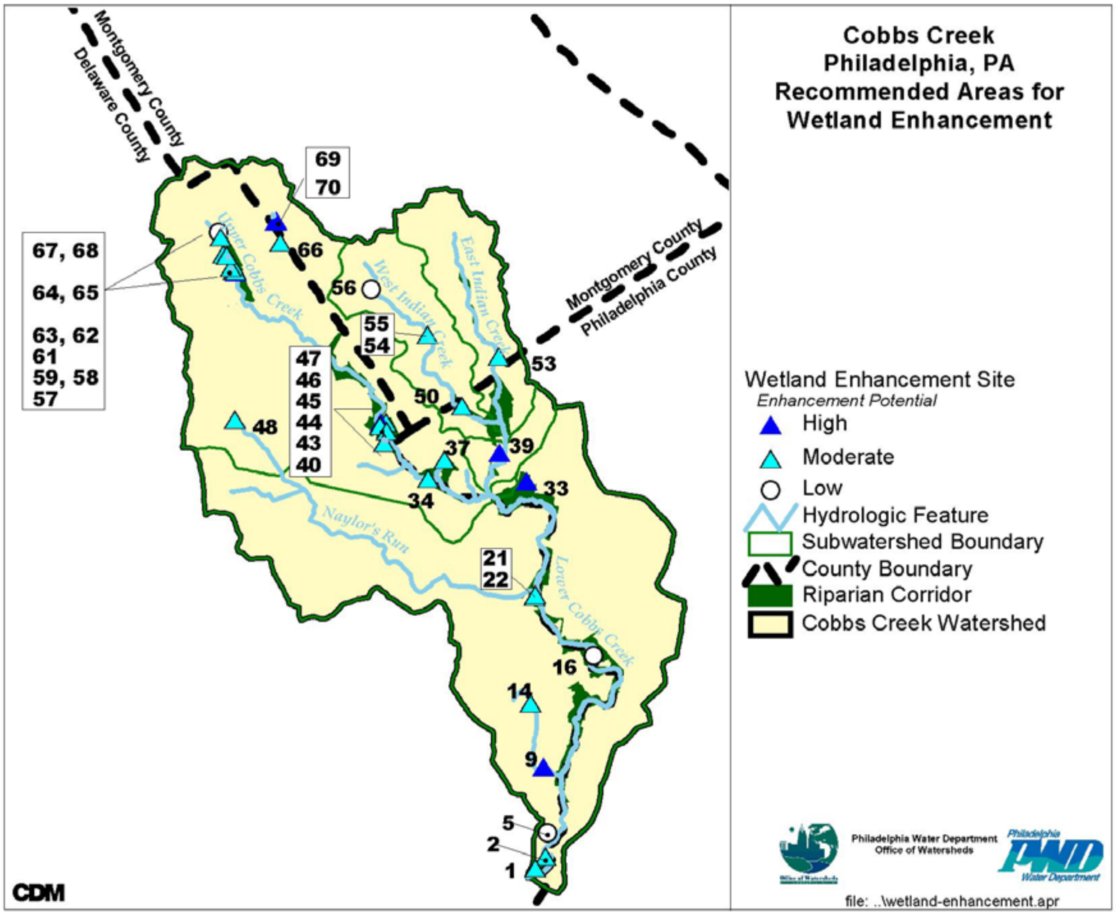


Figure 7-10 Potential Sites for Wetland Enhancement

Wetland Creation. Wetland creation opportunities have been evaluated for the many areas of Cobbs and Indian Creek where stream relocation and realignment are proposed. Because stream relocation and realignment typically involve extensive grading and replanting, new runoff patterns and hydrology can be created that are more similar to original riparian conditions, whereby the riparian corridor received storm runoff sheet flow from the adjacent landscape. In addition, wetland habitats can be created that allow more diverse habitat along Cobbs Creek. Wetlands are rich habitats that rely on saturated soils and vegetation adapted to these conditions. They could be recreated concurrently with channel realignment, bank restoration, and planting of more diverse native vegetation, including hydrophytic species adapted to saturated soil conditions.

Wetlands must have an adequate input of water, either by flooding or runoff, to maintain the soil and vegetation characteristics that are unique to wetlands. Field investigation of wetlands revealed, however, that several factors preclude the creation of extensive areas of new wetland. These include:

- extensive urban and suburban encroachment into the riparian corridor
- competing active recreational uses along the waterway

- steep slopes adjacent to the waterway limiting potential for floodplain hydrology

The wetland field investigation identified only 10 areas (comprising about 10-20 acres) *adjacent to the stream or in the floodplain* as wetland creation locations that would likely experience long-term success. These wetland creation locations are identified in Figure 7-11; the site numbers correspond to those in the Comprehensive Watershed Characterization Report.

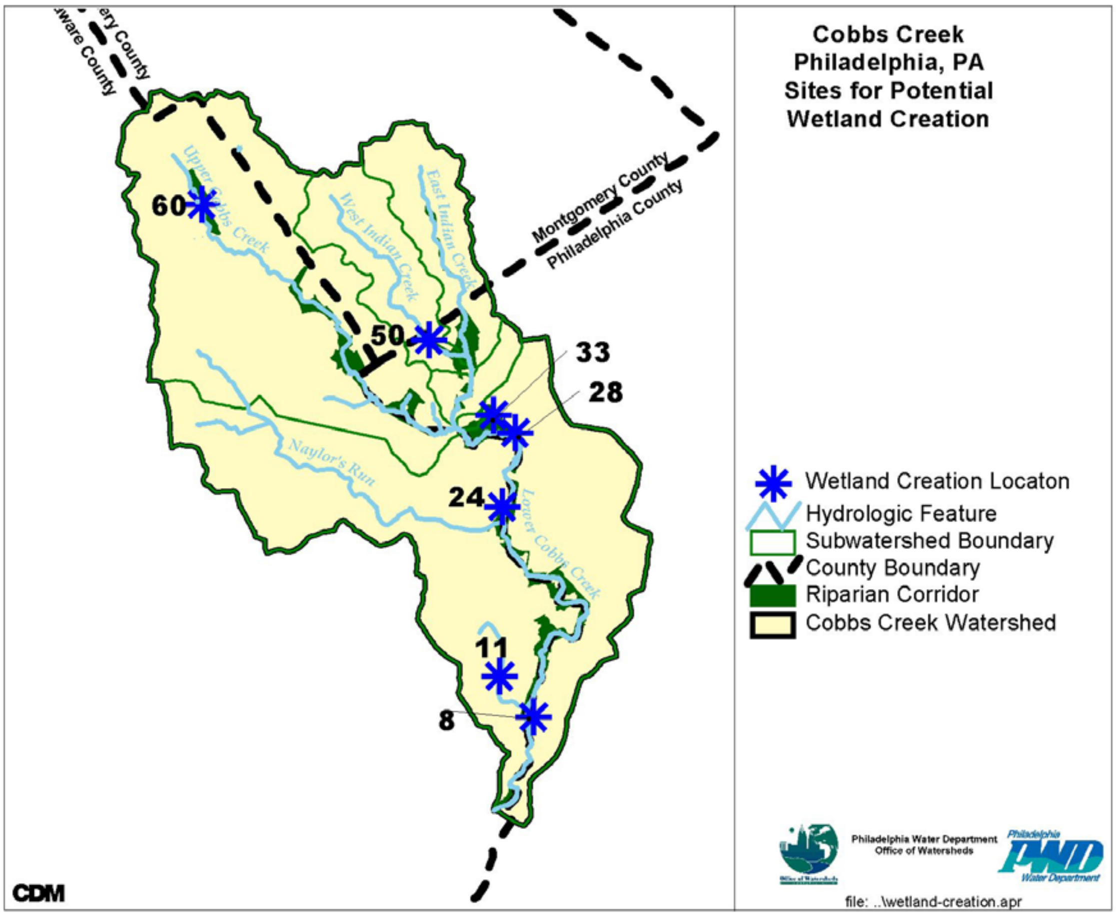


Figure 7-11 Potential Sites for Wetland Creation

However, as noted above, two types of wetland creation are recommended: floodplain wetlands and pocket wetlands. There are numerous opportunities for creation of pocket wetlands throughout the watershed; as stormwater runoff from the adjacent subwatershed is redirected over the riparian landscape, check dams and piping may be used to spread the runoff over the vegetated riparian land surface. Locations for creating pocket wetlands will need to be evaluated in the future as the riparian corridor restoration design is developed during the facilities planning stage. This is because opportunities for creation of pocket wetlands arise from bank restoration, revegetation, and biofiltration actions that will be implemented as part of the integrated riparian corridor improvement strategy for the Cobbs Creek watershed.

Both floodplain wetlands and pocket wetlands offer significant opportunity for water quality and ecological improvement along the Cobbs Creek riparian corridor, and will play a central role as the design of the riparian corridor improvements is developed.

Assuring long term success for wetland creation projects will involve future monitoring to measure integration of the wetland into the riparian landscape and to correct defective conditions, where possible. However, proper design of the wetland to assure adequate input of water (via flooding or runoff), protection from erosion, and maintenance of the diverse planted vegetation is essential to long-term success. Wetland creation projects typically involve monitoring and maintaining the created wetland's hydrology, vegetation (including invasive species), and erosion characteristics for a period of 3 years following creation.

It is estimated that wetlands can remove up to 80% of the total suspended sediments and pollutant loads they receive (Winer, 2000). It is estimated that approximately 50 to 100 acres of wetland creation may be possible in the Cobbs Creek watershed given an intensive creation effort as part of the riparian corridor improvement strategy. If implemented, the area of wetlands created could potentially provide significant improvement of CSO discharges and stormwater runoff from about 5,000 to 10,000 developed acres of the 14,000 acre Cobbs and Indian Creek watersheds (available in the Comprehensive Watershed Characterization report).

Wetland Creation (BM6) Related Goals: 1, 2, 4, 5, 7, 9, 10 Related Indicators: 1, 2, 3, 4, 7, 8, 9, 15, 19			
What	Who	Where	When
Wetland creation and enhancement for flood flow alteration, groundwater recharge, increased habitat, increased plant and animal diversity, and improved water quality.	PWD; Fairmount park NLREEP Municipalities bordering streams recommended for restoration.	Locations available for floodplain wetland creation are limited; areas for pocket wetland creation are extensive, especially where they are adjacent to lands proposed for stream realignment and back restoration. (See Figure 7-11)	Prototype design and evaluation phase in years 1-5; watershed-wide implementation over two 10 year phases, with initial high priority phase.

Further investigation of all potential wetland enhancement and creation opportunities should include the following: identification of landowners, rainfall data collection and evaluation, runoff calculations, soils investigation, water budget, native species investigation, and groundwater/soil saturation monitoring.

The existing historic dam near 67th Street and Race Street, known long ago as Old Mill Pond, has been identified as an area where a floodplain wetland could be created (Figure 7-12). A Philadelphia atlas from 1910 shows that this area has been inundated historically. The existing dam is on top of a natural rock ledge that has prevented fish from migrating further up the Cobbs. Enlargement of the historic dam at this location would recreate extensive floodplain wetlands in a largely undeveloped area, that would provide significant wetland acreage and water quality improvement for stormwater flows from the separate sanitary areas.

Any increase in the height of the dam would result in a gain of intermittently flooded area. This increased area would provide better “wetland treatment” of Cobbs Creek waters, especially during times of stormwater discharge. In the past, consideration has been given to lowering or removing the dam, but such actions would reduce both wetted area and treatment effectiveness. Raising the high water level by ten feet would provide a gain in approximate wetland area of close to 25 acres. The additional storage volume provided at high flow would be approximately 50 million gallons, representing a potential “treatment facility” equivalent value of $100 million to $200 million when compared to the cost of building treatment structures.

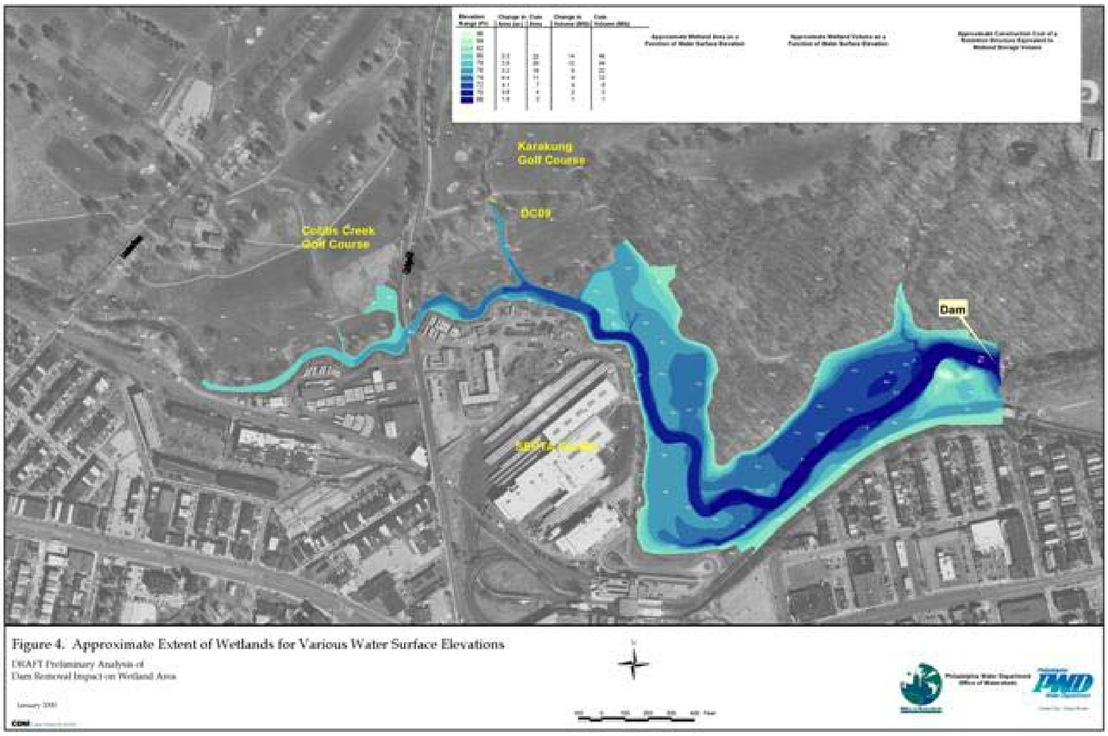


Figure 7-12 Proposed Dam Modification

Invasive Species Management (BM7) Related Goals: 7 Related Indicators: 12, 13, 14, 19			
What	Who	Where	When
Implement an Invasive Species Management Plan (already in effect in Fairmount Park)	PWD; Fairmount Park NLREEP	lowland and upland habitat restoration sites	Within 5 years

A plan to control invasive plant species is necessary when restoring or enhancing wetlands and riparian forests. Invasive species provide little value to native animals that depend on native species for habitat and food. Japanese knotweed (*Polygonum cuspidatum*) is the one prevalent invasive species that was observed during the field reconnaissance. In many areas, knotweed, due to its aggressive nature, has already out-competed native vegetation. Maintaining a healthy riparian plant community along Cobbs Creek, and East and West Indian Creeks will retain biodiversity and support a healthy stream ecosystem.

NLREEP has implemented an invasive species control program in the Fairmount Park portion of the stream corridor. It is recommended that invasive species control be expanded to the remaining natural areas of the corridor. Implementation of an invasive species management plan would assist natural succession within the riparian buffer and decrease further impacts of invasive species.

Planting plans for all restoration efforts should complement the invasive species management plan by recommending appropriate native planting to supplement areas where invasives have been eliminated. Although invasive species management priority areas are considered those that contain 80% or greater invasive species, the most practical approach is to recommend invasive species management be implemented for all riparian restoration sites. Recommended areas where restoration will occur are shown in Figure 7-10 above. An invasive species management plan will require, at a minimum, a three-year commitment to ensure success.

7.2.3 Upland Restoration and Enhancement

Biofiltration (BM8) Related Goals: 1, 4, 6, 9, 10 Related Indicators: 1, 2, 3, 4, 15, 19, 20			
What	Who	Where	When
Biofiltration involves creating sheet flow over the vegetated landscape to slow the rate of runoff, facilitate groundwater recharge, and remove sediment, nutrients, and toxicants from the runoff.	PWD; Fairmount Park NLREEP	Throughout Cobbs, East and West Indian Creek riparian corridors; focus on vegetated landscape	2 10-year implementation phases (high and medium priority)

The goal of the Cobbs Creek riparian corridor improvement strategy is to identify all opportunities along the riparian corridor for natural landscape designs that achieve water quality improvement. For higher landscape positions at the outer edges of the riparian corridor there are extensive opportunities to implement biofiltration to improve runoff. Biofiltration involves creating sheet flow over the vegetated landscape to slow the rate of runoff, facilitate groundwater recharge, and remove sediment, nutrients, and toxicants from the runoff. Typical biofiltration approaches include installation of stormwater swales and check dams along natural drainageways that spread runoff, creation of bioretention plantings and hydrology, and hydrologic features that allow sheet flow to spread over grassed and shrub/scrub fields to achieve water quality improvement. The advantage of biofiltration is that it is compatible with recreational use of the riparian corridor, because flows are very shallow and are usually only present during rainfall events.

Analysis of the existing stormwater management in the Cobbs Creek watershed shows that most stormwater outfalls discharge directly to the waterway. However, if the stormwater was redirected over the vegetated landscape higher in the stream valley, it would follow the natural slope and land contour as it traveled down to the stream. There are over 640 acres of undeveloped land along the Cobbs Creek riparian corridor, mostly in the Upper and Lower Cobbs Creek subwatersheds, but almost none of that land carries runoff sheet flow because the stormwater piping system conveys all flows, from storms large and small, directly to the stream. In order to achieve water quality improvement goals it is important to optimize the ability of this vegetated riparian land to receive overland runoff, rather than piping the runoff directly into the stream.

Under the Natural Lands Restoration Master Plan, NLREEP has constructed a number of stormwater infiltration and biofiltration projects in the Fairmount Park portion of the Cobbs corridor. One example is an excavated basin to capture runoff from a portion of Cobbs Creek golf course.

Biofiltration has an effectiveness range of about 25-60% in removing suspended solids from runoff, and the concept of directing runoff to sheet flow over the vegetated riparian landscape matches fully with the way that such lands function naturally in an undeveloped watershed. Thus, the goal of biofiltration is to restore sheet flow of runoff over the landscape, by using piping and hydraulic controls to spread runoff from smaller storms over the vegetated surface. It is essential that the design for biofiltration provide for high velocity flows from major storms to be bypassed, to avoid erosion.

Reforestation (BM9) Related Goals: 1, 3, 7, 8, 9 Related Indicators: 1, 2, 4, 12, 13, 16, 18, 19			
What	Who	Where	When
Reforestation adjacent to the channel to provide wetland habitat and other associated benefits.	PWD; Fairmount Park NLREEP Municipalities bordering streams recommended for restoration.	Priority reforestation sites: lands adjacent to the creek that are not developed and are currently unforested. Potential reforestation sites are existing ball fields, golf courses, hospital grounds, seminaries, and cemeteries located adjacent to the channel. These should also be evaluated. (See Figure 7-13)	begin 0-5 years; monthly maintenance schedule to be determined

The riparian corridor restoration and enhancement plan being proposed in this section covers the width of the stream corridor from developed edge to developed edge, including both lowland and upland forest. Reforestation that occurs adjacent to the channel will provide wetland habitat and other associated benefits. Although priority reforestation areas consist of floodplains, steep slopes, and wetlands, smaller areas such as public rights-of-way, parks, schools, and neighborhoods also provide reforestation opportunities. Benefits of reforestation are numerous: cooler temperatures, rainfall interception, reduced runoff, reduced sediment load, reduced discharge velocities, increased groundwater recharge, increased species diversity and habitat, and improved air quality and aesthetics. In the Fairmount Park portion of the corridor, NLREEP has planted over 26,000 trees, shrubs, and herbaceous species since 1998.

