EXECUTIVE SUMMARY

Study Background and Purpose

The Quittapahilla Creek Watershed is situated in the Ridge and Valley physiographic region in Lebanon County, Pennsylvania. Quittapahilla Creek is a tributary to Swatara Creek and is part of the Susquehanna River Basin. Its headwaters begin just southeast of Lebanon, Pennsylvania and it enters the Swatara Creek near North Annville, Pennsylvania.

The major land use in the watershed is agricultural. There are significant areas of urbanization along the Route 422 corridor in the City of Lebanon, West Lebanon, Cleona, and Annville. In addition, new development in the watershed is replacing farms with suburban communities. Past and current land use and land management practices in the rural areas, suburban communities, and urban centers have resulted in degraded water quality, stream bank and bed erosion, sedimentation, flooding, and the loss of riparian and in-stream habitat throughout the Quittapahilla Creek Watershed.

Studies conducted in the 1980's and 1990's by the Pennsylvania Department of Environmental Protection (DEP) clearly indicated impairment of aquatic resources in the Quittapahilla Creek Watershed. In fact, the mainstem as well as all of the major tributaries to the Quittapahilla Creek were listed as impaired in the 303(d) listings. The 2000 305(b) Report prepared by DEP indicated that there are 88.9 miles of stream in the Quittapahilla Creek Watershed. Only 1.82 miles of stream (2%) were found to support designated aquatic life uses. The identified land use activities contributing to impairment include agriculture, crop related agriculture, urban/storm sewers, and bank modification. Sources of impairment include nutrients, siltation, suspended solids, organic enrichment/low dissolved oxygen concentrations, flow alteration, and other habitat alterations.

The Total Maximum Daily Loads (TMDLs) Report (PADEP, 2000) cited excessive sediment and nutrient levels as a major water quality problem in the Quittapahilla Creek Watershed. The report indicated that these pollutants are causing increased algae growth, large accumulations of fine sediments on the streambed, and degradation of in-stream habitat. Although the report attributed the excessive sediment and nutrient levels principally to agricultural activities, these pollutants are also associated with other upland sources (e.g., urban runoff) as well as in-stream sources (e.g., stream bed and bank erosion).

The Quittapahilla Creek Watershed Association has been working with a number of private organizations and public agencies to improve the water quality and aquatic habitat of Quittapahilla Creek. However, there has been no comprehensive assessment, nor coordinated effort to identify and prioritize water quality, habitat and stream channel stability problems throughout the watershed. As a consequence, targeting of stream reaches for improvements has been on a project-by-project basis. There is no Master

Plan for the Quittapahilla Creek Watershed that serves to focus funding and restoration and management efforts where they are most needed.
The Quittapahilla Creek Watershed Association believes that their best chance for resolving the existing problems and avoiding future problems is to step back from the current project-based approach and develop a comprehensive plan of action based on an assessment of the entire watershed. They believe that this approach will serve to focus funding and restoration and management efforts where they are most needed. They also believe that it is the approach that has the greatest chance for long-term success.

The objectives of this project were:

1. Establish benchmarks for evaluating and documenting changes in the watershed by assessing current hydrologic, water quality, in-stream habitat, and channel stability conditions.
2. Identify and prioritize restoration and management strategies to address existing hydrologic, water quality, in-stream habitat, and channel stability problems.
3. Determine the potential for future hydrologic, water quality, in-stream habitat, and channel stability problems.
4. Develop recommendations for management and protection strategies that will prevent and/or minimize future problems.

An interdisciplinary team that included Clear Creeks Consulting LLC; Skelly & Loy, Inc.; U.S. Fish & Wildlife Service, Chesapeake Bay Field Office; Penn State Institutes of the Environment, Pennsylvania State University; Department of Biology, Lebanon Valley College; and U.S. Geological Survey, New Cumberland Field Office conducted the watershed assessment and developed the restoration and management plan for the Quittapahilla Creek Watershed Association. The Quittapahilla Creek Watershed Project was supported by Growing Greener Grants received from Pennsylvania DEP in 2001 and 2003.