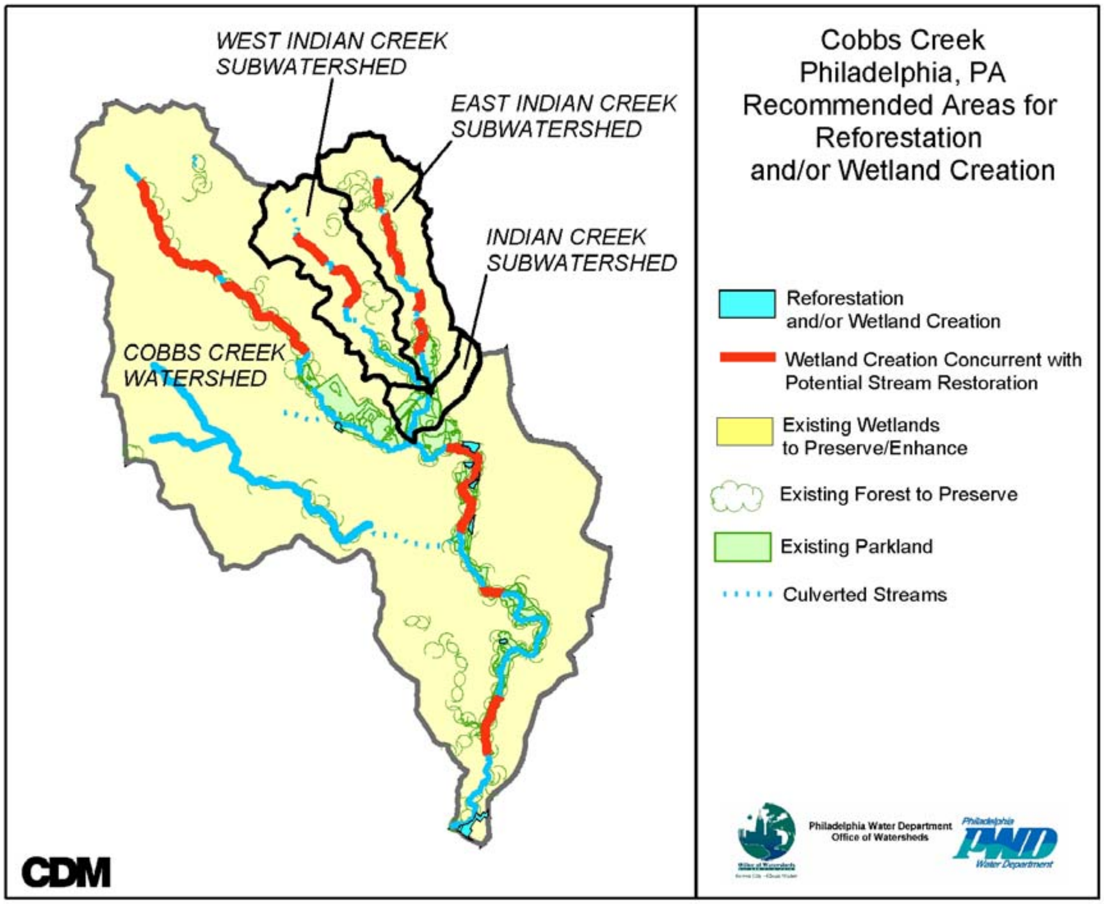


Figure 7-13 Recommended Areas for Reforestation

7.3 Target C: Wet Weather Water Quality and Quantity

Target C must be approached somewhat differently from the first two targets. Full achievement of this target means meeting all water quality standards during wet weather, as well as eliminating all flooding. Full achievement of these goals will be difficult, particularly with regard to wet weather water quality. It would certainly be extremely expensive, and would require a long term effort. The only rational approach to full achievement of Target C goals is through stepped implementation with interim targets for reducing wet weather pollutant loads and stormwater flows. During implementation, monitoring must continue to continuously assess the effectiveness of the program. Based on the extensive modeling analysis carried out for Cobbs Creek to date, an initial goal of a 20-30% reduction in stormwater flows and stormwater/CSO related pollutant loads is challenging but achievable.

In addition to the reduction in discharge volume, an important measure of progress is the percent capture of combined sewage in combined-sewered areas. It is estimated that implementing real time control will increase percent capture to approximately 80% in the middle portion of the Cobbs, and additional BMPs will increase it still further. In addition to capture by regulator structure, the quality of some CSO and stormwater flows will be improved in treatment wetlands before they reach the creek. A more precise assessment of percent capture will be performed during the initial stages of this plan.

It is expected that changes to the approach required to meet Target C, and even to the desired results, will occur as measures are implemented and results are monitored. With permits of 5-year duration for most discharge permits, discharge targets and reduction targets must be set and implementation designed in the first 5 years. Implementation for meeting Target C should occur over the next 5 years, with monitoring for effectiveness taking place for 5 years subsequent to implementation. During the last 5-year period, PWD should also work with the regulatory agencies to review water quality standards and determine whether any adjustments to them may be appropriate based on the results of monitoring.

Regulatory Approaches

Zoning and Land Use Control

CR2 Requiring Better Site Design in Redevelopment

CR3 Stormwater and Floodplain Management
CR4 Industrial Stormwater Pollution Prevention
CR5 Construction Stormwater Pollution Prevention
CR6 Post-construction Stormwater Runoff Management
CR7 Pollution Trading
CR8 Use Review and Attainability Analysis
CR9 Watershed-Based Permitting

Municipal Measures

CM1 Sanitary Sewer Overflow Detection
CM2 Sanitary Sewer Overflow Elimination: Structural Measures
CM3 Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers
CM4 Combined Sewer Overflow (CSO) Control Program

- Nine Minimum Controls
- Long Term CSO Control Plan
- Watershed-Based Planning

CM5 Catch Basin and Storm Inlet Maintenance
CM6 Street Sweeping
CM7 Responsible Landscaping Practices on Public Lands
CM9 *R*esponsible Bridge and Roadway Maintenance

Stormwater Management

Source Control Measures

CS1 Reducing Effective Impervious Cover Through Better Site Design
CS2 Increasing Urban Tree Canopy
CS3 Porous Pavement and Subsurface Storage
CS4 Green Rooftops
CS5 Capturing Roof Runoff in Rain Barrels or Cisterns

Onsite and Regional Stormwater Control Facilities

CS6 Maintaining/Retrofitting Existing Stormwater Structures
CS8 Retrofit of Existing Sewer Inlets with Dry Wells
CS9 Residential Dry Wells, Seepage Trenches, and Water Gardens
CS12 Bioretention Basins and Porous Media Filtration
CS13 Treatment Wetlands: Onsite and Regional

CMR Monitoring and Reporting

Table 7-11 Maximum Feasible Reductions for BMPs with Quantifiable Benefits

Target C	Recommended Implementation	DCIA Reduction	SW Reduction Inf./ET	CSO Reduction Captured	Pollutant Reduction
Municipal Measures					
CM4 Combined Sewer Overflow (CSO) Control Program					
• Real Time Control	15 Sites in PWD's SWDD	N/A	N/A	11%	14%
Structural Stormwater Management Facilities					
Source Control Measures					
CS1 Reducing Impervious Cover through Better Site Design		1%	2%	4%	N/A
CS2 Increasing Tree Canopy Cover	increase from 26% to 31%	5%	1%	not modeled	not modeled
CS3 Porous Pavement and Subsurface Storage	10% of parking lots	1%	0.05%	1%	2%
CS4 Green Rooftops	demonstration projects	N/A	N/A	N/A	N/A
CS5 Capturing Roof Runoff in Rain Barrels or Cisterns	5% of homes	5%	0.5%	2%	2%
Onsite and Regional Stormwater Control Facilities					
CS8 Retrofit of Existing Sewer Inlets with Dry Wells	10% of inlets in combined areas	3%	N/A	0.4%	0.4%
CS9 Residential Dry Wells, Seepage Pits, Water Gardens	10% of residences	14%	0.3%	3%	5%
CS12 Bioretention Basins and Porous Media Filtration	10% of parking lots		0.1%	1%	2%
CS13 Treatment Wetlands: Onsite and Regional		5%	1%	1%	2%
TOTAL		34%	27%		28%

7.3.1 Regulatory Approaches

Encouraging or Promoting Better Site Design in Redevelopment (CR2) Related Goals: 1, 7, 9, 10 Related Indicators: 1, 12, 13, 16, 19, 20			
What	Who	Where	When
Adopt or improve ordinances to encourage developers to use low impact methods for new ("greenfield") development and redevelopment of urban areas.	See Table 7-14 (may not identify all municipalities with ordinances)	Entire Watershed	within 5 years; update as needed

Environmentally friendly site design, also called low impact development (LID) and conservation site design, encompasses a range of site design elements for developers, and design requirements from municipalities. Some examples of LID design concepts include maintaining stream buffers, designing for open space, reduced street and sidewalk footprints where appropriate, and parking lot designs that reduce runoff and encourage infiltration. Stormwater source controls, infiltration BMPs, and treatment BMPs can be integrated with LID designs. Recommendations for incorporating these features in the Cobbs watershed are found throughout Target C.

LID is intended to reduce the impact of development on natural resources and water resources. Municipal design requirements are intended to preserve or increase open space, protect sensitive natural resources, and limit impervious cover. The environmental *goals* of land development and stormwater ordinances are closely related, although the ordinances themselves and mechanisms for enforcing them may be separate. This section discusses land use-related regulatory approaches to better site design, while the next section discusses regulatory approaches to stormwater management.

It appears that most of the municipalities in the Cobbs Creek watershed encourage several standard low impact development practices through their existing land use ordinances. However, these guidelines tend to focus on clustering housing by allowing higher-density multi-family residential developments with common open spaces. Separate language focusing specifically on the protection of natural resources is recommended. While most municipalities in the watershed have already adopted a steep slope ordinance, Lower Merion Township is currently the only municipality within the watershed with a cluster development ordinance and wetlands protection ordinance in place. Table 7-14 identifies the municipalities located in the watershed that have adopted low impact development ordinances.

Table 7-14 Better Site Design in Existing Ordinances

Municipality	Better Site Design Ordinance (at least one component)
Colwyn Borough	
Darby Borough	
East Lansdowne Borough**	
Haverford Township	X*
Lansdowne Borough	X
Lower Merion Township	X*
Millbourne Borough	
Narberth Borough	
Philadelphia	
Radnor Township	X*
Upper Darby Township	X*
Yeadon Borough	

Notes
** includes a steep slope*
***Ordinances for East Lansdowne Borough were not reviewed for this analysis.*
Source: www.ordinance.com, Delaware Valley Regional Planning Commission

The Delaware Valley Regional Planning Commission (DVRPC) has recently completed the task of reviewing the municipal zoning ordinances of the Delaware Valley's 353 municipalities. Based upon this analysis, DVRPC has created a list of "outstanding sample natural resource and open space protection ordinances." These model ordinances as well as additional information on DVRPC's program are available at:

- DVRPC Natural Resource Protection Information - http://www.dvrpc.org/planning/protectiontools.htm
- Model Ordinances - http://www.dvrpc.org/planning/Protection%20Tools/ordinances.htm

Guidelines for LID in an Urban Setting

Table 7-15 identifies various zoning ordinances that could be adopted by the municipalities in the Cobbs Creek watershed. While some municipalities already incorporate elements of these zoning measures within their existing code, it is recommended that ordinances specific to low impact development be adopted to better facilitate future growth and redevelopment within these municipalities. Model ordinances for each of these examples are available on the DVRPC website at the address listed above.

Table 7-15 Selected Components of Low Impact Development Ordinances

Municipal Zoning Ordinance	Description
Net-Out of Resources / Site Capacity Calculations	Protect wetlands, floodplains, and riparian buffers by removing them from the area considered for new development and redevelopment. In calculating the developable area, environmentally sensitive areas should be excluded. Some local governments allow increased densities in the remaining developable land area to provide an incentive for protecting sensitive environments. Existing trees should be protected if possible; if not, the land owner may contribute to a mitigation fund for each tree cut down.
Wetlands Management Ordinance	Protects environmentally sensitive wetlands areas. This ordinance usually requires wetlands delineation within the municipality and prohibits any type of development in a delineated wetland area.
Cluster Development Ordinance	Allows developers to build at higher densities on one portion of a site in exchange for preserving another portion as open space. Land preservation percentages and densities vary, but the preferred percentage is for at least 50% of the tract to remain as open space. Achieving a landowner's financial objectives may be a function both of partial development and donation of a conservation easement (and its inherent deductibility under the federal tax code).
Planned Residential Development (PRD)	Facilitates residential development in areas designated by the municipality. Provisions are made for higher housing densities, thereby creating larger contiguous common open spaces, and providing for pedestrian access between residential areas.
Steep Slope Ordinance	Regulates development on areas designated as steep slopes. The minimum gradient classified as steep varies by municipality, but according to DVRPC 8% is typical.
Transfer of Development Rights (TDR)	Designates areas of a municipality as "sending" and "receiving" areas. Allows community to preserve open space and natural features while still permitting growth. Development is moved from large tracts of rural land (sending area) to areas designated for higher densities (receiving area).

While the measures above were originally intended for new development, they may be adapted for larger redevelopment projects in urban areas. Older areas often have large areas of vacant and abandoned properties that may be demolished all at once, creating significant open space. Cluster development, for example, could be applied on these larger sites.

In addition to the specific ordinances above, municipalities should require, or provide strong incentives for, innovative site design when urbanized areas are redeveloped.

Effective conservation design techniques to consider include the following:

- Review municipal codes and require smaller footprints for impervious surfaces, such as road and sidewalk widths. Review any stipulation of a minimum size lot that development and stormwater ordinances apply to. In the City of Philadelphia, the ordinance requiring all downspouts to be connected directly to the sewer system is not appropriate in all cases; wherever feasible, infiltration (e.g., using dry wells) should be encouraged over disposal of stormwater to combined or separate storm sewers.

- Depending on the zoning classification, specify a maximum effective impervious cover allowed after construction. Many publications recommend that impervious cover connected directly to the drainage system be limited (see "Reducing Effective Impervious Cover through Conservation Site Design" for specific recommendations). Developers are then free to choose a combination of methods to meet the requirement: an absolute reduction in impervious cover, directing runoff onto depressed landscaped areas, tree credits, and structural BMPs. Consider incentives in the stormwater control calculations to reduce directly connected impervious surfaces.

- For areas experiencing redevelopment, structural stormwater controls may be tied to the impervious area calculations discussed above. Developers have an incentive to reduce impervious area because it may be more cost effective than installing structural stormwater BMPs. Specific recommendations for stormwater ordinances are discussed under option CR3.

- Promote discussions early in the development review process at the sketch plan/conceptual plan level (before developers have spent large sums of money on design and engineering). A number of municipalities around the U.S. have concluded that sketch/conceptual plans are more important in the planning process than preliminary plans because early intervention and change allows greater opportunity to include innovative low impact development designs. Some municipalities have opted to eliminate the final plan and accept the preliminary plan as the final plan as an incentive to developers to participate.

- After the final plan is submitted, require a pre-construction meeting and a site visit to discuss construction issues and pollution prevention.

- Consider incentives in addition to regulations. For example, award density or stormwater control bonuses for reducing impervious cover. Streamline project reviews and waive permit fees when conservation design objectives are met. Tie stormwater fees and/or property taxes to impervious cover and stormwater management practices.

Stormwater and Floodplain Management (CR3) Related Goals: 1, 4, 6, 7, 9, 10 Related Indicators: 1, 2, 12, 13, 15, 19, 20			
What	Who	Where	When
Participate in finalization of the watershed-wide Act 167 plan and model ordinance being developed by Delaware County. Adopt and enforce the model ordinance.	Counties to adopt plan and ordinance first, followed by all municipalities (See Table 7-16)	Entire Watershed	begin within 5 years; update as needed

Table 7-16 identifies the municipalities in the Cobbs Creek watershed that currently have a floodplain protection or stormwater ordinance in place.

Table 7-16 Floodplain and Stormwater Ordinances in the Cobbs Creek Watershed

Municipality	Floodplain Ordinance	Stormwater Ordinance
Colwyn Borough	X	
Darby Borough		
East Lansdowne Borough**		
Haverford Township	X	
Lansdowne Borough		
Lower Merion Township	X	X
Millbourne Borough	X	X
Narberth Borough		
Philadelphia	X	X
Radnor Township	X	X
Upper Darby Township	X	
Yeadon Borough		

*** Note: Ordinances for East Lansdowne Borough were not reviewed for this analysis.*
Source: www.ordinance.com, Delaware Valley Regional Planning Commission

The majority of municipalities in the watershed have adopted ordinances limiting development in the floodplain or designating a floodplain conservation district. The protection offered varies by municipality, but an effective ordinance should place controls on land development within the 100-year floodplain as well as limit development within riparian corridors.

EPA provides a model for a floodplain preservation ordinance at the following website link:

- EPA Model Ordinances
http://www.epa.gov/owow/nps/ordinance/osm1.htm

Led by Delaware County, the four counties in the Cobbs Creek watershed (and the Darby-Cobbs watershed as a whole) are cooperating to develop an official Act 167 Stormwater Management Plan and model ordinance. The model ordinance will specify measures that must be undertaken to promote infiltration, improve water quality, reduce streambank erosion rates, and protect against flooding. These requirements will apply to both new (also called "greenfield") development and redevelopment (including brownfields or former industrial sites), and to both separate-sewered and combined-sewered areas. As of February 2004, the plan and model ordinance were still under development; all counties and municipalities will be invited to provide input before the plan is finalized.

Adoption and implementation of the model ordinance is a critical step that will allow municipalities to begin implementing many of the wet weather management measures mentioned later under Target C. For example, the ordinance will require a specific storage volume to be created on a developed site and will indicate that it must be a BMP capable of water quality treatment. The developer will then consult a stormwater manual designated by the municipality to determine an appropriate BMP and appropriate design criteria.

While many of the state manuals provide excellent guidance for new development, PWD plans to develop a manual with specific guidance for redevelopment projects given local conditions. Some preliminary ideas for this BMP manual are listed below:

<u>Commercial/Industrial Land Uses</u>

1. Use better site design techniques, landscaped areas, and tree credits to decrease impervious cover directly connected to the drainage system.
2. Directly-Connected Parking Lots

- Convert to porous pavement (or other drainage mechanism) and subsurface storage if feasible. If converted, the entire parking lot is no longer considered effective impervious area.
- If porous pavement and storage are not feasible, install a depressed bioretention (and/or porous media filtration) system. If the parking lot area is drained to a bioretention system it is no longer considered effective impervious area.

3. Directly-Connected Rooftops

- If parking lot storage is installed, route rooftop drainage to the storage. The rooftop area will no longer be considered an effective impervious cover if it is drained to the storage.
- If parking lot storage is not feasible, route rooftop drainage to dry wells. If dry wells are not feasible, route rooftop drainage to rain barrels or tanks. In either case, the rooftop is no longer considered an effective impervious area.

3. Other approaches may be proposed and considered on a case-by-case basis.

Residential Land Uses

1. Use better site design techniques, landscaped areas, and tree credits to decrease effective impervious cover.
2. Route roof runoff to dry wells if feasible. If dry wells are not feasible, route rooftop drainage to rain barrels or tanks. In either case, the rooftop is no longer considered an effective impervious area.
3. Other approaches may be proposed and considered on a case-by-case basis.

Industrial Stormwater Pollution Prevention (CR4) Related Goals: 1, 5, 6, 9, 10 Related Indicators: 1, 2, 3, 4, 7, 8, 9, 10, 19, 20			
What	Who	Where	When
Enforcement of NPDES requirements for Industrial Stormwater Management Dissemination of information on spill prevention and pollution prevention plans.	The PADEP is the Designated Authority responsible for issuing, administering, and enforcing NPDES permits Municipalities are responsible for information dissemination.	All sites contributing storm water discharges associated with industrial activity within the watershed	Within 5 years

Industrial stormwater pollution prevention measures can contribute significantly to achieving the watershed plan's wet weather implementation targets. These measures include monitoring and enforcing existing industrial stormwater permit requirements under Phase I of the NPDES program, as well as, Official Industrial Pollution Prevention Plans and Spill Response Actions required by the state. Full implementation of these measures should be monitored and enforced throughout the watershed.

NPDES Industrial Stormwater Permits

All sites contributing storm water discharges associated with industrial activity, defined in federal regulations (40 CFR §§ 122.26(b)(14)(i)-(xi)), are required to be covered under Phase I of the NPDES stormwater program. This includes discharges from any conveyance that is used for collecting and conveying storm water and that is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. This includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and final products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. The term material handling activities includes storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, final product, by-product or waste product.

The PADEP is the Designated NPDES Authority responsible for issuing, administering, and enforcing NPDES stormwater permits under the EPA's regulatory provisions set forth in 40 CFR.

Storm water discharges from most industrial facilities are covered under General Permits when they discharge into municipal separate sanitary sewers. General NPDES permits have a fixed term not to exceed 5 years. An operator of a storm water discharge associated with industrial activity which discharges through a large or medium municipal separate storm sewer system shall submit, to the operator of the municipal separate storm sewer system receiving the discharge the following information: the name of the facility; a contact person and phone number; the location of the discharge; a description, including Standard Industrial Classification, which best reflects the principal products or services provided by each facility; and any existing NPDES permit number.

In addition, the operator of a storm water discharge associated with industrial activity covered under a general, group, or individual permit, shall provide the following minimum information (40 CFR § 122.26 (c)(i)):

- A site map showing topography, drainage features, buildings, and areas where materials or activities may contribute pollutants to storm water.
- An estimate of the area of impervious surfaces (including paved areas and building roofs) and the total area drained by each outfall (within a mile radius of the facility) and a narrative description of materials handled or stored as well as measures taken to control pollutants in the runoff.
- A certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested or evaluated for the presence of non-storm water discharges which are not covered by a NPDES permit; tests for such non-storm water discharges may include smoke tests, fluorometric dye tests, analysis of accurate schematics, as well as other appropriate tests. The certification shall include a description of the method used, the date of any testing, and the on-site drainage points that were directly observed during a test;
- Existing information regarding significant leaks or spills of toxic or hazardous pollutants at the facility that have taken place within the three years prior to the submittal of this application;
- Quantitative data based on samples collected during storm events from all outfalls containing a storm water discharge associated with industrial activity for a number of water quality parameters.

Industrial Pretreatment Requirements

Industrial pretreatment requirements are another area where enforcement can result in lower pollutant concentrations in storm water. Under PA Code Title 25 § 94.15, the operator of the sewerage facilities in cases where pollutants contributed by industrial users result in interference or pass through, and the violation is likely to recur, must develop and implement specific local limits for industrial users and other users, as appropriate, that together with appropriate sewerage facility or operational changes, are necessary to ensure renewed or continued compliance with the plant's NPDES permit or sludge use or disposal practices.

Additional Measures

Information on existing pollution prevention plans and spill response requirements should be provided to relevant industries in the watershed as part of the Phase II public education measures.

Industrial Pollution Prevention Plans are one means to prevent spills and accidental releases. Under PA Code Title 25 § 91.34 (Activities Utilizing Pollutants):

- Persons engaged in an activity which includes the impoundment, production, processing, transportation, storage, use, application or disposal of pollutants shall take necessary measures to prevent the substances from directly or indirectly reaching waters of this Commonwealth, through accident, carelessness, maliciousness, hazards of weather or from another cause.

- PADEP may require a person to submit a report or plan setting forth the nature of the activity and the nature of the preventative measures taken. The Department will encourage consideration of the following pollution prevention measures, in descending order of preference, for environmental management of wastes: reuse, recycling, treatment and disposal.

Spill response is another area that can improve wet weather water quality in Cobbs Creek. Spill response requirements are promulgated under PA Code Title 25 and issued under section 5 of The Clean Streams Law (35 P. S. § 691.5).

Under PA Code Title 25 § 91.33 (Incidents Causing or Threatening Pollution):

- If, because of an accident or other activity or incident, a toxic substance or another substance which would endanger downstream users is discharged, it is the responsibility of the person at the time in charge of the substance to immediately notify PADEP by telephone of the location and nature of the danger and, if reasonably possible to do so, to notify known downstream users of the waters.

- In addition to the notices, the person shall immediately take steps necessary to prevent injury to property and downstream users, and within 15 days from the incident, remove from the ground the residual substances to prevent further pollution.

Construction Stormwater Pollution Prevention (CR5) Related Goals: 1, 5, 6, 9, 10 Related Indicators: 1, 2, 3, 4, 7, 8, 9, 10, 19, 20			
What	Who	Where	When
Construction Site Stormwater Program in conformance with Phase II Stormwater Permits • Enact an Ordinance • Review and approve Erosion and Sediment Control Plans • Distribute Educational Materials	All Municipalities required to do Phase II permit (see Table 7-4)	N/A	Five year program associated with stormwater permit (See Table 7-15)

In accordance with the Cobbs Creek Plan's stated purpose of integrating various existing programs, and to avoid duplication of effort, the recommended implementation plan follows the Stormwater Management Program Protocol ("Protocol") to meet the six minimum control measures required of municipal permittees under the Phase II NPDES Stormwater Regulations (found at 40 CFR §§ 122.26 – 123.35). One of the six minimum controls is a Construction Site Stormwater (CSS) Program.

In Pennsylvania, two programs currently exist that address stormwater runoff from construction activities: 1) the Erosion and Sediment Control Program under 25 Pa. Code Chapter 102, and 2) the NPDES Stormwater Construction Permit Program.

The Erosion and Sediment Control Plan submitted by the developer must contain BMPs appropriate to the site and the surrounding area that might be impacted by the construction activities, as well as for post-construction runoff. Construction activity-related BMPs are available to developers and others through the Erosion and Sediment Pollution Control Program Manual, (PADEP ID: 363-2134-008) on PADEP's website, www.dep.state.pa.us, directLINK "stormwater," and available at the County Conservation District (CCD).

The CSS program can be summarized as consisting of the following steps:

- Enact, implement and enforce a stormwater control ordinance using PADEP model language (a model PADEP is available),
- Coordinate the review and approval of Erosion and Sediment Control Plans with the County Conservation District(s) (CCD) or PADEP for any earth disturbance of one acre or more causing runoff or any earth disturbance five acres or more. Make approval of the Erosion and Sediment Control Plan a prerequisite for the formal approval of land development and redevelopment plans or the issuance of building permits, and

- Distribute educational materials to land developers with the applications for building permits and other land development/redevelopment.

Municipalities must have an agreement with their local CCD that addresses these reviews and permitting requirements. This agreement ensures the close coordination between the municipality and the CCD on these important issues affecting water quality. Note that a NPDES Stormwater Construction Permit is required for earth disturbance activities where the construction disturbs five acres or more, or there is a discharge from a site to the MS4 where earth disturbance is one acre or more.

In most cases, the County Conservation District implements these two programs, and PADEP is responsible for implementing and enforcing these programs in cases where the County does not have this responsibility. By requiring review and approval of Erosion and Sediment Control Plans by the CCD or PADEP (and proof of NPDES Stormwater Construction Permits where required), and by coordinating building permit and other land development permits or approvals with the CCD (or PADEP in some cases), municipalities will meet MS4 permit requirements for this component of the Construction Stormwater Runoff Management Minimum Control Measure. Utilizing this existing statewide program, the municipality avoids the need to do a duplicative, independent review of every Erosion and Sediment Control plan.

All municipalities in the watershed are required to fulfill this aspect of the stormwater regulations. Table 7-15 shows the schedule for implementation.

Table 7-15 Implementation Schedule for Construction Stormwater Pollution Prevention

PERMIT YEAR	*IMPLEMENTATION SCHEDULE* **Construction Site Stormwater Program**	**Developer Education**
Year 1	• Ordinance: enact an ordinance requiring: • the review and approval of Erosion and Sediment Control Plans by the local County Conservation District or PADEP • for any earth disturbance one acre or more with runoff to the MS4, or five acres or more regardless of the planned runoff, and • as a prerequisite for the formal approval of land development plans or the issuance of building permits • Process: Establish an agreement with the local CCD for the review and approval of Erosion and Sediment Control Plans for all earth disturbance activities equal to or greater than one acre with runoff to the MS4 (or five acres or more regardless of the planned runoff) • Standard: Require that the Erosion and Sediment Control Plans be developed in accordance with the requirements of Chapters 102 (erosion and sedimentation) of the PADEP regulations	Meet permit requirements and measurable goals for Year 1 under Public Education and Outreach minimum control measure.
Years 2-5	Implement the ordinance and agreement for review of Erosion and Sediment Control Plans	Meet permit requirements and measurable goals for Year 2 under Public Education and Outreach minimum control measure.

Post-Construction Stormwater Runoff Management (CR6) Related Goals: 1, 5, 6, 9, 10 Related Indicators: 1, 2, 3, 4, 7, 8, 9, 10, 19, 20			
What	Who	Where	When
Post-Construction Stormwater Runoff Management in conformance with Phase II Stormwater Permits • Enact Ordinance • Coordinate Review and Approval of Plans • Ensure BMP Maintenance	All Municipalities required to do Phase II permit (see Table 7-4)	N/A	Five year program associated with stormwater permit. (See Table 7-16)

In accordance with the Cobbs Creek Plan's stated purpose of integrating various existing programs, and to avoid duplication of effort, the recommended implementation plan follows the Stormwater Management Program Protocol ("Protocol") to meets the six minimum control measures required of municipal permittees under the Phase II NPDES Stormwater Regulations (found at 40 CFR §§ 122.26 – 123.35). One of the six minimum controls is a Post-Construction Stormwater Runoff Management Program. The program can be summarized as consisting of the following steps:

- Enact, implement and enforce a stormwater control ordinance using PADEP model language,

- Coordinate the review and approval of post-construction BMPs simultaneously with the review and approval for construction Erosion and Sediment Control Plans as described in the Construction Minimum Control Measure, and

- Ensure long-term operation and maintenance of the BMPs

PADEP links management of post-construction run-off with the Construction Minimum Control Measure component discussed above. Approvals for construction activities will be dependent on how post-construction issues are addressed. For example, if an applicant's plan for a land development or redevelopment project adequately addresses stormwater issues during construction but does not do so for post-construction impacts, then it must not be approved until the post-construction issues are addressed.

Ordinance

Municipalities must enact, implement and enforce a stormwater control ordinance using PADEP model language. The ordinance must address the proper standard for BMPs and operations and maintenance requirements for the BMPs. The ordinance will apply a statewide post-construction requirement until the water quality-based

Act 167 Plan is adopted by the County and implemented by the municipality, at which time the municipality will need to amend it to include those requirements.

The ordinance should require that all development and redevelopment activities with earth disturbance one acre or more with runoff to the MS4 (or five acres or more regardless of the planned runoff), be conducted in accordance with the ordinance. No formal approval of land development plans or issuance of building permits should occur without municipal approval of post-construction stormwater controls. A Model Ordinance is available from PADEP.

Implement Program

The municipalities must commit municipal resources or establish an agreement with the local CCD or other service provider (e.g., municipality's consulting engineer) for coordination of post-construction BMP approvals. There must be a process to review the post-construction controls in conjunction with the review process for construction approval.

Ensure that the post-construction controls will meet state water quality requirements.

The requirements for post-construction controls depend upon the status of the Act 167 Stormwater Management planning in the watershed. Where a water-quality-based Act 167 plan has been completed (or updated), those local watershed requirements apply. Otherwise, statewide requirements must be implemented.

It is the municipalities' responsibility to ensure that the BMPs meet the water quality requirements. However, PADEP will be reviewing post-construction plans for Individual permits, and some County Conservation Districts have the expertise to conduct the reviews under an agreement with the municipality similar to that for the Construction Minimum Control Measure.

Operation and Maintenance of Post-Construction BMPs

It is the municipalities' responsibility to ensure that the post-construction BMPs required and approved pursuant to the program are constructed, operated and maintained. Many BMPs may be "non-structural"; they will require no operation or maintenance. Examples are use of open space and vegetated buffers in development design, minimization of soil disturbance and compaction during construction, and minimization of directly-connected impervious areas. Other BMPs - "structural BMPs" - will require proper operation and maintenance. Examples include wet ponds, grassed swales, infiltration basins and bioretention areas.

Municipalities will need to have a monitoring program that ensures that the post-construction BMPs are constructed, operated and maintained, within the first permit term of 5-years.

The program must have two elements:

- Implementation: ensure installation of the BMPs as designed. Coordinate the monitoring with the CCD, especially where a permit has been issued.

- Operation and Maintenance: some of the structural BMPs will require maintenance over time to be effective. Municipalities must have a system to monitor these BMPs. If any BMPs are not operated or maintained and are ineffective, municipalities must develop a plan to address them. The PADEP Model Ordinance provides legal tools to accomplish this.

All municipalities within the Cobbs Creek Watershed must carry out this program (see Table 7-4). The schedule for full implementation is provided, in accordance with the new Phase II rules, in Table 7-16.

Table 7-16 Post-Construction Stormwater Runoff Management: Implementation Schedule

PERMIT YEAR	*IMPLMENTATION SCHEDULE*	
	Stormwater Management Program	Long Term Operation and Maintenance
Year 1	• Ordinance: Enact an ordinance requiring: • No formal approval of land development plans or issuance of building permits without municipal approval of post-construction stormwater controls • Development and redevelopment activities with earth disturbance of one acre or more with runoff to the MS4, or five acres or more regardless of the planned runoff, be conducted in accordance with the ordinance • Process: Rely on PADEP review of permits where applicable; where no PADEP review of post-construction controls is conducted, use municipal resources, or establish an agreement with the local CCD or other service provider (e.g., municipal engineer), for coordination of post-construction BMP approvals • Standard: Require post-construction structural and non-structural BMPs be designed, constructed and maintained to meet (1) the requirements of the approved Act 167 plan and the municipal ordinance, or until such Act 167 Plan is in place, (2) the PADEP statewide water quality requirements.	• Ensure that stormwater BMPs are built, operated and maintained as designed
Years 2-5	• Implement the ordinance and post-construction BMP approval process	• Ensure that stormwater BMPs are built, operated and maintained as designed

Pollution Trading (CR7) Related Goals: 1, 2, 5, 6, 7, 9, 10 Related Indicators: 1, 7, 8, 9, 10, 11, 12, 13, 14, 16, 19, 20			
What	Who	Where	When
Investigate Opportunities for Pollution Trading; potentially use as part of the framework for distributing BMPs throughout the watershed	All Municipalities	Cobbs Creek Watershed	Long Term, following establishment of TMDLs.

Pollution trading presents an intriguing option to mitigating the impacts of stormwater on Cobbs Creek. Trading could focus on sources of stormwater, TSS, Fecal Coliform, and Cryptosporidium, and could occur between municipalities within the watershed. In Cobbs Creek, only trading between non-point sources is feasible in the absence of point sources, which presents a greater challenge than point source trading. Trading could only occur between municipalities and or private entities responsible for controlling stormwater.

Trading under TMDLs is not yet well established, however, some general guidelines exist. Usually under trading arrangements, the total pollutant reduction must be the same or greater than what would be achieved if no trade occurred. A “buyer” and “seller” would agree to a trade in which the buyer compensates the seller to reduce pollutant loads. Buyers would purchase pollutant reductions at a lower cost than what they would spend to achieve the reductions themselves. Sellers would provide pollutant reductions and receive compensation. Stormwater sources could negotiate trades bilaterally or may trade within the context of an organized program. Sources could negotiate prices or exchange rates for loading reductions themselves, or they may face those established by a market.

To form a tradable allowance market, a few conditions must exist.

- Mitigation measures must show a variety of unit costs, some high, some low. In the case of Cobbs Creek, there are potential cost differences between types of BMPs, and potential cost differences based on the placement of the BMP (either in a CSO area or in a separate storm sewered area).

- All participants are price conscious and seek the lowest cost alternative. This is generally true; however, issues of jurisdiction may impede trading. For example, a municipality may not wish to install a BMP in another municipality.

- An authority exists for the management of stormwater that has determined the ecological limits of Cobbs Creek and can facilitate trading credits. At this time, no such authority exists, however elements of this watershed plan do address this issue through Target C objectives.

- The authority can compute appropriate allowance prices (based on the private and public cost of stormwater management) and can operate as a clearinghouse for purchase and sale of allowances among participants.

- Runoff is apportioned to each parcel based on “natural” runoff rates, and additional runoff must be controlled, either by use of BMPs, or by buying allowances to cover their storm-water management responsibility. This aspect would be an integral part of any TMDL, which would establish total loads and apportion reductions.

In general, trading will not occur except in the context of a TMDL. Under the TMDL, total loads would be established and apportioned based on ecological impact and assessment of current loads. For Cobbs Creek, TMDLs have not been established, and trading remains a potential, future activity. (Thurston, Goddard, Szlag, Lemberg, 03; USEPA, 1996)

Use Review and Attainability Analysis (CR8) Related Goals: 5, 6, 7, 9, 10 Related Indicators: 7, 8, 9, 10, 11, 12, 13, 14, 19			
What	Who	Where	When
Coordinate water quality standards review and revision with PWD's CSO LTCP	EPA and PADEP in partnership with PWD and other permitted dischargers	Cobbs Creek and tributaries	within 5 years (1 NPDES CSO permit cycle)

The CSO Policy calls for the development of a long-term control plan (LTCP) which includes measures that provide for compliance with the Clean Water Act, including attainment of water quality standards. The CSO Policy provides that "development of the long term plan should be coordinated with the review and appropriate revision of water quality standards (WQS) and implementation procedures on CSO-impacted receiving waters to ensure that the long-term controls will be sufficient to meet water quality standards" (59 FR 18694).

As part of a renewed focus on this commitment, EPA has issued a guidance document, Coordinating CSO Long-Term Planning with Water Quality Standards Reviews (EPA-833-R-01-002). This document lays a strong foundation for integrating water quality standards reviews, implementation of high-priority CSO controls, and development of well-designed and operated LTCPs that support attainment of water quality standards without causing substantial and widespread economic and social impacts. In addition to CSO impacts, many of the processes, procedures and ideas presented can be used to address wet weather issues such as stormwater and other point and nonpoint sources on a watershed basis. An iterative, phased implementation of CSO controls fits well with the watershed approach. Because Cobbs Creek is impacted by a variety of sources, and because some existing water quality criteria may be difficult to meet (e.g., bacteria levels during wet weather), it is an appropriate candidate for designated use review and possible revision.

Depending on the impacts, possible water quality standards revisions could include:

1. Re-evaluating recreational uses and applying criteria for bacteria at the point of contact rather than at the end-of-pipe,
2. Segmenting the water body to preserve recreation in areas where it actually occurs, and
3. Revising the use by creating subclasses to recognize intermittent exceedances of bacteriological criteria.

EPA identifies 11 steps to integrate use review into an LTCP. Steps 1 through 5 address the completion and initiation of an LTCP, steps which have been completed on the Cobbs. Steps 6 through 9 specifically address incorporating use review in the LTCP as discussed in more detail below. Steps 10 and 11 consist of LTCP implementation and compliance monitoring.

Step 6 - Review and accept draft LTCP and evaluate the attainability of water quality standards; implement and, through water quality monitoring, evaluate effectiveness of priority controls (e.g., for sensitive areas) and controls common to all alternatives.

The use review processes begins when watershed communities and the team coordinating LTCP implementation approach the state to discuss possible changes. EPA regulations at 40 CFR 131.10(j) require a Use Attainability Analysis (UAA) whenever a state proposes to reduce the level of protection for a water body. A UAA is a structured scientific assessment of the physical, chemical, biological, and economic factors affecting the attainment of the use. If the State Water Director agrees that a UAA is appropriate, UAA guidance is available from EPA.

If sufficient data are available, the State Water Director evaluates the attainability of the applicable water quality standards. The data collected and analyses conducted by the CSO community may be sufficient to justify a water quality standards revision, or may show that a water quality standards revision is not justified. If the regulating authority agrees that the data and analyses support a water quality standard revision (recognizing the revision may produce more or less stringent standards), this represents a commitment from the regulating authority to proceed with proposing water quality standards revisions. If the data and analyses show that currently applicable water quality standards can be attained, and that revisions to the water quality standards are not justified, the regulatory authority notifies the community and the coordination team.

If sufficient data are not available to evaluate the attainability of the use, the state water director, in consultation with the coordination team, identifies the parameters for which additional information is needed. If the community wishes to pursue a water quality standards review, these additional data should be collected while implementation of the LTCP is initiated.

Step 7 - Propose revisions and revise WQS, if needed.

Once the community has implemented priority CSO controls, the state may determine that a water body has the potential to support improved aquatic life. Under this circumstance, the state would upgrade the aquatic life use for the water body. In other cases, the state may determine that the recreational uses are not fully attained all the time, and may refine the recreational uses to reflect the maximum level of control from a well-designed and operated control program that does not cause substantial and widespread economic and social impact.

EPA's water quality standards regulations at 40 CFR 131.21(b) require that any analyses, including the UAA, used in support of the water quality standard revision be made available for public review and comment at the time the revisions are proposed. Subsequent to public review and comment and appropriate revision, the state submits the revision, supporting analyses and public comments to EPA for review.

Before the revisions in the water quality standards may be used for CWA programs, including TMDLs and NPDES permits, EPA must approve the state-adopted water quality standards revision (see 65 FR 24641, April 27, 2000). Where there has been close coordination and cooperation, the approval process is more likely to proceed expeditiously. EPA is expected to approve a state's new or revised standard within 60 days, or disapprove within 90 days.

Step 8 - Revise LTCP, as appropriate.

If the water quality standards decisions differ from those that the CSO community anticipated, or if the previously implemented controls have not performed as predicted, the community would have to revise the draft LTCP.

Step 9 - Review and approve LTCP, and modify permit.