The major components of this study included watershed characterization, morphologic stream assessment, subwatershed analysis, ecological assessment, water quality modeling, water quality monitoring, problem identification and prioritization, and restoration and management recommendations. Each of the assessment study components is presented in a section of Volume 1 – Findings Report. Problem identification and prioritization and restoration and management recommendations are presented in Volume 2 – Restoration and Management Plan.

Volume 1 – Watershed Assessment Findings Report

The Assessment Phase of this project was focused on: evaluating the natural watershed characteristics such as soils, geology, land use, hydrology, as well as an assessment of current stream channel morphology and stability, in-stream habitat, biological communities, and water quality conditions of Quittapahilla Creek and its tributaries.

Section 2 – Watershed Characterization summarizes the regional weather patterns, natural watershed characteristics, and historic and current land use practices of Quittapahilla Creek and its tributaries.

Section 3 – Morphologic Stream Assessment summarizes the results of the morphologic stream assessment that was conducted along the mainstem Quittapahilla Creek.

Section 4 - Subwatershed Analyses summarizes the results of a field reconnaissance that was conducted to assess and document existing conditions in each of the major subwatersheds from their headwaters to confluence with Quittapahilla Creek.

Section 5 – Ecological Assessment summarizes the results of a comprehensive assessment that was conducted of the existing habitat conditions and the biological communities in the Quittapahilla Creek watershed.

Section 6 – Water Quality Assessment summarizes the results of the water quality modeling analyses and water quality monitoring program developed to evaluate existing water quality conditions along Quittapahilla Creek and its tributaries.

Volume 2 – Restoration and Management Plan

Section 2 – Methods for Identifying and Prioritizing Restoration and Management Strategies outlines the comprehensive analysis that was conducted to identify and prioritize potential best management practices and restoration projects in the subwatersheds and along the main stem of Quittapahilla Creek.

Section 3 – Potential Best Management Practices summarizes a comprehensive evaluation and prioritization of general as well as site specific Best Management Practices (BMPs) for controlling agricultural and urban runoff in the subwatersheds and along the main stem of Quittapahilla Creek.

Section 4 – Potential Restoration Measures summarizes a comprehensive evaluation of general as well as site specific restoration measures to correct stream stability and habitat problems along the main stem Quittapahilla Creek and its tributaries.

Section 5 – Long-Term Management Strategies summarizes current policies and programs and outlines recommendations for policies and programs focused on stream, wetland and floodplain protection and management.

Restoration and Management Plan

Methods for Identifying and Prioritizing Restoration and Management Strategies

A comprehensive analysis was conducted to identify and prioritize potential best management practices and restoration projects in the subwatersheds and along the main stem of Quittapahilla Creek. The analysis was based on an evaluation of the data collected during the assessment phase of the project. The comprehensive analysis process included:

- Identification of Potential Watershed and Stream Management and Restoration Projects.

Potential projects were identified from a list of subwatershed and main stem problem sites identified in Volume 1 of this report. These projects were selected for their potential for reducing loadings of sediment and other pollutants, correcting channel instability, and improving in-stream habitat problems and include two major types of measures.

  - Source-Based Measures

Source-Based Measures are focused on upland problem areas and include implementation of agricultural best management practices such as crop rotation, cover crops, conservation tillage and residue management, strip cropping/contour farming, terraces and diversions, nutrient management, grazing land management; installation of quality and quantity management facilities for controlling urban storm water runoff, construction of wetlands in floodplain areas to increase valley storage, reduce the erosive effects of flood waters, and create wildlife habitat.

  - Stream-Based Measures

Stream-Based Measures are focused on stream channel problems and include installation of stream bank fencing and livestock crossings to limit the impacts associated with livestock grazing, modifications to golf course maintenance practices to reduce impacts to riparian vegetation, modifications to bridges and culverts to reduce effects on flood conveyance and sediment transport capacity, removal of fish barriers, restoration of stable channel form, and stream bed and bank stabilization utilizing grade control and flow diversion structures and native materials.

- An Evaluation of the Effectiveness of Implementing Restoration and Management Projects

An evaluation was conducted to determine the effectiveness of implementing the recommended restoration and management measures. The measures were grouped into three major categories, each denoting the water quality problems they are intended to correct. The categories include agricultural best management practices, urban best management practices, and channel stabilization measures. Although other benefits are

expected to be derived from implementing the various measures (e.g., reduced peak flows, improved habitat, etc.) the evaluation focused on determining the effectiveness of measures in reducing sediment and nutrient loadings. This required that category specific evaluation methods be developed. The evaluation methods used to evaluate each category are described below.

- Prioritization of Management and Restoration Projects

Restoration and management measures were evaluated based on their potential for correcting channel stability, water quality, and in-stream habitat problems along Quittapahilla Creek and its tributaries.

Potential Best Management Practices

When considering options for BMP implementation, it is useful to know how effective such BMPs might be in terms of reducing various types of pollutants such as sediment, nitrogen, and phosphorus. There is a very wide range of BMPs that could potentially be employed, as well as a wide range of associated costs and inherent pollutant reduction efficiencies.

- Best Management Practices for Controlling Agricultural Runoff
    - Evaluation Methods

As described in the Findings Report, the Generalized Watershed Loading Function (GWLF) model with a GIS software (ArcView) interface (AVGWLF) developed by Pennsylvania State University was utilized to analyze water quality during the assessment phase of this study. The analysis focused on identifying general areas where pollutant loadings indicate that best management practices should be implemented.

A companion tool that runs within *AVGWLF* was used in this phase of the study to evaluate the potential benefits of using various best management practices (BMPs) within the Quittapahilla watershed. This tool, called *PRedICT* (The Pollution Reduction Impact Comparison Tool), allows the user to create various "scenarios" in which current landscape conditions and pollutant loads (both point and non-point) can be compared against "future" conditions that reflect the use of different pollution reduction strategies such as agricultural and urban best management practices (BMPs), stream protection activities, the conversion of septic systems to centralized wastewater treatment, and upgrading of treatment plants from primary to secondary to tertiary.

In estimating the potential load reduction benefits of various mitigation strategies within the Quittapahilla watershed, the intent was to estimate the maximum reductions in sediment and nutrient loads that might be obtained by implementing agricultural BMPs. To simplify the BMP evaluation process, scenarios in which a combination of conservation tillage, nutrient management, and grazing land management was used in each of the sub-watersheds were developed. Other potential combinations are, of course,

possible. However, it was not the intent of this exercise to find the optimum BMP scenario within each sub-watershed; rather, it was to provide a sense of the magnitude of possible reductions that might be possible solely via the implementation of agricultural BMPs.

Description	Option	Comments
Cropland Protection	BMP 1	Crop rotation, cover crops
Conservation Tillage	BMP 2	Cultivation with minimal soil disturbance
Strip Cropping/Contour Farming	BMP 3	
Agricultural Land to Forest Conversion	BMP 4	
Agricultural Land to Wetland Conversion	BMP 5	
Nutrient Management	BMP 6	
Grazing Land Management	BMP 7	Rotational grazing with fenced areas
Terraces and Diversions	BMP 8	

Table ES.1 - Agricultural BMP options used in *PRedICT*

- Implementation Costs

As with the reduction efficiency values, the costs associated with implementing the various individual BMPs were drawn from several sources. The primary one used, however, was the Conservation Catalog prepared by the Pennsylvania Conservation Partnership (2000). In addition to a description of various agricultural conservation practices currently used in Pennsylvania, the publication also has average costs for these practices at the time the document was written. Another useful document was a BMP guidance document prepared earlier by the U.S. EPA (1990).

BMP Type	Cost
Conservation Tillage	$30 per acre
Cover Crops	$20 per acre
Grazing Land Management	$360 per acre
Contour Farming / Strip Cropping	$10 per acre
Vegetated Buffer Strips	$1,500 per mile
Terraces and Diversions	$500 per acre
Nutrient Management	$110 per acre
Crop Rotation	$30 per acre
Agricultural Land Retirement	$5,000 per acre

Table ES 2 - Costs by Best Management Practice type.

- Prioritization of Agricultural Best Management Practices

The agricultural BMPs that have the most significant effect on reducing nutrient and sediment loadings involve conversion of marginal crop and pasture land to forest and/or wetlands. These marginal areas include land with steep slopes with highly erodible soils, and very wet or very droughty soils. These types of conditions generally provide poor productivity and should be given strong consideration for conversion. The other BMPs that have a significant effect on reducing nutrient and sediment loadings include conservation tillage and the use of terraces and diversions for cultivated land.