The NPDES authority coordinates the review of the revisions and, if appropriate, approves the final LTCP, which provides that CSO discharges do not contribute to exceeding of water quality standards or noncompliance with other CWA requirements. The NPDES authority issues a permit or administrative order, or proceeds with revisions to an enforceable order requiring implementation of the approved LTCP.

Watershed-Based National Pollutant Discharge Elimination System (NPDES) Permitting Implementation (CR9) Related Goals: 1, 5, 6, 8, 9, 10 Related Indicators: 2, 7, 8, 9, 10, 11, 16,19, 20			
What	Who	Where	When
Explore approaches to developing NPDES permits for multiple point sources located within the watershed to meet the goals of this integrated watershed management plan.	PADEP	Watershed-wide	Long term

Source: Watershed-Based National Pollutant Discharge Elimination System (NPDES) Permitting Implementation Guidance, December 2003 (EPA 833-B-03-004)

Watershed-Based NPDES Permitting

Watershed-based NPDES permitting is an approach to developing NPDES permits for multiple point sources located within a defined geographic area (watershed boundaries) to meet water quality standards. This approach, aimed at achieving new efficiencies and environmental results, provides a process for considering all stressors within a hydrologically defined drainage basin or other geographic area, rather than addressing individual pollutant sources on a discharge-by-discharge basis. This plan provides the first steps in this process. In the long term, a watershed-based permit in the Cobbs system can provide the regulatory framework for implementation of this integrated watershed management plan.

Watershed-Based NPDES Permitting Related to Other Watershed Management Activities

A truly comprehensive watershed management approach should bring together key programs under the Clean Water Act, such as the NPDES Program, the TMDL Program, the Section 319 Nonpoint Source Program, and Section 404 Wetlands Permitting, as well as the Source Water Assessment Program under the Safe Drinking Water Act. Watershed-based NPDES permitting can be another tool to facilitate comprehensive programmatic integration at a watershed level and ensure that permitting activities tie into existing watershed management efforts.

Developing and Implementing a Watershed-Based NPDES Permitting Approach

EPA's suggested process for developing and implementing a watershed-based NPDES permitting approach consists of the following six steps. This integrated watershed management plan fulfills most requirements of the first three steps.

Step One - Select a Watershed and Determine the Boundaries
Step Two - Identify Stakeholders and Facilitate Their Participation

Step Three - Collect and Analyze Data for Permit Development
Step Four - Develop Watershed-Based Permit Conditions and Documentation
Step Five - Issue Watershed-Based NPDES Permit
Step Six - Measure and Report Progress

Step One - Select a Watershed and Determine the Boundaries

Watershed boundaries will influence the scale and scope of every aspect of the process, particularly stakeholder involvement and data collection. The physical characteristics of the area and the jurisdictional limits affect the process for defining the boundaries of a watershed. The larger the watershed boundaries, the larger the scope of complexities such as multi jurisdictional issues, data collection and management, stakeholder involvement, and funding. Those initiating the process for watershed-based NPDES permitting should keep these factors in mind when defining watershed boundaries. The watershed should be of a manageable size to allow for integration and coordination of water quality program activities with the permitting process. This step is complete for the Cobbs system.

Step Two - Identify Stakeholders and Facilitate Their Participation

Successful watershed management efforts require identifying and involving the key players, or stakeholders, that should participate in the process from the outset because they influence and are affected by watershed decisions. Early and continuous stakeholder involvement can garner stakeholder participation and support on potentially contentious decisions. Stakeholder involvement is particularly important in watershed-based permitting, where sustained voluntary participation of nonpoint sources might be the key to meeting water quality goals, regardless of the watershed-based permit limits reflected in NPDES permits for point sources.

The stakeholder group could serve as the collective decision making body for some aspects of the watershed-based NPDES permitting effort (e.g., goal setting) or as a group that simply provides advice and guidance to the permitting authority. Given the various backgrounds, interests, and areas of expertise among the group, it is important that everyone has a general understanding of the NPDES program and the watershed-based NPDES permitting concept.

The Darby-Cobbs Watershed Partnership provides the foundation of this stakeholder group. In the long term, a more formal group with clearly defined responsibilities may need to be formed. This possibility is discussed in the institutional arrangements section of this plan.

Step Three - Collect and Analyze Data for Permit Development

A watershed-based permit addresses multiple sources within the watershed. This data collection and analysis process will be similar to that used in developing TMDLs for impaired water bodies. Data collection and analysis for watershed-based permitting, however, is further complicated by the fact that the analysis might address not only multiple sources but also multiple pollutants. This section lists questions stakeholders should consider when conducting initial data collection and analysis, and lists potential sources for those data. The water quality data and pollutant loading model results produced as part of this plan form the foundation for step 3.

Step Four - Develop Watershed-Based Permit Conditions and Documentation

In addition to individual monitoring and reporting requirements, watershed-based NPDES permits may contain watershed-wide requirements that could be applied to multiple dischargers in the watershed. For example, permittees might form a monitoring consortium to collect ambient water quality data that supplements end-of-pipe monitoring data required by NPDES permits. Through a monitoring consortium, permittees could generate data that could be used in Clean Water Act section 305(b) water quality reports and other watershed assessments. Depending on the structure of the watershed-based permit(s), watershed-wide requirements might be coordinated across several individual permits or contained in a single permit that applies to multiple sources. EPA has developed guidance on monitoring consortiums that might be helpful to permitting authorities in developing watershed-wide monitoring and reporting requirements (USEPA 1997). Although no mechanism currently exists in Pennsylvania to implement watershed-based permitting, the CCIWMP presents sufficient information to develop permit conditions because there are no point sources other then stormwater discharges in the watershed.

Step Five - Issue Watershed-Based NPDES Permit

The most important factors affecting the process for issuing a watershed-based permit will be the administrative requirements and the type or structure of the permit. Permitting authorities, permittees, and other stakeholders need to be familiar with the specific administrative requirements for permit issuance in their jurisdiction (in accordance with 40 CFR Part 124). Administrative requirements address public notice and comment; public hearings; EPA and state or tribal permit review; actions required for final permit issuance (e.g., approval of the state environmental board); and requirements for modification or for permit appeal after final permit issuance. These requirements vary by jurisdiction.

Watershed-based NPDES permitting approaches will vary from watershed to watershed. As a result, the types of permits developed through a watershed-based permitting process will vary. There is no single model or example of what an NPDES permit developed through watershed-based permitting should look like. Possible watershed-based permitting mechanisms are variations of general and individual point source NPDES permitting approaches.

Step Six - Measure and Report Progress

The ultimate goal of watershed-based permitting is to ensure that receiving water quality is protected through the implementation of an integrated, holistic approach. Progress toward attaining this overall goal can be measured at both the watershed and permit levels. The monitoring and reporting recommendations made in this plan form the foundation for step 6.

Potential Benefits and Challenges of Watershed-Based NPDES Permitting

A number of benefits can be expected from watershed-based permitting. Although the specific benefits will be unique to each project, they will likely include a mix of environmental and administrative benefits such as; integration of water-related programs, targeted and maximized use of resources to achieve greatest environmental results, local cooperative efforts, watershed-wide monitoring plans, and trading and other market-based strategies.

Like the benefits of watershed-based permitting, the challenges of implementing this approach will be unique to each watershed and each permit. Some challenges would be; expanded stakeholder involvement, integrating nonpoint sources, need for more flexible program infrastructure, conflicting jurisdictional requirements, and making an initial investment.

7.3.2 Public Education and Volunteer Programs

Public Education and Volunteer Programs (CP1) Related Goals: Related Indicators:			
What	Who	Where	When
See Public Education and Volunteer Programs under Target A options.	All Municipalities	All Municipalities	Short-term: first 5 years coinciding with the stormwater permit (See Table 7-5)

7.3.3 Municipal Measures

Sanitary Sewer Overflow Detection (CM1) Related Goals: 6, 9, 10 Related Indicators: 10, 11, 19, 20			
What	Who	Where	When
SSO Detection Program	Municipalities with separate sewer systems in Cobbs Creek (see Table 7-4)	See Figure 7-2 (map of separate sewers and responsible authorities)	Permanent ongoing program should be part of each agencies program

Discharges from sanitary sewers to Cobbs Creek during wet weather have been identified as a serious concern. Some of the techniques used for inspection of sewer lines can also be used for identifying potential locations of SSOs. Some of the most effective techniques for identifying the location of SSOs are listed below. (Source: Protocols for Identifying Sanitary Sewer Overflows, American Society of Civil Engineers EPA Cooperative Agreement #CX 826097-01-0, June 2000)

Sewer System Mapping

GIS maps of the sewer system should be developed in all municipalities. These maps serve as the basis for hydraulic modeling, and are key to many of the techniques described below.

Customer and/or Public Complaint

When a basement backup occurs or an SSO occurs in an area exposed to view, it is almost certain that someone will call the sewerage agency and report the incident. The agency should have a plan in place to investigate the reported SSO, find its cause, and take remedial measures to avoid recurrence of the SSO.

Visual Inspections after Overflows

Visual inspections can be used to confirm the occurrence of SSOs at suspected locations. The agency should develop a list of such locations and update it periodically. Immediately following a major storm, an inspection team should be sent to investigate these locations. A visual inspection program can be enhanced by encouraging participation of the public through providing opportunities for the public to become part of the solution.

Scheduled Maintenance Inspection

Municipal sewerage agencies should be performing routine maintenance inspections of their system. While the maintenance crew is performing the inspection, it can also look for signs of SSO. SSOs are most likely to occur pumping stations, manholes, stream crossings, and cleanouts.

GIS-Based Analysis of Past SSOs

GIS analysis can answer questions related to location, condition, trends, patterns, and modeling. Listed below are some typical questions that GIS can answer:

- What exists at a given location?
- Where is the location of an object or outcome with a number of specific characteristics?
- What has changed over a given period?
- What is the spatial distribution of areas with a certain attribute?

Sanitary Sewer Management Systems

A Sanitary Sewer Management System (SSMS) can be used to store, organize and analyze large quantities of data associated with sewer system operation, maintenance, inspection, modeling and rehabilitation. The SSMS may include the following modules:

- Inventory Module
- Flow Module
- Modeling Module
- Inspection Module
- Maintenance Module
- Rehabilitation (CIP) Module
- Mapping Module

Analysis of the data in the SSMS can reveal many problem areas, trends, and patterns. For example, the database can be searched to develop a list of lines with flat slopes or areas where frequent maintenance is needed. Another application of the SSMS is analysis of historical data.

Flow Monitoring

Flow monitoring at strategic locations may be used to identify potential locations of SSOs. Flow monitors can be installed in open channels and pumping stations to obtain the data necessary for proper system evaluation. In conjunction with flow monitoring, rain gauges should also be installed. Many open channel temporary flow meters have both velocity and depth measuring sensors. Municipalities are encouraged to make use of the existing rain gauge network in the Cobbs Creek watershed.

Flow data can be used to determine the average daily flow, the infiltration rate, and the inflow rate. The rain gauge data can be used to determine the recurrence interval or severity of the storm event (for example, 5-year) that caused the inflow. The flow data will also indicate whether a surcharge occurred during the flow monitoring period.

Monitoring of Receiving Stream for Sewage Indicators

This technique may be used for identifying the locations of dry weather SSOs. Samples from a nearby stream are taken at regular intervals along the stream and tested for fecal coliforms. Significant presence of these bacteria could be an indication of sewage leaking from the sewer line into the stream.

Closed Circuit Television (CCTV) Inspection

CCTV inspection has been widely used for inspection of sewer line interiors. The final product of a CCTV inspection is videotape and a field log prepared and narrated by an operator. The videotape provides a visual and audio record of problem areas in the sewer line. Evaluation of the CCTV records help identify structural problems; locate leaking joints and non-structural cracks, blockages, and dropped joints; and identify areas of root intrusion.

Sewer Scanner and Evaluation Technology Surveys (SSET)

The SSET is a new pipeline inspection technology developed in Japan. The equipment consists of a scanner, a CCTV, and a three-axis mechanical gyroscope. The mechanics of placing the SSET in the sewer line are similar to those of CCTV inspection. The images produced by SSET are of higher quality than CCTV images. Interpretation of the results is done in the office by an engineer rather than in the field by a technician. This increases the speed of field operations and reduces the cost.

Surcharge Level Alarms/Remote Monitoring

These devices can be placed at strategic locations in the manholes and pumping stations. Once the flow reaches a certain elevation, the alarm goes off and sends a signal to a control center via a telephone line or SCADA system. The sewerage agency should have a plan in place to respond immediately to such alarms. In addition to taking appropriate action, the responding agency should also record the event in a database.

Dye Tracing

Dyed water testing consists of dye tracing or flooding, and is done to locate possible sources of inflow such as area drains or catch basins suspected of being connected to the sewer line, or sources of rainfall-induced infiltration/inflow which indirectly contribute to the flow in the sewer line through the soil and pipe cracks. Dye testing is normally used to complement smoke testing of suspect areas. The downstream manhole is monitored to see if the dye water injected into an outside source such as a downspout has found its way into the sewer system. Color CCTV may also be used for locating problem areas after the dye enters the pipeline through the surrounding soil. Figure 5-4 is a sample form for recording the results of dye water inspection.

Smoke Testing

The purpose of smoke testing is to locate rainfall-dependent I/I sources which could lead to SSOs during a storm events. Public notification is an important and critical element of any smoke testing program. Specific I/I sources detected by smoke testing includes roof, yard, and area drain connections; catch basins; and broken service lines. The testing procedure consists of pumping non-toxic smoke through a manhole into the sewer pipe for distances up to 600 ft. The smoke will surface through open breaks in the pipe connections. All such sources are photographed and documented.

Aerial Monitoring

Aerial monitoring by helicopter may be used to gain a general understanding of conditions along a sewer line which may lead to an SSO. For example, washout may expose a section of pipe, which would then be at risk of damage and subsequent SSO. Examples of features which may be observed during such monitoring include manholes with broken or missing covers and sewer lines exposed by erosion.

Monitoring of Grease Buildup

A significant cause of SSOs during dry weather is sewer stoppages resulting from grease buildup. Such stoppages occur most frequently in downtown areas where restaurants are major sources of flow in the sewer system. A list of locations of grease buildup should be developed and these locations should be regularly inspected. Grease buildup can be prevented by enforcing grease ordinances, by effective pretreatment programs, and by promoting public education. The grease accumulations can be removed using the many available cleaning techniques, such as bucket machines with brushes, power rodders, and high velocity jet cleaners. Bioaugmentation, which involves the addition of bacteria cultures to sewers to speed up the breakdown of grease deposits, can also be effective.

Pump Station Inspection

Pump station failures can lead to significant SSO problems. Such failures can be avoided by regular inspections. The frequency of inspections may vary from once a day to once a month, depending on the size and criticality of the station, and reliance on monitoring by means such as the SCADA system.

Manhole Inspection

Manhole interiors are inspected for physical soundness for evidence surcharging such as high water marks on manhole walls. The observed defects should be compiled into a database that will be used to estimate the I/I attributable to each manhole and to establish manhole maintenance and rehabilitation program.

Line Lamping

Line lamping is done in conjunction with manhole inspection by inspecting the interior of the sewer lines connected to the manhole using an artificial light and a mirror. Lamping helps identify pipe defects and provides a basis for selecting sewers for television inspection.

Building Inspection

Building inspections are conducted to investigate extraneous flow from connections to sump pumps, foundation drains, downspouts, or leaking laterals. Building inspections should include investigation of the causes of basement backups.

Ground Penetrating Radar

Ground penetrating radar uses the transmission and reflection properties of an electromagnetic wave passing through the soil to determine soil properties and the depth and extent of subsurface objects. The speed and amplitude of the electromagnetic wave are dependent on the moisture content of the soil. This principle can be used to detect leaking joints in the line and voids around the pipe, which may be caused by soils being washed out. In such locations, the signal will be delayed because the speed of the wave will be reduced, and the amplitude of the wave will be attenuated.

Soil Moisture and Temperature Monitoring

When the ground is relatively dry, a larger portion of the rainfall will penetrate the soil, which will result in a decrease of groundwater to sanitary sewers. However, as the soil moisture increases, the amount of infiltration to sewers increases. For this reason, the impact of subsequent storm will be more severe: while the system did not overflow during the first storm, it will do so during the second storm, although the second storm of smaller intensity than the first. By monitoring the soil moisture and temperature, it may be possible to develop a measure for assessing the occurrence of SSOs.

Inspections of Stream Crossings and Parallel Lines

Pipes running alongside or crossing streams are often vulnerable to SSOs. If the sewer is buried under the streambed, the scouring action of the stream bed will eventually expose it, causing the pipe to lose its soil support. The pipe segments may move under the water pressure and joints may open, or the pipe may become exposed as a result of bank erosion. Any such openings admit significant amounts of flow, which may exceed the capacity of the sewer pipe. Stream crossings that include inverted siphons often become clogged with accumulations of silt and debris, which may cause an overflow upstream. The foundations of aerial stream crossing piers are also subject to scouring and may lead to foundation failure of the sewer line.

Sewer pipes that cross or parallel streams should be inspected to ensure that they are not broken or cracked. The manholes on each side of the stream should be checked for excess flow, which would indicate a leaking sewer under the stream. Since these sewers are usually in remote areas, they are vulnerable to vandalism and can overflow undetected for long periods.

All municipalities in the Cobbs Creek watershed should have a routine and effective SSO detection program. Once SSOs are found and the cause determined, proper measures to eliminate the SSO should be taken.

Figure 7-2 shows the areas where separate sanitary sewers exist. All municipalities with separate sanitary sewers are responsible for developing an effective SSO detection program.

Sanitary Sewer Overflow (SSO) Elimination: Structural Measures (CM2) Related Goals: 6, 9, 10 Related Indicators: 10, 11, 19, 20			
What	Who	Where	When
Implement a CMOM program (option AM1). Update and implement official Act 537 Sewage Facilities Plans.	Municipalities with separate sewer systems in Cobbs Creek (see Table 7-4)	See Figure 7-2 (map of separate sewers and responsible authorities)	Short-term (within 5 years of SSO detection)

Discharges to waters of the United States from municipal sanitary sewer collection systems are prohibited, unless authorized by an NPDES permit. Permits authorizing discharges from such systems must contain technology-based effluent limitations, based upon secondary treatment and applicable water quality standards. NPDES permits for municipal wastewater treatment plants should require record-keeping and reporting of overflows that result in a discharge. Permits should also contain requirements for operation and maintenance of the sanitary sewer collection system.

The EPA and PADEP are continuing to address SSO problems with compliance assistance and enforcement in accordance with the Compliance and Enforcement Strategy Addressing Combined Sewer Overflows and Sanitary Sewer Overflows, issued April 27, 2000. In addition to the national policy, Act 537, enacted by the Pennsylvania Legislature in 1966, requires that every municipality in the state develops and maintains an up-to-date sewage facilities plan. The main purpose of a municipality's sewage facilities plan is to ensure that the sewage collection and treatment systems have adequate capacity to convey present and future to sewage flows to a wastewater treatment facility. Official plans contain comprehensive information, including:

- The location of treatment plants, main intercepting lines, pumping stations and force mains, including their size, capacity, point of discharge and drainage basin served (preferably in a GIS format).
- Descriptions of problems with existing sewerage facilities and operation and maintenance requirements
- Planning objectives and needs
- Physical description of planning area
- Evaluation of existing wastewater treatment and conveyance systems
- Evaluation of wastewater conveyance and treatment needs

EPA has developed a comprehensive management framework called Capacity, Management, Operations, and Maintenance (CMOM) to assist municipalities in developing more comprehensive sanitary sewer system management programs. A

CMOM program, as described in option AM1, helps to prevent SSOs. Once a recurring SSO is detected using the methods recommended under option CM1, measures must be taken to eliminate the discharge.

Reduction of Stormwater Inflow and Infiltration (RDII) to Sanitary Sewers (CM3) Related Goals: 6, 9, 10 Related Indicators: 10, 11, 19, 20			
What	Who	Where	When
RDII Reduction Program	Municipalities with separate sewer systems in Cobbs Creek (see Table 7-4)	See Figure 7-2 (map of separate sewers and responsible authorities)	Short-term

Where significant RDII is detected, measures can be taken to seal the sanitary sewer system to reduce inflow of stormwater and groundwater. These measures are discussed in detail under option AM3, sanitary sewer rehabilitation.