The subwatersheds that would achieve the greatest reduction in nutrient loadings by implementing all of the above practices include Subwatersheds 6 – Upper Killinger Creek; 14 – Lower Snitz Creek; 3 – Confluence of Main Stem Quittaphilla Creek and Killinger Creek; and 15 – Brandywine Creek.

The subwatersheds that would achieve the greatest reduction in sediment loadings by implementing all of the above practices include Subwatersheds 5 – Upper Killinger Creek and Gingrich Run; 8 – Middle Gingrich Run; 7 – Buckholder Run; 21 – East Fork Tributary of Snitz Creek; 9 – Tributary of Gingrich Run; 2 – Lower Main Stem Quittapahilla Creek; 10 – Upper Gingrich Run; 17 – Upper Quittapahilla Creek; 18 – Upper Bachman Run; and 4 – Middle Killinger Creek.

It is strongly recommended that NRCS and the Conservation District work closely with the agricultural landowners in these subwatersheds to implement these agricultural practices where they are applicable.

- Best Management Practices for Controlling Urban Runoff

Urban stream restoration is arguably the most difficult of all watershed objectives to attain. The broad objective of this plan is to restore the functional integrity of the Quittapahilla Creek ecosystem, as demonstrated by the reestablishment and persistence of important aquatic species or ecosystem functions that had been diminished over time by urbanization. It is a complex and costly process of repair that involves stormwater retrofits, riparian reforestation, stream restoration, wetland restoration and creation, and removal of fish barriers. The ability to meet this target in the urbanized subwatersheds will be governed by two factors. First, enough opportunities must be available to retrofit BMP systems into the urban subwatersheds to provide meaningful hydrologic control and pollutant removal. Second, any new watershed development that occurs must be accompanied by stringent BMP systems so that the improvements brought about by retrofits are not cancelled out.

    - Regional Approach versus On-Site Management Practices

In developing an Urban Stormwater Control Plan for the Quittapahilla Creek watershed, consideration was given to a regional approach versus on-site management practices. Significant advantages were identified relative to regional on-stream facilities in

comparison to smaller on-site management practices. One significant advantage of regional facilities is that, when dealing with non-point source pollutant sources, this approach is better able to capture and treat pollutants that are generated from often-times non-discrete sources. These regional facilities capture and treat the aggregate runoff from larger subwatershed areas without the need to identify specific pollutant sources. In comparison, site-specific BMP's, assuming they could even be effective at capturing non-point pollutant sources, would require substantial additional watershed assessment and investigation to inventory pollutant sources and localized topographic drainage patterns well outside the immediate stream corridor.

Additionally, regional BMP's provide the flexibility to locate facilities where open space exists. This means that areas contributing to the problems have already been developed and may no longer have open space areas available for BMP construction. In this situation, many cases would literally be untreatable using an on-site approach.

The regional facilities also have an advantage in terms of generally involving fewer total number of individual land owners throughout the watershed. Though the land area required at each regional facility location is larger than an individual site-specific BMP site, the number of site-specific locations required to achieve the same level of treatment is greatly increased, thus increasing the number of involved individual land owners. In several cases, the regional BMP sites identified in this study are even located on publicly owned land, further simplifying the process to obtain land owner consent.

One final generalized comparison relates to project funding. For regional facilities, their benefits are more easily understood and recognized as having broader application to a larger number of people and a larger area than a site-specific, more localized BMP. Consequently, funding for regional facilities can often times be more easily justified.

- Evaluating BMP Options

Best Management Practices (BMPs) for controlling urban runoff include a wide range of structures and treatment options that can be used to convey storm water runoff, reduce the hydrological impacts due to increased quantity of storm water runoff, and reduce the pollutant loadings delivered by storm water runoff. As shown in Table ES 3 below, stormwater BMPs can include: bioretention, grassed filter strips, grassed swales, infiltration trenches and basins, riparian buffers, sand and organic filters, stormwater wetlands, water quality inlets, and retention or extended detention wet ponds.