Combined Sewer Overflow (CSO) Control Program (CM4) Related Goals: 5, 6, 9, 10 Related Indicators: 7, 8, 9, 10, 11, 19, 20			
What	Who	Where	When
Nine Minimum Controls Long Term Control Plan (LTCP) Capital Projects Watershed Plan Development	Philadelphia Water Department (PWD)	Philadelphia combined sewer system (Figure 7-14)	NMCs complete and ongoing RTC short-term (within 5 years)

The fundamental goal of the Philadelphia Water Department's (PWD) combined sewer overflow (CSO) program is to improve and preserve the water environment in the Philadelphia area and to fulfill PWD's obligations under the Clean Water Act and the Pennsylvania Clean Streams Law by implementing technically viable, cost-effective improvements and operational changes.

The PWD's strategy to attain these goals has three primary phases: aggressive implementation of a comprehensive program for Nine Minimum Controls; planning, design and construction of 17 capital projects that further enhance system performance and reduce CSO volume and frequency; and comprehensive watershed-based planning and analyses that will identify additional, priority actions to further improve water quality in Philadelphia area water bodies.

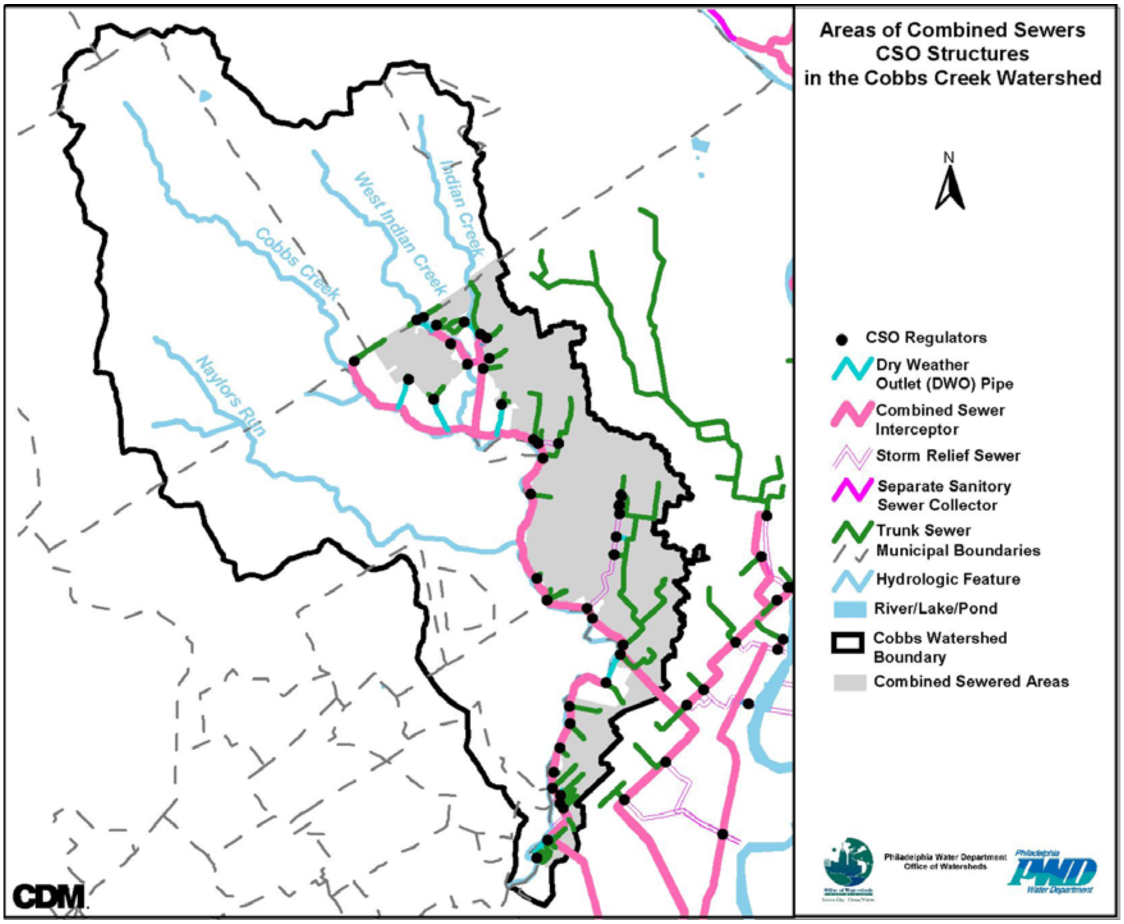


Figure 7-14 Areas of Combined Sewers and CSO Structures

The implementation of each of these control measures is discussed briefly below.

Nine Minimum Controls

In the first phase of the PWD's CSO strategy, and in compliance with its NPDES permits, the PWD submitted CSO Documentation: Implementation of Nine Minimum Controls to the Pennsylvania Department of Environmental Protection on September 27, 1995. The nine minimum controls are low-cost actions or measures that can reduce CSO discharges and their effect on receiving waters, do not require significant engineering studies or major construction, and can be implemented in a relatively short time frame. To provide information needed for the development of the Nine Minimum Controls (NMC) program, the PWD instituted a $6.5 million project to upgrade its comprehensive system flow monitoring network. This program provides information necessary to identify and eliminate dry weather overflows, monitor system performance and operation, and configure and calibrate computer hydraulic models needed to develop the NMCs and long-term CSO control plans. This information provided the basis for the System Hydraulic Characterization Report that was submitted to the PADEP in June 1995 and provided the technical basis for the development of the NMC plan.

Extensive data from the PWD's Geographic Information System (GIS), flow monitoring system, the U.S. Army Corps of Engineer's Storage, Treatment, Overflow, Runoff Model (STORM), and the EXTRAN and RUNOFF blocks of the EPA Stormwater Management Model (SWMM) were used to support each phase of the CSO program. These tools were developed to support concept engineering through implementation and post-construction monitoring. The monitoring system, models, and GIS will serve as the basis for planning improvements and enhancing operation of the sewerage system over the long-term.

Using the above tools, the PWD's NMC program includes comprehensive, aggressive measures to maximize water quality improvements through the following measures:

1. Review and improvement of on-going operation and maintenance programs

CSO Regulator Inspection & Maintenance Program

PWD has committed to demonstrating an improved follow-up response to sites experiencing a dry weather overflow. PWD has instituted a policy of next day follow-up inspection at sites that experience an overflow. PWD will conduct an evaluation of the effectiveness of twice-weekly inspections.

A database has been developed to document the maintenance performed on each CSO site. This system will ensure that proper regulator settings are maintained and system changes are documented. This database can also store scanned plan view and profile view drawings of CSO regulator and hydraulic control point chambers for inclusion in the filed inspection report forms.

Additional components of the O&M program include:

- Pumping Station Maintenance
- Sewer Cleaning Contracts
- Inflow Prevention Program
- Tide Gate Inspection and Maintenance Program
- Emergency Overflow Weir Modification

2. Measures to maximize the use of the collection system for storage

Use of the collection system for storage has long been recognized as a potentially cost-effective means to mitigate the occurrence and impacts of CSOs. PWD has been implementing in-system storage in Philadelphia's combined sewer system for nearly twenty years, using a variety of technologies.

- Reducing tidal inflows at regulators along the Southwest Main Gravity and the Lower Schuylkill West Side interceptors can reduce CSO overflows to Cobbs Creek by increasing available treatment capacity at the SWWPCP.

- A program to install tide gates or other backflow prevention structures at Cobbs Creek regulators to protect these regulators from potential inundation.

- Another approach that can be implemented to gain additional in-system storage is to raise the overflow elevation by physically modifying the overflow structure (e.g. raising an overflow weir). However, this approach must be implemented cautiously, since raising the overflow elevation also raises the hydraulic grade line in the combined trunk sewer during storm flows, and therefore increases the risk of basement and other structural flooding within the upstream sewer system due to backup or surcharge problems.

<u>3. Review and modification of PWD's industrial pretreatment program</u>

(also see the section from Regulatory Approaches: Industrial Pollution Prevention)

- Over the years, PWD has implemented a rigorous industrial pretreatment program. The effectiveness of this program has allowed the City to develop one of the largest and most successful biosolids beneficial reuse programs in the nation. As part of the nine minimum controls effort, the Department is committed to taking actions to encourage industries to better manage their process water discharges to the sewer collection system during wet weather periods.

<u>4. Measures to maximize flow to the wastewater treatment facilities</u>

As a minimum control, maximizing flow to the publicly owned treatment works (POTW) means making simple modifications to the sewer system and treatment plant to enable as much wet weather flow as possible to reach the treatment plant and receive treatment. The secondary capacity of the treatment plant should be maximized, and all flows exceeding the capacity of secondary treatment should receive a minimum of primary treatment (and disinfection, when necessary). The most effective way to determine the ability of the POTW to operate acceptably at incremental increases in wet weather flow, and to estimate the effect of the POTW's compliance with its permit requirement, is to perform stress testing to determine optimum flows, loads, and operations of the plant's unit processes.

<u>5. Measures to detect and eliminate dry weather overflows</u>

Relevant measures are discussed under the municipal measures of Target A.

<u>6. Control of the discharge of solid and floatable materials</u>

Solids are waterborne waste material and debris consisting of sand, gravel, silts, clay, and organic matter. Significant concentrations of solids are not only a visual nuisance, but can affect turbidity, dissolved oxygen, and carry pathogens in the receiving water. In addition, excessive amounts of solids can affect the combined sewer system by decreasing hydraulic capacity, thus increasing the frequency of overflows. Solids can enter the system through domestic and industrial wastewater, and debris washed from streets.

Floatables are waterborne waste material and debris (e.g., plastics, polystyrene, and paper) that float at or below the water surface. Floatables seen in significant quantities are aesthetically undesirable and can cause beach closings, interfere with navigation by fouling propellers and water intake systems, and impact wildlife through entanglement and ingestion.

Floatables and solids control measures consist of non structural and structural technologies.

Non structural technologies include combined sewer system maintenance procedures such as sewer flushing, street sweeping, and catch basin cleaning. Public education, land use planning and zoning, and ordinances are also considered non-structural technologies implemented to reduce solids and floatables entering the combined sewer system. These technologies are discussed under separate subsections and therefore will not be discussed further here.

Structural controls typically consist of abatement devices that would be constructed near the point of discharge. Technologies used for removing solids and floatables from CSOs include: Baffles, Booms, Catch Basin Modifications, Netting Systems, Swirl Concentrators, Screens, and Trash Racks. Modification of storm and combined sewer inlets for solids control, as well as catch basin and storm inlet maintenance are discussed under separate subsections.

Solids and floatables discharged from CSOs may represent a potentially significant impact to Cobbs Creek. PWD currently expends considerable effort to minimize the potential discharge of solids and floatables.

- PWD performs over 50,000 inlet cleanings each year preventing many tons of street surface-related materials from discharging to waterways through CSOs. The significant pipe cleaning and grit removal activities conducted by the department also remove a great deal of material that otherwise might discharge through CSO outlets during wet weather.

- The continued practice of regularly cleaning and maintaining grit pockets at critical locations in the trunk and interceptor system is an important part of the CSO control strategy. Grit buildup reduces the hydraulic capacity of the interceptor both by constricting its cross sectional area, and by increasing its frictional resistance. For example, quarterly cleaning of the 100-foot deep siphon grit pocket located at the Central Schuylkill wastewater pumping station is a major undertaking requiring specialized equipment and the commitment of significant labor resources. This practice has been shown to reduce the hydraulic grade surface at the siphon, increasing the wet weather flow capacity to the SWWPCP. Prior to the institution of this cleaning practice, the grit pit at this location had not been cleaned regularly in over 40 years.

- Inspections have revealed that grit has accumulated in the 30-inch Cobbs Creek Low-Level (CCLL) interceptor to a depth of approximately 12 inches. This project entails the removal of grit and debris along the entire 30-inch interceptor. This project will reduce the frequency and volume of overflows to Cobbs Creek by restoring the conveyance capacity of the 30-inch Cobbs Creek interceptor between the 75th and Gray's Avenue chamber and the SWWPCP low level pumping station. When grit is removed from this interceptor segment, the model indicates that the capacity nearly doubles from 5.9 mgd to 15 mgd. This project results in a 50 MG volume reduction on an average annual basis.

- Operation condition inspections of regulator chamber and backflow prevention devices are conducted for each structure approximately weekly, resulting in more than 10,000 inspections conducted each year. Additionally, comprehensive structural and preventative maintenance inspections are performed annually.
- Floatables will be monitored. If additional floatables control is warranted, then structural technologies will be considered. Structural technologies that would be considered first are catch basin modifications, including further enhancement of inlet grating and submerged outlet installations, netting systems, and static screens. More structurally intensive controls would be considered only if the application of the controls mentioned above proved not to be feasible under specific site requirements.

<u>7. Implementation of programs to prevent generation and discharge of pollutants at the source</u>

Most of the city ordinances related to this minimum control are housekeeping practices that help to prohibit litter and debris from actually being deposited on the streets and within the watershed area. These options are discussed under Target A, including litter ordinances and illegal dumping policies and enforcement. If these pollutants eventually accumulate within the watershed, practices such as street sweeping and regular maintenance of catch basins can help to reduce the amount of pollutants entering the combined system and ultimately, the receiving water.

<u>8. Measures to ensure that the public is informed about the occurrence, location and impacts of CSOs</u>

The Water Department has developed and will continue to develop a series of informational brochures and other materials about its CSO discharges and the potential affect on the receiving waters, in addition to information regarding dry weather flows from its stormwater outfalls. The brochures provide phone contacts for additional information. Also, the opportunity to recruit citizen volunteers to check or adopt CSO outfalls in their watersheds (i.e., notifying the PWD of dry weather overflows, etc.) will be explored through the watershed partnership framework. Brochures and other educational materials discuss the detrimental affects of these overflows and request that the public report these incidences to the department. In addition, the Water Department has enlisted watershed organizations to assist it with this endeavor. The department continued with this focus in 2002 to raise the level of awareness in its citizens about the function of combined and stormwater outfalls through a variety of educational mediums. The watershed partnerships are important for this kind of public/private effort to protect stream water quality. Lastly, the department's Clean Streams Team will investigate the feasibility of installing signs that can withstand nature and vandals at the department's outfalls

A more recent development in 2002/2003 was discussion among the state, PWD and the Delaware Estuary Program, to begin a marina best management practices education program that, in addition to alerting recreational users of the Delaware and Schuylkill Rivers regarding questionable water quality following rain storms, will also provide tips and information to marina operators to ensure their practices are environmentally sound. To complement this effort, the PWD has also been working with other city agencies to devise a "Recreational River Rating System" for the Schuylkill River due to the number of recreational activities that take place on the river year around. This system's educational message will be similar to that of the marina program as the advisories are based upon rainfall, CSOs and upstream influences on water quality.

<u>9. Comprehensive inspection and monitoring programs to characterize and report overflows and other conditions in the combined sewer system.</u>

Monitoring and characterization of CSO impacts from a combined wastewater collection and treatment system are necessary to document existing conditions and to identify water quality benefits achievable by CSO mitigation measures. Tables are compiled annually to represent average annual CSO overflow statistics as required in the NPDES Permit.

Long Term Control Plan Capital Projects

The second phase of the PWD's CSO strategy is focused on technology-based capital improvements to the City's sewerage system that will further increase its ability to store and treat combined sewer flow, reduce inflow to the system, eliminate flooding due to system surcharging, decrease CSO volumes and improve receiving water quality. The recommended capital improvement program is the result of a detailed analysis of a broad range of technology-based control alternatives.

<u>Real Time Control</u>

PWD has been evaluating and implementing computer controlled CSO outfall/regulator gate facilities that use level monitors to control the position of the dry-weather outlet (DWO) gate and tide gate at each location for maximizing the utilization of in-system storage in the combined sewer system. These computer controlled outfall facilities apply real-time control (RTC) mechanisms to maximize in-system storage. The use of RTC allows the capture and delivery to the treatment works of flow at the maximum rate at which it can be treated. This approach is attractive in terms of optimizing the use of the existing sewer system to capture combined wastewater and minimize CSOs.

- PWD is pursuing an opportunity to install an RTC system along the Lower Schuylkill combined sewer system, which takes the flow from the Cobbs Creek High Level (CCHL) interceptor. The modifications affect regulator structure C_17. The C_17 chamber regulates the capture of combined sewage from the largest combined-sewered area in the CCHL system. Due to its location and overflow elevation, C_17 controls the maximum head in the CCHL Cutoff Sewer and the conveyance capacity for the entire CCHL system. The proposed chamber modifications include raising the C_17 diversion dam and increasing its dry weather outlet (DWO) pipe diameter. The locations of C_17, the CCHL Cutoff Sewer and the SWWPCP are displayed on Figure 7-12.

Figure 7-15 Proposed RTC Sites

<u>Cobbs Creek Low Level Interceptor Conveyance Improvements</u>

Inspections have revealed that grit has accumulated in the 30-inch Cobbs Creek Low-Level (CCLL) interceptor to a depth of approximately 12 inches. Grit buildup reduces the hydraulic capacity of the interceptor both by constricting its cross sectional area, and by increasing its frictional resistance. This project entails the removal of grit and debris along the entire 30-inch interceptor. The estimated cost for the project is $440,000.

This project will reduce the frequency and volume of overflows to Cobbs Creek by restoring the conveyance capacity of the 30-inch Cobbs Creek interceptor between the 75th and Gray's Avenue chamber and the SWWPCP low level pumping station. When grit is removed from this interceptor segment, the model indicates that the capacity nearly doubles from 5.9 mgd to 15 mgd. This project results in a 50 MG volume reduction on an average annual basis.

Cobbs Creek Low Level (CCLL) Control Project

Control pipes, located in the CCLL interceptor near Glenmore Avenue, are two 18-inch orifice openings in an interceptor manhole bulkhead. The control pipes were installed to prevent chronic flooding occurring at the 75th and Grays Avenue chamber downstream. The 75th and Grays chamber is a former regulator (C-28), whose outfall to Cobbs Creek was sealed but still contained a 12-inch by 18-inch orifice opening to the interceptor. Grit accumulation has reduced the capacity of this orifice. The orifice opening at the 75th and Gray's chamber was the limiting hydraulic element in the interceptor. The opening restricted flow to the 30-inch interceptor that conveys flow from the 75th and Gray's Avenue chamber to the SWWPCP low level pumping station. The maximum flow through this opening was 11.8 mgd, assuming the 30- inch interceptor downstream of the 75th and Gray's Avenue has been cleaned (Cobbs Creek Low Level Interceptor Conveyance Improvements.) Flow was recently rerouted the flow past the orifice in the 75th and Gray's chamber with a new 30-inch pipe, increasing the capacity to 15 mgd. The hydraulic limit of the 30-inch CCLL interceptor can now be realized. This project was completed at a cost of $200,000. Additionally, the upstream interceptor will be cleaned and lined and a smooth transition between the brick sewer and the new 30-inch RCP bypass will be constructed. The two 18-inch orifices will be reconfigured in order to facilitate cleaning. While these orifices will control flooding problems at the 75th and Grays Avenue, they will not reduce the flow delivered to the interceptor below the interceptor capacity of 15 mgd. The projected cost for this project is $2,500,000.

These projects reduce the frequency and volume of overflows to Cobbs Creek, one of the smaller receiving streams. Interceptor capacity increases from 11.8 to 15 mgd due to the new 30-inch bypass line in conjunction with grit removal in the downstream interceptor (Cobbs Creek Low Level Interceptor Conveyance Improvements). The reduction in overflow volume is 10 MG on an average annual basis.

Watershed-Based Planning and Management

The third component of the City's CSO strategy involves a substantial commitment by the City to watershed planning to identify long term improvements throughout the watershed, including possibly additional CSO controls, which will result in further improvements in water quality and, ultimately, the attainment of water quality standards. The need for this watershed initiative is rooted in the fact that, prior to development of the Watershed Management Plan, insufficient physical, chemical and biological information existed on the nature and causes of water quality impairments, sources of pollution, and appropriate remedial measures. Because of this deficiency, it was impossible to determine what needed to be done for additional CSO control or control of other wet weather sources throughout the watershed. This deficiency, especially with respect to the effects of wet weather discharges and receiving water dynamics, is increasingly recognized nationwide and has led to a broader recognition of the need for watershed-based planning and management to properly define water quality standards and goals. The PWD believes that the National CSO Policy, state and federal permitting and water quality management authorities, cities, environmental groups, and industry, now recognize that effective long-term water quality management can be accomplished only through watershed-based planning. Completion of the Cobbs Creek Integrated Watershed Management Plan represents the realization of this commitment to watershed-based planning.

Catch Basin and Storm Inlet Maintenance (CM5) Related Goals: 4, 6, 8, 9, 10 Related Indicators: 11, 15, 16, 19, 20			
What	Who	Where	When
Regularly inspect catch basins (in combined areas) and storm inlets (in separate areas). Remove sediment as needed.	Sewer Owners (PWD and municipalities)	All inlets throughout watershed	Continue existing programs

Catchbasins and storm inlets that are part of the stormwater collection and conveyance system should be cleaned on a regular basis. Sediments, leaves, grass clippings, pet wastes, litter and other materials commonly accumulate in catchbasins. These materials can contain significant concentrations of nutrients, organics, bacteria, metals, hydrocarbons, and other pollutants. When a storm occurs, runoff entering the basin may dislodge and suspend some of this material. This debris can be conveyed along the storm sewer system and released to a surface water body. Catchbasin clean out should be scheduled for the fall and early spring in order to remove leaves and road salt and sand before the spring rains. In general, this is done with vacuum trucks, with disposal of the debris handled as solid waste.

In separate sewered areas of Cobbs Creek, each municipality is responsible for an effective storm sewer cleaning program. In Philadelphia, PWD has this responsibility.

Street Sweeping (CM6) Related Goals: 4, 6, 8, 9, 10 Related Indicators: 11, 15, 16, 19, 20			
What	Who	Where	When
Evaluate Existing Street Sweeping Programs Implement Enhanced Street Sweeping Practices	All Municipalities	Streets and Parking Lots in Commercial and Dense Residential Areas	Within next 5 years

Street and parking lot cleaning performed on a regular basis in urban and dense residential areas can be an effective measure for minimizing stormwater pollutant, sediment, and floatables loading to receiving waters.

Street sweeping programs had largely fallen out of favor as a pollutant removal practice following the 1983 NURP report. Recent improvements in street sweeper technology, however, have enhanced the ability of modern machines to pick up the fine grained sediment particles that carry a substantial portion of the storm water pollutant load, and have led to a recent reevaluation of their effectiveness. New studies show that conventional mechanical broom and vacuum-assisted wet sweepers reduce non-point pollution by 5 to 30 percent and nutrient content by 0 to 15 percent. However, newer dry vacuum sweepers can reduce non-point pollution by 35 to 80 percent and nutrients by 15 to 40 percent for those areas that can be swept (Runoff Report, 1998). A benefit of high-efficiency street sweeping is that by capturing pollutants before they are made soluble by rainwater, the need for structural storm water control measures might be reduced. Structural controls often require costly added measures, such as adding filters to remove some of these pollutants and requiring regular maintenance to change-out filters. Street sweepers that can show a significant level of sediment removal efficiency may prove to be more cost-effective than certain structural controls, especially in more urbanized areas with greater areas of pavement.

Computer modeling of pollutant removal in the Pacific Northwest suggests that the optimum sweeping frequency appears to be once every week or two (CWP, 1999). More frequent sweeping operations yielded only a small increment in additional removal (Bannerman, 1999; Claytor, 1999).

The following measures should be implemented toward achieving non-point source reductions in wet weather pollutant loads:

- Evaluate existing street and parking lot sweeping practices by municipalities with urban and dense residential areas contributing stormwater runoff to the watershed.
- Implement enhanced street and parking lot sweeping programs in urban and dense residential areas, prioritizing those not served by existing stormwater BMPs designed to reduce stormwater pollutant, sediment, or floatables loading to the receiving waters.

Responsible Landscaping on Public lands (CM7) Related Goals: 1, 6, 7, 8, 9, 10 Related Indicators: 1, 10, 11, 12, 13, 16, 19			
What	Who	Where	When
Incorporate integrated pest management (IPM) to reduce chemical use on public lands. Prevent clippings and cuttings from being transported by stormwater, and dispose of them through composting if possible.	Fairmount Park, municipalities PennDOT for vegetation along state roads	Parks, golf courses, school and institutional grounds, roadside vegetation	Short-term (within 5 years)

Common pesticides such as diazinon and chlorpyrifos (CWP, 1999 and Schueler, 1995) can be harmful to aquatic life even at very low levels. Proper use of these chemicals can be encouraged through public relations campaigns and demonstrated on public lands. Clippings and cuttings carried into the stormwater system and receiving streams can degrade water quality in a variety ways. A related problem exists with the illegal dumping of clippings and cuttings in or near drainage facilities. Recommended controls include:

- Consider an integrated pest management (IPM) program that encourages the use of alternatives to chemical pesticides. An IPM program incorporates preventative practices in combination with non-chemical and chemical pest controls to minimize the use of pesticides and promote natural control of pest species. In those instances when pesticides are required, programs encourage the use of less toxic products such as insecticidal soaps. The development of higher tolerance levels for certain weed species is a central concept of IPM programs for reducing herbicide use. This approach should be balanced with the invasive species control methods discussed under Target B.

- Collect clippings and cuttings on slopes and the bottom of stormwater control facilities and near stormwater inlets. Avoid mowing when significant rain events are predicted. Dispose of material through composting when possible.

Responsible Bridge and Roadway Maintenance (CM9) Related Goals: 1, 7, 9, 10 Related Indicators: 1, 19			
What	Who	Where	When
Incorporate BMPs into regular maintenance and repairs: Road and bridge resurfacing practices Deicing chemicals and practices Existing bridge drains	Bridge and roadway owners (municipalities and PennDOT)	Roadways and bridges (Figure 7-16)	Short-term (within 5 years)

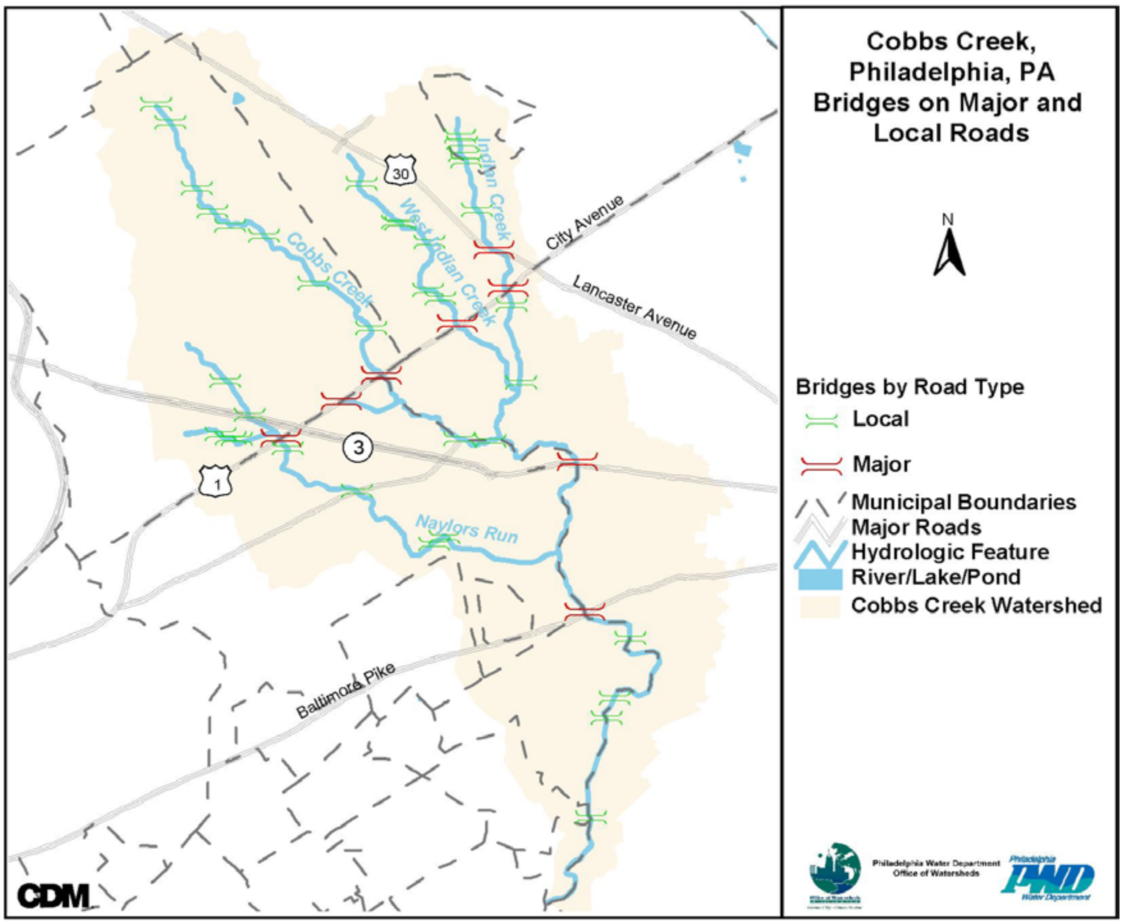


Figure 7-16 Major Roads and Bridges

Sediment and pollutants are generated during daily roadway and bridge use and scheduled repair operations, and these pollutants can impact local water quality by contributing heavy metals, hydrocarbons, sediment and debris to stormwater runoff. The use of road salt is a public safety as well as a water quality issue. Aside from contaminating surface and groundwater, high levels of sodium chloride from road salt can kill roadside vegetation, impair aquatic ecosystems, and corrode infrastructure such as bridges, roads, and stormwater management devices.

Recommended techniques are as follows:

- Consider alterations to road and bridge resurfacing practices near the creeks (Figure 7-16). Perform paving operations only under dry conditions. Cover storm drain inlets and manholes during paving operations, use erosion and sediment control measures, and use pollution prevention materials such as drip pans and absorbent material for all paving machines to limit leaks and spills of paving materials and fluids. Finally, consider employing porous asphalt for shoulder areas to reduce runoff.

- Consider alterations to the way deicing materials are used and applied as summarized in Table 7-17.

Table 7-17 Watershed Protection Techniques for Snow and Snowmelt Conditions

Use of De-icing Compounds
▪ Consider alternative de-icing compounds such as $CaCl_2$ and calcium magnesium acetate (CMA).
▪ Designate salt-free areas on roads adjacent to key streams, wetlands, and resource areas.
▪ Reduce use of de-icing compounds through better driver training, equipment calibration, and careful application.
▪ Sweep accumulated salt and grit from roads as soon as practical after surface clears.
Storage of De-icing Compounds
▪ Store compounds on sheltered, impervious pads.
▪ Locate at least 100 feet away from streams and floodplains.
▪ Direct internal flow to collection system and route external flow around shelters.
Dump Snow in Pervious Areas Where It Can Infiltrate
▪ Stockpile snow in flat areas at least 100 feet from stream or floodplain.
▪ Plant stockpile areas with salt-tolerant ground cover species.
▪ Remove sediments and debris from dump areas each spring.
▪ Choose areas with some soil-filtering capacity.
Blow Snow from Curbside to Pervious Areas
Operate Stormwater Ponds on a Seasonal Mode
Use Level Spreaders and Berms to Spread Melt water Over Vegetated Areas
Intensive Street Cleaning in Early Spring can Help Remove Particulates on Road Surfaces

- Consider alterations to existing bridge drains. Scupper drains can cause direct discharges to surface waters and have been found to carry relatively high concentrations of pollutants (CDM, 1993). At a minimum, routinely clean existing drains to avoid sediment and debris buildup, and consider retrofitting with catch basins or redirecting runoff to vegetated areas to provide treatment.

7.3.4 Stormwater Management

Source Control Measures

Reducing Effective Impervious Cover through Better Site Design (CS1) Related Goals: 1, 7, 9, 10 Related Indicators: 1, 16, 19, 20			
What	Who	Where	When
Reduce effective impervious cover by approximately 1% through: Downspout disconnection Pervious landscaping Sidewalk and driveway width reduction Vacant lands management	All municipalities require and/or encourage these measures using regulatory and/or public education options discussed elsewhere in this section.	All areas	Long term: 15+ years

Small changes in site design can lead to a gradual reduction in effective impervious cover that becomes significant over time. When applied consistently, the measures above can result in a 5-10% reduction in areas that are redeveloped. Assuming 10% of the watershed might be redeveloped over the planning horizon, a reduction in effective impervious area of 1% is a reasonable goal. Programs to require or encourage these practices are discussed under the regulatory approaches and public education options.

Downspout disconnection
In highly urbanized areas of the watershed, it is not always possible to direct runoff to pervious areas, and an informal inspection of lower density areas indicates that many properties are already disconnected. However, a further reduction in directly connected roof leaders from just 10% of residences will result in an effective impervious cover reduction of about 5%.

Pervious Landscaping
When repaving parking lots and loading areas, conversion of 10% of the area in half of parking lots to pervious landscaping (a measure required by municipalities including Portland, OR) will decrease watershed effective impervious cover by approximately 0.5%.

Sidewalk and Driveway Width Reduction
Reducing sidewalk and driveway widths by one foot will result in a watershed

effective impervious cover reduction of approximately 1%.

Vacant Lands Management

Vacant and abandoned lands in the City of Philadelphia account for approximately 2% of watershed effective impervious area. These sites are gradually being acquired and demolished by the City. Proper grading of these sites to encourage infiltration, or addition of small, inexpensive BMPs if needed, can eliminate runoff from these sites during all but the largest storms. Similar techniques can be followed for vacant and abandoned lands in the other counties.

Increasing Urban Tree Canopy (CS2) Related Goals: 1, 7, 8, 9, 10 Related Indicators: 1, 4, 13, 16, 17, 18, 19, 20			
What	Who	Where	When
Increase tree canopy in the watershed from 26% to 31%.	Municipalities (through ordinances, education, and incentive programs affecting land owners)	Private property Parking lots Streets Parks (riparian corridors under Target B)	Medium-term (5-15 years)

Tree planting and urban reforestation programs provide hydrologic benefits in addition to quality of life improvements. Leaf surfaces intercept some rainfall that might otherwise fall on impervious surfaces. The rainfall then either evaporates or is conveyed more slowly to the ground along plant stems and trunks. American Forests has assessed tree canopy in the Cobbs watershed at 26% (report "Urban Ecosystem Analysis, Delaware Valley Region" available at www.americanforests.org). American Forests recommends the following levels of tree canopy coverage for urban watersheds:

- 40% overall
- 50% in suburban residential zones
- 25% in urban residential zones
- 15% in central business districts

A goal of increasing tree canopy by 5% of the watershed over the medium term was selected as a feasible implementation level. Several regulatory and incentive-based strategies to achieve these goals include:

- Requirements to protect existing trees on private property, or creation of "tree banks" to offset loss (see regulatory/incentive approaches).
- Tree credits for redevelopers as part of impervious cover requirements or incentives (see regulatory/incentive approaches). The city of Portland, OR has given developers an impervious cover credit equal to 25% of tree canopy over impervious area.
- Parking lot landscaping or shade requirements (see regulatory/incentive approaches).
- Reforestation in parks and along the stream corridor (Target B).
- Increases in the number of trees along public streets and on vacant lots. The City of Philadelphia is taking this approach as part of its Green City Strategy.

Tree canopy over an additional 5% of impervious cover will result in an effective impervious cover reduction of approximately 1.5% over the watershed.

Municipalities with tree related ordinances are shown in Table 7-18.

Table 7-18 Landscape and Tree Related Ordinances

Municipality	Landscaping	Shade Tree/Street Trees	Wooded Lots
Colwyn Borough	X		
Darby Borough	X		
East Lansdowne Borough**			
Haverford Township	X		
Lansdowne Borough	X		
Lower Merion Township	X	X	X
Millbourne Borough	X	X	
Narberth Borough	X	X	
Philadelphia	X		
Radnor Township	X	X	
Upper Darby Township	X		
Yeadon Borough	X		

Forming a tree commission is one way of implementing an urban forestry program in Pennsylvania. The powers and responsibilities of a tree commission are based on state statute and are assumed by local government. By forming and empowering a tree commission, a community can empower and motivate volunteers to run an effective urban forestry program. Tree commissions are either advisory or administrative and may have various responsibilities.

- Advise community leaders and staff on administering the community forest
- Stimulate and organize tree planting and maintenance
- Develop and implement urban forest inventories, management plans, and ordinances
- Lessen liability by arranging to remove hazardous trees and repair damage caused by trees

In Pennsylvania, a tree commission created by municipal ordinance as a decision-making body has exclusive control over a community's shade trees. No tree can be planted or removed within the public right-of-way except under the auspices of the tree commission. This includes public trees that may be planted or removed in conjunction with subdivisions or approved development plans. Tree commissions can be given additional power within a municipality by a council, including:

- Control over all public trees such as trees within community parks
- Review and approval of landscaping proposed in development plans

The formation and empowerment of a tree commission can be a crucial element in developing broad-based support for community trees and ensuring long-term success and continuance of a community forestry program. (For more information, contact the Extension Urban Forestry Program, School of Forest Resources. The Pennsylvania State University, 108 Ferguson, University Park, PA 16802; (814) 863-7941.)

Porous Pavement and Subsurface Storage (CS3) Related Goals: 1, 6, 7, 8, 9, 10 Related Indicators: 1, 10, 11, 16, 19, 20			
What	Who	Where	When
Install porous pavement and subsurface storage in 10-50% of parking lots; coverage to be chosen by municipality to meet a share of watershed-wide reduction targets. Route runoff from nearby impervious cover to storage when possible.	Public and private parking lot owners.	See Figure 7-17.	Long-term: 15+ years

As discussed in Section 5, subsurface storage under parking lots is the best way to create storage and promote infiltration in the highly urbanized environment. Porous pavement is an effective way of directing parking lot runoff to storage, but more conventional inlets or grates are also possibilities. The depth of storage is important. Whenever possible, runoff from nearby impervious areas should be routed into the storage under nearby parking lots. When this is not possible, only a few inches of gravel is needed to store a chosen design storm. Storage designs always include an overflow mechanism for very large storms.

The total parking lot area in the Cobbs watershed is estimated at 120 acres in the combined-sewered portion and 240 acres in the separate-sewered portion (Figure 7-17). Philadelphia has approximately 31% of parking lot area in the watershed. Other municipalities with large parking lot areas are Lower Merion (26%), Upper Darby (23%), and Haverford (12%). Other municipalities have smaller percentages as listed in Figure 7-18.

Because this BMP is believed to be the most important, an ambitious target of retrofitting 10-50% of parking lots over the long term is proposed. Begin with demonstration projects on public land. Over the long term, convert 10%-50% of parking lots watershed-wide to porous pavement with subsurface gravel storage.

The Partnership may choose among a variety of approaches to implementing porous pavement and other structural BMPs. Regulatory and incentive-based approaches were discussed in the low-impact redevelopment section. Distribution of structural BMPs may also be incorporated in a pollution trading program.

- Install demonstration projects in public parking lots.

- Require all parking lots to be retrofit with porous pavement (or other drainage mechanisms) and subsurface storage when they are redone. Private land owners cannot be expected to bear the entire cost of this approach; municipalities should fund the additional cost of these changes either directly or through tax incentives.

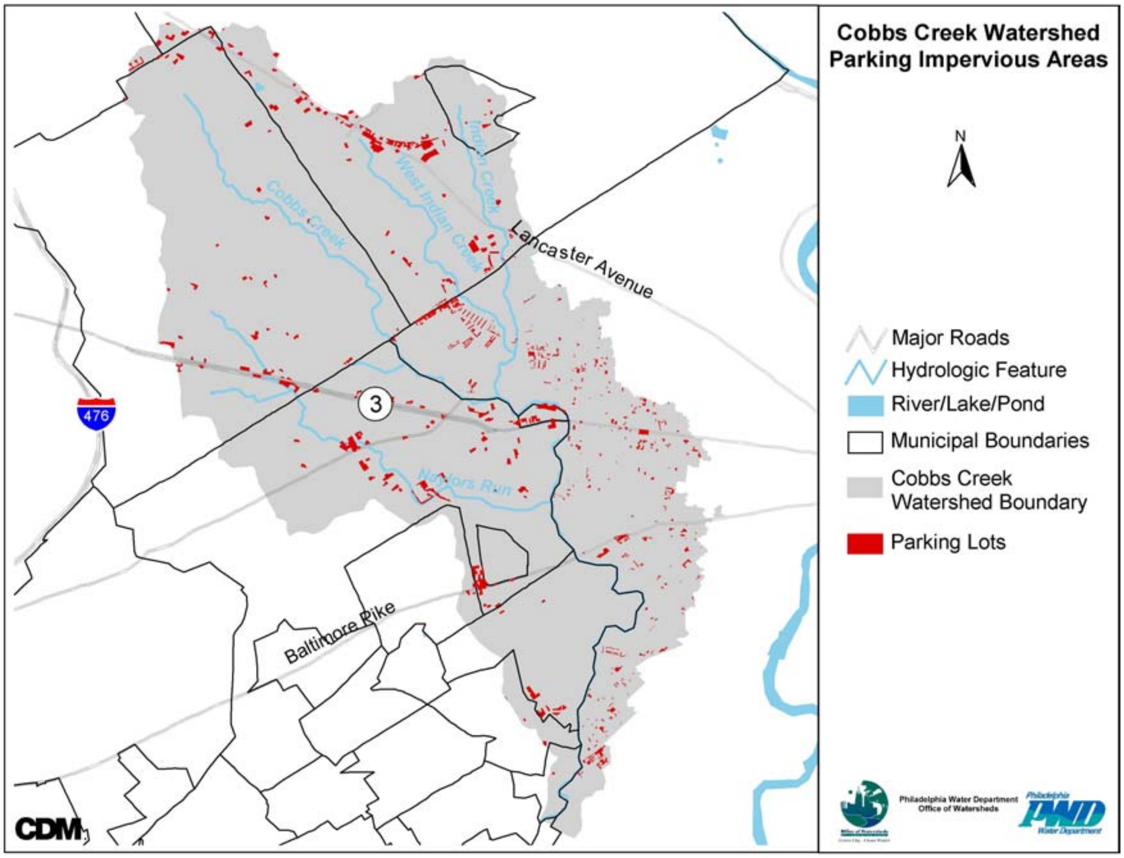


Figure 7-17 Parking Areas in Cobbs Creek Watershed

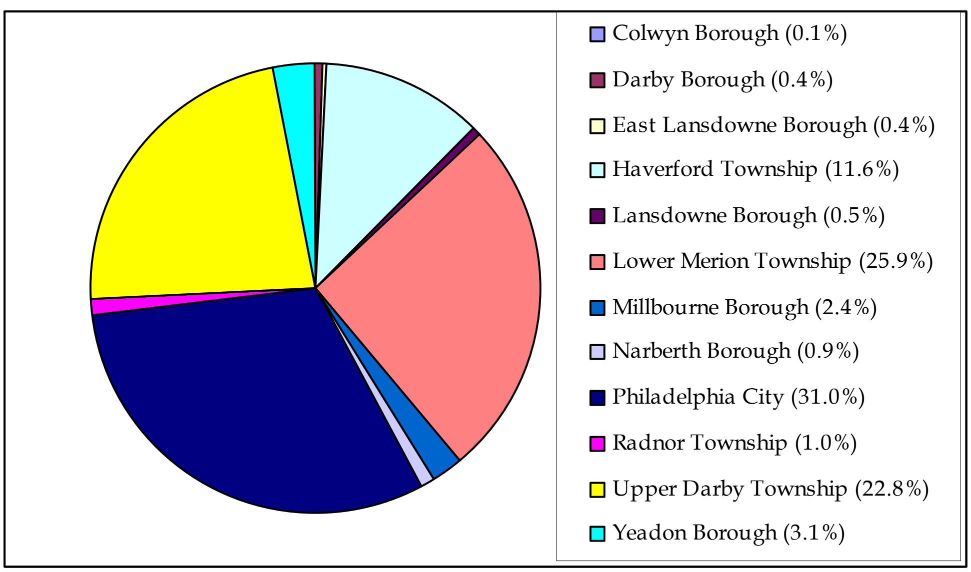


Figure 7-18 Percent of Total Parking Area by Municipality

Green Rooftops (CS4) Related Goals: 1, 7, 8, 9, 10 Related Indicators: 1, 16, 18, 19, 20			
What	Who	Where	When
Green rooftop demonstrations Targeted public information campaign on advantages of green roofs. Feasibility study and green roof implementation plan.	PWD	Appropriate public buildings chosen by PWD	Medium term: 5-15 years

The analyses in Sections 5 and 6 indicate that green rooftops, while highly effective at detaining and evaporating stormwater, are not currently a cost-effective option for the Cobbs. However, there is a potential for them to become more cost-effective in the future. As more successful demonstration projects are implemented in the United States, the materials and construction techniques will become more common and the economies of scale will improve. To facilitate this long-term change locally, this plan recommends that Philadelphia take the lead and implement one or more projects on public buildings in the City. Along with this project, we recommend a feasibility study of the potential for a larger-scale green roof program throughout the watershed. The feasibility study will form the basis for future recommendations when this plan is revised. In addition, we recommend a public relations campaign to change the perceptions of citizens, public officials, and contractors.

Capturing Roof Runoff in Rain Barrels or Cisterns (CS5) Related Goals: 1, 7, 8, 9 Related Indicators: 1, 16, 18, 19			
What	Who	Where	When
Install rain barrels on 5-25% of homes; coverage to be chosen by municipality to meet a share of watershed-wide reduction targets.	Homeowners through municipal incentive and education programs	Homes where dry wells are not feasible	Medium term: 5-15 years

As discussed in Section 5, rain barrels can be an effective stormwater management tool if they are properly designed and maintained. For detention of residential roof runoff, dry wells are the preferred technique because they have a larger capacity, require no maintenance, and allow more infiltration. Rain barrels are recommended as a secondary technique in areas where dry wells are infeasible. Proper design, including an appropriate slow release, is the responsibility of the municipality or nonprofit group leading the rain barrel program. Proper maintenance is accomplished through an intensive public education campaign and series of workshops. An ambitious target is to install rain barrels on 5-25% of homes throughout the watershed in the medium term. Adding barrels to 5% of homes will provide an estimated stormwater runoff reduction of 0.5%, a CSO reduction of 2%, and a pollutant (Total Suspended Solids) reduction of 2%.

Onsite and Regional Facilities

Maintain/Retrofit Existing Stormwater Structures (CS6) Related Goals: 1, 4, 6, 7, 9, 10 Related Indicators: 4, 11, 15, 19			
What	Who	Where	When
Inventory structures Assess potential for increased infiltration	Municipalities	Outside Philadelphia	Short term (within 5 years)

An inventory of existing detention and retention basins in Philadelphia indicates that there are none in the Cobbs portion. Other municipalities are asked to inventory and inspect existing stormwater control structures. Although this is not an explicit requirement of the Act 167 program, it is a reasonable task to include within the Act 167 framework. Older dry and wet detention basins may have been designed to reduce flood peaks but not to facilitate infiltration; this approach helps prevent property damage but may actually increase stream erosion. In some cases, it may be possible to retrofit these older basins to allow infiltration. Specific guidance on retention times and design recommendations will be included in the Act 167 plan.

Retrofitting Existing Sewer Inlets with Dry Wells (CS8) Related Goals: 4, 6, 9 Related Indicators: 11, 15, 19			
What	Who	Where	When
Retrofit 10-40% of existing stormwater catch basins in the combined sewered area to provide storage and allow infiltration	PWD	10-40% of existing inlets in combined-sewered areas	Long-term: 15+ years

As discussed in Section 5, retrofitting existing sewer inlets with dry wells is an expensive but effective measure in combined-sewered areas. Each inlet provides small amounts of storage and detention; distributed over a significant area, these measures reduce the number and duration of overflows.

There are approximately 2000 inlets in the combined-sewered portions of the Cobbs Creek watershed. It is proposed that at least 10% of these be retrofitted with dry wells. This measure will reduce CSO volume by approximately 0.4% and pollutant loads by approximately 0.4%.

During the first permit cycle this plan is in effect, inlets that are being repaired or replaced can be retrofitted at the same time. If, after the first 5 years, the program is not on track to affect the targeted number of inlets in 15 years, existing inlets in good condition may be retrofitted.

Residential Dry Wells, Seepage Trenches, and Water Gardens (CS9) Related Goals: 1, 4, 6, 7, 8, 9, 10 Related Indicators: 1, 11, 15, 16, 17, 19			
What	Who	Where	When
Install dry wells in 10-40% of residential yards; coverage to be chosen by municipality to meet a share of watershed-wide reduction targets. Install water gardens on school grounds	Municipalities School boards	Dry wells throughout watershed Water gardens in school yards with enough space	Long term: 15+ years

Routing residential roof runoff to dry wells is recommended as a priority control for the Cobbs watershed. Dry wells are cost-effective, can potentially affect a large portion of impervious cover, and require virtually no maintenance. They are clearly applicable in the lower-density residential areas but can be installed in some higher density areas; only a small lawn area is necessary. A properly sited and designed dry well will not cause basement flooding. Where soil conditions are insufficient to infiltrate all roof runoff, excess flows can be routed to a combined or sanitary sewer. Because dry wells are a priority control, they are recommended for implementation in the yards of 10%-40% of all homes in the watershed. At the 10% level, this measure could reduce CSO by approximately 3%, stormwater runoff by 0.3%, and pollutant loads (represented by TSS) by 5%.

Water gardens are recommended for implementation on school grounds, where they can both promote infiltration and educate students about stormwater management.

Bioretention Basins and Porous Media Filtration (CS12) Related Goals: 1, 4, 5, 7, 9, 10 Related Indicators: 1, 7, 8, 9, 15, 19, 20			
What	Who	Where	When
Install bioretention and/or sand filters in 10-50% of parking lots; coverage to be chosen by municipality to meet a share of watershed-wide reduction targets.	Public and private parking lot owners.	Everywhere in watershed	Long-term: 15+ Focus on redevelopment

The screening and modeling analyses in Section 5 targeted parking lot runoff for widespread implementation of BMPs. The preferred approach for parking lots is to route runoff to subsurface gravel storage through porous pavement, inlets, or grates. However, there will be cases where that approach is infeasible. The second preferred alternative is to direct parking lot runoff to a bioretention basin and/or a porous media filter. These systems infiltrate smaller storms completely, detain larger storms, and provide effective water quality treatment in separate sewered areas. 10-50% of parking lots are targeted for retrofit with bioretention. At the 10% level, this measure will reduce CSO by an estimated 1.3%, stormwater runoff by 0.1%, and pollutant loads by 2%. Over the long term, it is the goal to retrofit 50% of parking lots with either subsurface storage or bioretention. However, private land owners should not be expected to bear the entire cost of this approach; municipalities should fund the additional cost of these changes either directly or through tax incentives.

Treatment Wetlands: Onsite and Regional (CS13) Related Goals: 1, 5, 6, 7, 9, 10 Related Indicators: 1, 10, 11, 13, 19			
What	Who	Where	When
create and enhance wetlands for treatment	Municipalities	See Figure 7-11 in Target B.	Medium term: 5-15 years

Wetland creation and enhancement has benefits in terms of habitat, water quality, and water quantity. These benefits and proposed sites are discussed extensively under Target B.

Section 8: Cost and Institutional Analysis

8.1 Estimated Cost of Implementation

Planning-level costs have been developed for many of the options being recommended. Because costs are highly dependent on site specific conditions as well as the extent to which implementation occurs, costs are only approximate. These costs are useful, however, in providing order of magnitude funding needs, and also, as a comparison to potential costs associated with more traditional approaches to CSO control such as large scale storage tanks designed to reach the 85% capture goal.

Planning level costs are provided for each of the options discussed under the three Targets. "N/A" means that costs are not applicable because they are relatively small, or the option would be implemented by existing municipal staff. "N/A" can also mean that a cost estimate could not be developed based on existing information.

The combination of structural BMPs and implementation percentages in this section are suggested as a feasible plan that will equal or exceed the 20% discharge reduction target. The exact combination of BMPs implemented in each area of the watershed will be determined by local municipalities or by a government or institutional body to be chosen at a later time.

Order-of-magnitude, planning-level cost estimates are shown in Tables 8-1 through 8-5 for the two components of the plan:

1. A total cost for all options other than real time control and structural stormwater management BMPs.

2. A cost range for real time control and structural stormwater management BMPs. The cost for these measures varies depending on the combination chosen.

Table 8-1 Planning-level Cost Estimates for Target A Options

	Total		Philadelphia		Other Counties	
	Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
Regulatory Approaches						
AR2 On-Lot Disposal (Septic System) Management	$75,000				$75,000	
AR2 Pet Waste, Litter, and Dumping Ordinances[1]						
Public Education and Volunteer Programs	$615,000		$276,000		$340,000	
Municipal Measures						
AM1 Capacity Management Operation and Maintenance (CMOM)[2]						
AM2 Inspection and Cleaning of Combined Sewers	$2,000,000	$21,120,000	$896,000	$8,448,000	$1,104,000	$12,672,000
AM3 Sanitary Sewer Rehabilitation[2]						
AM4 Combined Sewer Rehabilitation[2]						
AM5 Illicit Discharge, Detection, and Elimination (IDD&E)		$22,500,000		$10,125,000		$12,375,000
AM6 Stream Cleanup and Maintenance	$33,000	$31,000	$16,500	$15,000	$16,500	$15,000
AO1 Enhancing Stream Corridor Recreational and Cultural Resources[1]						
AMR Monitoring and Reporting[3]						
Total Cost for Target A Options	$2,723,000	$43,651,000	$1,189,000	$18,588,000	$1,535,000	$25,062,000
Cost per acre for Target A Options	$190	$3,070	$330	$5,220	$140	$2,350

1 - already in place in most locations, or costs difficult to quantify
2 - costs included in option AM2
3 - monitoring and reporting costs not included in this table

Table 8-2 Planning-level Costs for Target B Options

	Total		Philadelphia		Other Counties	
	Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
Channel Stability and Aquatic Habitat Restoration[1]	$33,000	$26,400,000	$16,500	$13,200,000	$16,500	$13,200,000
BM1 Bed Stabilization and Habitat Restoration[2]						
BM2 Bank Stabilization and Habitat Restoration[2]						
BM3 Channel Realignment and Relocation[2]						
BM4 Plunge Pool Removal[2]						
BM5 Improvement of Fish Passage		$130,000		$130,000		
Lowland Restoration and Enhancement						
BM6 Wetland Creation[2]						
BM7 Invasive Species Management[2]						
Upland Restoration and Enhancement						
BM8 Biofiltration[2]						
BM9 Reforestation[3]						
BMR Monitoring and Reporting[4]						
Total Cost for Target B Options	$33,000	$26,530,000	$16,500	$13,330,000	$16,500	$13,200,000
Cost per acre for Target B Options	$2.30	$1,870	$4.60	$3,740	$1.50	$1,240

1 – cost based on restoring high-priority reaches at a cost of $700/lineal ft. If actual cost is lower, medium priority reaches may also be restored
2 – costs included under general "Channel Stability and Aquatic Habitat Restoration" costs
3 – costs included in Target C urban tree canopy costs
4 - monitoring and reporting costs not included in this table

Table 8-3 Planning-level Costs for Nonstructural Target C Options

	Total		Philadelphia		Other Counties	
	Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
Regulatory Approaches						
Zoning and Land Use Control						
CR2 Requiring Better Site Design in Redevelopment[1]		$300,000		$100,000		$200,000
CR3 Stormwater and Floodplain Management[1]		$350,000		$175,000		$175,000
CR4 Industrial Stormwater Pollution Prevention[2]						
CR5 Construction Stormwater Pollution Prevention[2]						
CR6 Post-construction Stormwater Runoff Management[2]						
CR7 Pollution Trading[2]						
CR8 Use Review and Attainability Analysis[2]						
CR9 Watershed-Based Permitting[2]						
Municipal Measures						
CM1 Sanitary Sewer Overflow Detection[3]						
CM2 Sanitary Sewer Overflow Elimination: Structural Measures[3]						
CM3 Reduction of Stormwater Inflow and Infiltration to Sanitary Sewers[3]						
CM4 Combined Sewer Overflow (CSO) Control Program[4]						
CM5 Catch Basin and Storm Inlet Maintenance	$600,000		$269,000		$331,000	
CM6 Street Sweeping	$135,000		$45,000		$90,000	
CM7 Responsible Landscaping Practices on Public Lands[2]						
CM9 Responsible Bridge and Roadway Maintenance[2]						
CMR Monitoring and Reporting[5]						
Stormwater Management						
Source Control Measures						
CS1 Reducing Effective Impervious Cover Through Better Site Design[2]						
CS2 Increasing Urban Tree Canopy	$1,500,000	$15,000,000	$500,000	$5,000,000	$1,000,000	$10,000,000
Onsite and Regional Stormwater Control Facilities						
CS6 Maintaining/Retrofitting Existing Stormwater Structures	$20,000	$100,000	$10,000	$50,000	$10,000	$50,000
Use Review and Attainability Analysis		$300,000		$300,000		
Total Cost for Target C Options	$2,255,000	$16,050,000	$824,000	$5,625,000	$1,431,000	$10,425,000
Cost per acre for Target C Options	$160	$1,130	$230	$1,580	$130	$980

1 - estimated cost for ordinance development
2 - costs difficult to quantify
3 - costs included in option AM2
4 - costs included in AM2 or in Table E-8
5 - monitoring and reporting costs not included in this table

Table 8-4 Range of Costs for Structural Target C Options

Cost		Philadelphia	Other Counties
Lowest		Alternative 1: RTC	Alternative 1: Cost-Effective Stormwater BMPs
		$1,750,000	$5,340,000
Highest		Alternative 5: Focus on Public and Parking BMPs	Alternative 5: Focus on Public and Parking BMPs
		$17,900,000	$42,100,000

Table 8-5 Total Watershed Plan Cost

Total		Philadelphia		Other Counties	
Annual Cost	One-Time	Annual Cost	One-Time	Annual Cost	One-Time
$5,000,000	$93,000,000 - $146,000,000	$2,000,000	$39,000,000 - $55,000,000	$3,000,000	$54,000,000 - $91,000,000
$350/ac	$6,550/ac - $10,280/ac	$560/ac	$10,950/ac - $15,440/ac	$280/ac	$5,080/ac - $8,550/ac

8.2 Distribution of Costs Among Communities

8.2.1 Comparison of Philadelphia to other Watershed Communities

In addition to total estimated costs associated with the CCIWMP, it is useful to express the costs on an annual basis and in the context of acreage and number of households affected. Presenting costs this way allows comparison to existing wastewater infrastructure-related costs supported by users and taxpayers.

Table 8-6 compares projected costs on a per-acre basis and per-household basis in the City of Philadelphia and outside the City of Philadelphia. Philadelphia pays approximately 40% of the total annual cost (line 3) while representing approximately 25% of the watershed area. On a per-acre basis, costs within Philadelphia are approximately double costs outside the City. This difference occurs because of the greater proportion of impervious cover in Philadelphia compared to the remaining aggregated communities; for a given land area, there is more impervious cover and water-related infrastructure requiring management. It is important to note that population density, degree of urbanization, and income vary greatly among the communities outside Philadelphia. An illustrative distribution of costs among municipalities in the watershed is shown in section 8.2.2.

In addition to showing costs per unit area, it is useful to express costs on a per-household basis. Line 7 in Table 8-6 expresses cost per household, assuming only householdes inside the watershed boundaries would be required to pay. This comparison is made because improvements occur, and citizens benefit, primarily within the watershed boundaries. Expressed in this manner, the cost is greater for households outside Philadelphia (line 7, outside parentheses); because of greater population density within the urban watershed, there are more households to distribute the cost among inside the City.

Line 8 of Table 8-6 expresses the per-household cost inside the watershed boundary as a percentage of mean household income (line 8, outside parentheses). Although the per-household cost in Philadelphia is lower, it represents a greater fraction of household income for a median family because of the generally lower mean household income of Philadelphia households when compared with the outside municipalities.

While expressing costs in terms of households inside the watershed boundary allows direct comparison between communities, it is also useful to express costs on the basis of all households within the boundaries of municipalities that intersect the watershed. Currently, most funding and institutional mechanisms occur on a municipal basis. For example, a given township may use a percentage of all water and sewer bills paid to finance improvements related to the CCIWMP, including bills paid by households outside the Cobbs watershed boundary.

The numbers in parentheses on lines 7 through 9 of Table 8-6 present the costs in terms of all residents of municipalities intersecting the watershed. These costs are lowest in Philadelphia because it has the greatest number of households; all households paying sewer bills will pay approximately 0.03% of household income to support the CCIWMP, compared to over 0.1% for the remaining communities. Compared to the other municipalities, Philadelphia has many more households to spread the cost of the CCIWMP over, but ultimately it has many more watersheds that will require management activities. Over time and on a regional basis, watershed management costs are expected to approach 0.3% to 0.5% of MHI within affected communities.

The costs associated with the CCIWMP are generally incremental to existing maintenance and management activities associated with water-related infrastructure. Therefore, it is useful to add the CCIWMP cost to current wastewater charges paid by households to obtain an approximate measure of the total annual cost of watershed and water-related infrastructure management. These costs, shown in the final line of Table 8-6, range from approximately 0.6% to 1.6% of MHI regionally.

Table 8-6 Affordability Impact on Philadelphia and Suburban Communities

		Philadelphia	Suburban Communities *(Combined)*
1	Capital:	$3,770,000	$5,820,000
2	Operating:	$2,000,000	$3,000,000
3	Total Annual Cost Associated with WMP	$5,770,000	$8,820,000
4	Cost per acre in watershed	$1,642	$826
5	2000 Median Household Income	$30,746	$61,962
6	Estimated Annual Sewer User Charge*	$343	$197
7	WMP cost per household in watershed (in entire municipalities)	$146.04 ($9.77)	$185.71 ($87.52)
8	WMP cost as % of MHI in watershed (in entire municipalities)	0.47% (0.03%)	0.30% (0.14%)
9	Existing sewer cost + WMP cost in watershed (entire municipalities)	1.59% (1.15%)	0.62% (0.46%)

* The sewer user charge in Philadelphia includes a stormwater collection and treatment fee. Stormwater-related charges outside Philadelphia were not investigated.

8.2.2 Distribution of Costs Among Communities Outside Philadelphia

Tables 8-7 and 8-8 provide data to assist communities outside Philadelphia in placing projected CCIWMP costs in a local context. Table 8-7 expresses estimated costs for communities per acre and per household inside the watershed boundaries; Table 8-8 presents costs within the boundaries of all municipalities that intersect the watershed. For the purposes of this illustrative example of cost distribution, general, watershed-related costs for communities outside of Philadelphia are apportioned according to the percentage of the watershed area within each municipality's jurisdiction.

These cost tables are but one illustration of a possible cost distribution, and are provided to aid municipalities in deciding what funding and institutional mechanisms may be most appropriate given local conditions.

Table 8-7 Distribution of Costs Among Rate Payers in Cobbs Watershed in Communities Outside Philadelphia

	Colwyn	Darby	East Lansdowne	Haverford	Lansdowne	Lower Merion	Milbourne	Narberth	Radnor	Upper Darby	Yeadon
Municipality area in watershed (ac)	96	140	132	3,873	111	2,375	44	268	32	2,700	910
Area of municipality in watershed (% of municipality total)	59%	27%	100%	60%	15%	16%	100%	85%	0.4%	56%	88%
Households in municipality and watershed	484	1219	939	12185	755	7151	366	1619	141	18357	4277
Annual cost associated with CCIWMP	$79,252	$115,576	$108,971	$3,197,315	$91,635	$1,960,656	$36,324	$221,245	$26,417	$2,228,957	$751,241
Cost per acre (within watershed)	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54	$825.54
Cost per household (within watershed)	$163.74	$94.81	$116.05	$262.40	$121.37	$274.18	$99.25	$136.66	$187.36	$121.42	$175.65
Median household income ($/year)	$33,150	$30,938	$44,205	$65,714	$47,017	$86,373	$30,185	$60,408	$74,272	$41,489	$45,450
Cost per household (% of MHI)	0.49%	0.31%	0.26%	0.40%	0.26%	0.32%	0.33%	0.23%	0.25%	0.29%	0.39%

Table 8-8 Distribution of Costs Among all Rate Payers in Communities Outside Philadelphia

	Colwyn	Darby	East Lansdowne	Haverford	Lansdowne	Lower Merion	Milbourne	Narberth	Radnor	Upper Darby	Yeadon
Municipality area (ac)	164	522	132	6,406	753	15,265	44	316	4,824	4,824	1,032
Watershed area in municipality (ac)	96	140	132	3874	111	2376	44	268	32	2701	910
Watershed area in municipality (% of watershed total)	0.7%	1.0%	0.9%	27.3%	0.8%	16.7%	0.3%	1.9%	0.2%	19.0%	6.4%
Households in municipality	857	3,411	939	18,069	4,688	22,845	368	1,895	10,383	32,594	4,730
Annual cost associated with CCIWMP	$79,252	$115,576	$108,971	$3,197,315	$91,635	$1,960,656	$36,324	$221,245	$26,417	$2,228,957	$751,241
Cost per acre (whole municipality)	$483.24	$221.41	$825.54	$499.11	$121.69	$128.44	$825.54	$700.14	$5.48	$462.06	$727.95
Cost per household (whole municipality)	$92.48	$33.88	$116.05	$176.95	$19.55	$85.82	$98.71	$116.75	$2.54	$68.39	$158.82
Median household income ($/year)	$33,150	$30,938	$44,205	$65,714	$47,017	$86,373	$30,185	$60,408	$74,272	$41,489	$45,450
Cost per household (% of MHI)	0.28%	0.11%	0.26%	0.27%	0.04%	0.10%	0.33%	0.19%	0.003%	0.16%	0.35%

8.3 Institutional Analysis

The primary purpose of Section 7 of this plan is to provide recommendations and guidance to stakeholders - primarily state, county and other government agencies, municipalities, non-government organizations, land owners, and individuals - on ways to better manage water resources of Cobbs Creek. Everyone in the watershed communities can contribute in numerous ways to the protection of water resources. Roles of primary stakeholders and participants in the plan are briefly described below, followed by the recommendation that a watershed-wide management organization be created to facilitate implementation.

8.3.1 Description of Roles

Both government and non-government organizations will play a role in the successful implementation of the Cobbs Creek Watershed Management Plan. The primary roles are outlined below.

PADEP Role

Two agencies of the Commonwealth of Pennsylvania are directly and indirectly involved in watershed planning in Cobbs Creek: the Pennsylvania Department of Environmental Protection (PADEP) and PA Department of Conservation and Natural Resources (PADCNR). Achievement of Watershed Plan goals and objectives through local implementation will require continued support through funding and integration of the various existing state level stormwater management and runoff related programs. Particular attention should be paid to the following programs:

- Act 167 Plans
- Phase II Stormwater permits
- Act 537 / CMOM Plans
- Construction Stormwater Pollution Prevention
- Industrial Stormwater Pollution Prevention
- Watershed monitoring and performance reporting
- Exploring Watershed Permitting Opportunities

A critical PADEP role will be activities required under Section 303(d) of the Clean Water Act (PADEP, 2004) and the EPA's Water Quality Planning and Management Regulations (40 CFR Part 130). PADEP will need to actively administer the water quality standards process for portions of Cobbs Creek in the near future. TMDLs should be integrated with the findings of this watershed plan, and the approaches recommended by this plan should be designed to meet the TMDL requirements as they arise. Most of the regulatory approaches will need to define guidelines and limits, including TMDLs, in order to create possibilities for pollution trading. PADEP would also need to support the review and revision of water quality standards and a

Use Attainability Analysis.

PWD Role

PWD, as the primary author of this plan, plays a central role in its implementation, as well as in continued monitoring to chart improvements to water quality and to provide the scientific foundation for eventual TMDLs and for a Use Review and Attainability Analysis. PWD will take a lead role in implementing a variety of the recommendations, including;

- Stream Restoration
- Improvement of Fish Passage
- CSO Control
- Green Rooftop Demonstrations
- Stormwater BMP installation
- Organization of Stakeholder Participation
- Monitoring

Municipal Role

Municipalities can play a key role in the implementation of recommendations through the incorporation of water resources strategies into their land use planning and governance functions. Because of the authorities contained in the Pennsylvania Municipalities Planning Code (MPC), municipalities are one of the two main foci of implementation efforts (PWD being the other). Enabled by the MPC, municipalities are the focal point to address runoff from redeveloped and existing developed lands, to address problems associated with sanitary sewer collection systems, to enhance recreational opportunities, and to protect natural resources from the effects of land disturbance.

The most fundamental roles recommended for municipalities are to consider undertaking a comprehensive review of their existing land use regulations, policies and requirements to identify where they may be unnecessarily causing impacts to water resources; and to undertake the necessary actions needed to eliminate SSOs and sanitary sewer leaks.

The primary actions recommended for municipalities include: encouraging connection of roof leaders to storm sewers, reduction of expansive paved (impervious) parking lot requirements and replacement of asphalt with porous paving surfaces, repair and maintenance of leaking sanitary sewers, instituting a urban tree planting and maintenance program through establishment of a Tree Commission, and the elimination of SSOs.

County Role

The primary role of Delaware County (and to a lesser extent, Montgomery County) is to conduct the necessary comprehensive stormwater management studies to:

- Complete an Act 167 stormwater plan that is consistent with and furthers the achievement of the goals and objectives of this plan.
- Work with municipalities to update Act 537 plans

In addition, the Delaware County Conservation District has several important responsibilities within the watershed, including:

- Chapter 102 Erosion Control: Administers of the State's program to control sediment pollution from earth disturbance activities.
- National Pollution Discharge Elimination System (NPDES): Processes applications and seeks compliance towards stormwater discharge permits for Construction Activities.
- Chapter 105 Waterways and Wetlands General Permitting: Assists applicants with permit information. Processes general permits for work within wetlands and streams.

These are important elements in coordinating Act 167 planning requirements with Phase II of the NPDES Stormwater Program.

Non-Government Organization Role

The Darby-Cobbs Partnership is an important organization within the watershed, and the partnership should continue to work with PWD through the implementation phase. A Tree Commission could be created within the watershed to manage the urban forest program recommendations. In Pennsylvania, a tree commission is created by municipal ordinance as a decision-making body, and once empowered, can have exclusive control over a community’s shade trees.

Land Owners’ Role

Voluntary watershed stewardship by all land owners can contribute significantly toward the protection and restoration of the Cobbs Creek watershed while simultaneously minimizing the need for additional regulatory controls. Recommended roles for land owners include:

- Implementing “watershed stewardship” practices in their landscape and outdoor housekeeping practices.
- Actively working to eliminate litter, trash, and illegal dumping through participation in cleanup activities and through heightened awareness.
- Disconnecting roof leaders and installing rain barrels or dry wells

- Considering pervious solutions for driveways
- Joining and supporting the activities of the watershed partnership.

8.3.2 Possible Organizational Structures

The above outlined roles can be, and often are, carried out within the existing regulatory structure without any real coordination or formal agreement to join and work through a watershed organization. In the absence of a central watershed organization, PWD would commit to implementation of recommended projects and programs within the City, and each of the major municipalities would respond to various regulatory requirements individually. Collectively, these activities would improve water quality and habitat in the watershed; however, there would be significant overlap, duplication of effort, and potential gaps in the implementation. This is far from ideal.

As an alternative, it is preferred that a Cobbs Creek Watershed Organization be created to coordinate activities. A Watershed Organization could be set up with a County or the City of Philadelphia as the primary organization running the program, with other organizations participating through stakeholder meetings. In this case, PWD could assume this role.

Alternatively, a separate, non-profit organization with member organizations bound by formal agreement could be established (perhaps as an expansion of the current Cobbs Creek Partnership). The Organization could be allowed to start modestly, and to grow as the need arises. Thus, the ultimate structure of the Organization and its responsibilities would evolve over time, but participants in the Organization would work together by formally adopting this plan, and providing funds for the completion of the major recommendations. Potential sources of funding could include member assessments, grants, in-kind and cash matches from implementing organizations, and in-kind services from member organizations.

An example of just such an organization was formed for the Rouge River in Michigan. Using the Rouge River Assembly as a guide, the Cobbs Creek Watershed Organization could have some or all of the following characteristics.

- Membership could be open to PWD, all the municipalities, and the two counties in the watershed. All members would either have a permit to discharge storm water into the creek, or are responsible for CSO into the creek.
- Membership could be expanded to include PADEP and EPA in an advisory capacity.
- For the City of Philadelphia, municipalities and the two counties, voting shares and costs could be apportioned based upon land and population in watershed.
- A General Assembly of participants could be set up to meet twice per year to focus on priorities, budget, and assessments.

- An Executive Committee with a representative from each major participating body could be set up to meet 6 times per year to provide management oversight.

- Standing Committees (e.g. Finance, Technical, and Public Involvement) could be established to provide day to day guidance and advice, with members drawn from the member organizations.

- An Organization Committee could be established to consider long term changes for the permanent organization to best meet needs.

Some of the primary functions of the newly formed organization could include:

- Seeking implementation plan approval. This approval includes obtaining signatures from municipalities followed by a letter of support from PADEP. The Organization would encourage PADEP to adopt the Plan as a governing document for the watershed. The existing Watershed Restoration Action Strategy (WRAS) program could provide a framework for implementation of the Plan.

- Instituting a program to hire watershed plan implementation specialists, similar to existing county conservation district specialists. A county would have several specialists, and each specialist would be assigned to several municipalities. The specialists would represent their assigned communities in Organization meetings and other regional meetings. The watershed Organization would apply to the Growing Greener program as a source of funding for these specialists.

- Overseeing the continued implementation of basic, essential services required of all municipalities by stormwater permits (e.g., sewer system maintenance).

- Overseeing continued monitoring, sampling, data analysis, and reporting on both the water quality and biology of the system using the established indicators.

- Providing public participation and public education.

- Exploring innovative solutions to long-term operation and maintenance of stormwater management facilities.

- Requiring that projects applying for state funding (Growing Greener, DCNR) must be reviewed and shown to be consistent with the Plan. The specialists, directed by the Organization, would review all submitted projects and apply a rating scale for consistency with the plan.

- Encouraging the idea of applying for federal funding for regional projects (e.g., stream restoration, regional wetlands); however, most smaller-scale projects would be funded locally. Public funding for major infrastructure projects on private land could be explored.

Appendix A: Glossary of Terms

Adaptive management	Process of continually monitoring progress and adjusting the approach
Bankfull flow	The high flow stage of a fluvial system distinguished by the highest stage elevation a stream can reach before spilling over.
Baseflow	The portion of streamflow contributed by groundwater.
Benthic	Used to describe aquatic organisms living at the bottom of a body of water
Benthic macroinvertebrates	Are mainly aquatic insect larvae that live on the stream bottom. Since they are short-lived and relatively immobile, they reflect the chemical and physical characteristics of a stream and chronic sources of pollution.
BMP -	*Best Management Practice* – Also called a "management option," BMP is a technique, measure, or structural control that addresses one or more objectives (e.g., a detention basin that gets built, an ordinance that gets passed, an educational program that gets implemented).
BOD	Biochemical Oxygen Demand
CCD	County Conservation District(s)
CCHL	Cobbs Creek High-Level Combined Sewer System
CCLL	Cobbs Creek Low-Level Combined Sewer System
CCTV	Closed Circuit Television
Clean Streams Law	
CSO	Combined Sewer Overflow
CSS	Combined Sewer System

CWA	*Clean Water Act* – The Federal Amendment that authorizes the EPA to implement pollution control programs and to set water quality standards for all contaminants in surface waters. "The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by nonpoint source pollution." (EPA website)
CWA Section 104(b)(3) Program	Promotes the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction and elimination of pollution.
CWA Section 208 Wastewater Planning	Intended to encourage and facilitate the development and implementation of area-wide waste treatment management plans.
CWA Section 319(b) Non-point Source Management Program	Designed to address mine drainage, agricultural runoff, construction/urban runoff, hydrologic and habitat modifications, on-lot wastewater systems, and silviculture.
DCIA	Directly Connected Impervious Area
DCVA	Darby Creek Valley Association
DO	Dissolved Oxygen
DRBC	Delaware River Basin Commission
DVRPC	Delaware Valley Regional Planning Commission
DWO	*Dry-Weather Outlet* - connector pipe between a CSO regulator and interceptor sewer.

IDD&E	*Illicit Discharge, Detection, and Elimination* – one of the six minimum control measures required of permittees under the Phase II NPDES Stormwater Regulations. Program steps include developing maps of municipal separate storm sewer system outfalls and receiving waterbodies; prohibiting illicit discharges via PADEP-approved ordinance; implementing an IDD&E Program that includes a field screening program and procedures, and elimination of illicit discharges; conducting public awareness and reporting program. A similar program is being followed by PWD in the Long Term Control Plan (LTCP) for CSOs.
EACs	Environmental Action Committees
Floatables	Waterborne waste material and debris (e.g., plastics, polystyrene, paper) that float at or below the water surface.
ET	*Evapotranspiration* – the sum of water vapor evaporation from the earth's surface and transpiration from plants.
EVAMIX	A multi-criteria evaluation program to help choose objectively between various alternatives
GIS	Geographic Information Systems
Handheld DO	Dissolved oxygen readings taken with a handheld meter.
HIS	Habitat Suitability Indices
IPM	Integrated Pest Management
LID	Low-Impact Development (similar to "better site design" and "conservation site design")
LTCP	*Long-Term CSO Control Plan* – part of the EPA's CSO Control Policy for regulation of CSOs under NPDES that guides municipalities, state, and federal permitting agencies in reaching full compliance with the CWA.
Macro invertebrates	Macroinvertebrates are invertebrate animals that are can be seen without the aid of a microscope.
MPC	Municipalities Planning Code

MS4	Municipal Separate Storm Sewer System
NLREEP	Natural Lands and Restoration and Environmental Education Program (a unit of Philadelphia's Fairmount Park Commission)
NOAA	National Oceanic and Atmospheric Administration
Non-point source pollution	Pollution that comes from a diffuse source such as atmospheric deposition, stormwater runoff from pasture and crop land, and individual on-lot domestic sewage systems discharging through shallow groundwater.
Non-structural BMPs	These BMPs will require no operation or maintenance. Examples are use of open space and vegetated buffers in development design, minimization of soil disturbance and compaction during construction, and minimization of directly-connected impervious areas.
NPDES	National Pollutant Discharge Elimination System
NPDES Phase I	The stormwater management component of the NPDES program, instituted in 1990, which addressed the storm runoff sources most threatening to water quality. Under this phase, sites with larger communities, industrial activity, and construction sites are required to obtain permits for the storm water leaving the site.
NPDES Phase II	Additional stormwater management regulations enacted in 1999, applying to smaller communities and construction sites.
OLDS	On-Lot sewage Disposal Systems
O&M	Operations and Maintenance
OOW	PWD's Office of Watersheds
PA Act 167	Stormwater Management Act
PA Act 537	Sewage Facilities Planning Act
PADCNR	Pennsylvania Department of Conservation and Natural Resources
PADEP	Pennsylvania Department of Environmental Protection

PADEP Greenways Program	An Action Plan for Creating Connections is designed to provide a coordinated and strategic approach to creating connections through the establishment of greenways in the State.
PEC	Pennsylvania Environmental Council
PENNVEST	*Pennsylvania State Revolving Fund Program* - Provides funding for sewer, stormwater, and water projects throughout the Commonwealth.
Point source	Pollution discharged from a single point, defined in the CWA as "any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft from which pollutants are or may be discharged." (pg20 Section 7)
POTW	Publicly Owned Treatment Works
PRD	Planned Residential Development
PWD	Philadelphia Water Department
QA/QC	Quality Assurance/Quality Control
RBP	Rapid Bioassessment Protocol (developed by the EPA) a standard method to assess aquatic health through fish and macroinvertebrate diversity (EPA Website).
RBP III	Section of the RBP dealing benthic macroinvertebrates.
RCP	PADCNR's Rivers Conservation Program
Riparian corridor	The area of land along the bank or shoreline of a body of water (EPA website).
Riparian woodlands	Woodlands that grow within the riparian corridor.
RTC	*Real Time Control* - a dynamic system of hydraulic controls to provide additional storage and reduce overflows from a combined sewer system
SEO	Sewage Enforcement Officers (designated by PADEP)

Solids	Waterborne waste material and debris consisting of sand, gravel, silts, clay, and organic matter.
Sonde	Shallow depth continuous water quality monitor manufactured by YSI Inc.
SSA	Separate-Sewered Area stormwater runoff
SSET	Sewer Scanner and Evaluation Technology
SSMS	Sanitary Sewer Management System
SSO	Sanitary Sewer Overflow
STORET	USEPA's water quality database (STOrage and RETrieval)
Stormwater Management Program Protocol ("Protocol")	PADEP guidance for implementing the requirements of the NPDES Phase II stormwater regulations
Structural BMPs	These BMPS will require proper operation and maintenance. Examples include wet ponds, grassed swales, infiltration basins and bioretention areas.
SWMM	Storm Water Management Model
TDR	Transfer of Development Rights
TIGER	Topologically Integrated Geographic Encoding and Referencing (U.S. Census database)
TMDL program	*Total Maximum Daily Load program* - EPA/PADEP program for limiting and allocating discharges of a pollutant within a watershed.
Transpiration	The process by which water vapor passes through the membrane or pores of plants to the atmosphere.
TSS	Total Suspended Solids
UA	Urban Areas
UAA	Use Attainability Analysis
USGS	United States Geological Survey

Watershed	The area of land draining to a stream, river, or water body. Watershed boundaries are established where any precipitation falling inside the boundary will drain to that particular watershed water body. Precipitation falling outside the boundary will drain to a different watershed. Watershed boundaries are typically formed on high elevation ridges. The water bodies formed from the watershed drainage are usually at the lowest elevation in the watershed. Watersheds can also be called drainage basins.
WMP	Watershed Management Plan
WQS	Water Quality Standards
WRAS	PADEP's *Watershed Restoration Action Strategy*

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