Best Management Practice	Cost	Maintenance	Pollutant Removal (%)				
			TSS	Phosphorus	Nitrogen	Metals	Bacteria
Bioretention	Expensive	Intense Initially, Less over time	NA	65 – 85	49 – 92 *	43 – 97	NA
Grassed Filter Strip	Moderate – Low	Low	54 – 84**	25 – 40**	27 – 20**	16 – 55**	NA
Grassed Swale	Moderate – Low	Low	81	29	38	14 – 55	50
Infiltration Basin	Cost Effective	High to maintain effectiveness	75	60 – 70	55 – 60	85 – 90	90
Infiltration Trench	Somewhat Expensive	Very High, Moderate with pretreatment	75	60 - 70	55 – 60	85 – 90	90
Riparian Buffers	Low, increase property values	Low	63 – 89**	8 – 74**	17 – 99**	NA	NA
Sand and Organic Filters	Moderate – High	Very High, Moderate with pretreatment	66 – 98***	4 – 84***	44 – 47***	26 – 100***	55
Storm Water Wetland	Cost Effective	Moderate	71 – 83***	39 – 64***	19 – 56***	21 – 85**	78
Water Quality Inlets	Moderate – High	Very High	21	17	5	17 – 24	NA
Wet Pond	Cost Effective	Moderate	67	48	31	24 – 73	65

Table 3.5 Comparison of Post-Construction Best Management Practices (Source: USEPA, Office of Water Website)

Notes: NA – Not Available; * varies with chemical form; ** varies with filter/buffer width; *** varies with design components

Each BMP option considered has both unique capabilities and persistent limitations. These, in turn, were balanced with both the physical constraints imposed by natural features and historic land use and the overall management objectives for the watershed. In developing the BMP plan for Quittapahilla Creek watershed consideration was given to the following objectives and concerns:

- Developing the BMP Plan for Quittapahilla Creek

For this study, BMP's were analyzed based upon the ability to attenuate peak discharges while providing pollutant load removal for the lowest cost and lowest maintenance requirements over the life of the facility. The BMP that best obtains these goals is an extended wet detention pond.

When evaluating which areas of the Quittapahilla Creek watershed to target for implementation of urban best management practices, the subwatersheds draining the City of Lebanon ranked highest. Several factors lead to this determination: 1) the high percentage of impervious area in these subwatersheds; 2) the nature of urban runoff and its effects on stream channels; 3) the most intensely developed areas in these subwatersheds predate stormwater runoff control regulations and technology; 4) results of the water quality modeling, water quality monitoring, and sediment discharge study all indicate that the Upper Quittapahilla Creek and Brandywine subwatersheds are contributing a major portion of the sediment load to Quittapahilla Creek;. and 5) the U.S. EPA's Phase II NPDES requirements mean that municipalities like the City of Lebanon are required to develop storm water management plans for controlling and treating urban runoff.

Twelve (12) sites were initially identified for implementation of storm water control best management practices (BMPs) during the field reconnaissance phase of the watershed assessment. Subsequent development of previously vacant parcels and other site constraints eliminated three of the original twelve sites. The nine (9) remaining BMP sites (shown on Plate 1) were conceptually designed using GIS topography with the goal of achieving maximum amount of attenuation volume based upon the physical characteristics of the sites.

- Evaluation Methods
    - Hydrologic Improvements

One major objective of the extended wet detention pond BMP implementation is the reduction of the bankfull discharge. Urbanization and development within the watershed over the past few decades has altered the infiltration/runoff characteristics of the watershed, and have led to higher peak flows at the 1-year to 2-year recurrence level. As previously mentioned, the bankfull discharge (usually falling between the 1- and 2-year discharges) is recognized as being the channel forming flow. The increases of the peak discharges within the Quittapahilla Creek system have led to increased rates of streambed and stream bank erosion, which takes a toll on downstream receiving waters. Therefore,

in an effort to counteract the increases of the bankfull discharge from urbanization, the effect of placing extended wet detention ponds within various locales in the greater Lebanon area was studied to determine the magnitude of improvements that would be realized.

- Water Quality Improvements

A second major objective of implementing the proposed BMPs is to reduce the pollutant loading from the urbanized areas of the upper watershed. Creation of extended detention basins with a permanent pool will realize a water quality benefit. The standing volume of water within the wet pond will be displaced by the volume of storm runoff that enters the wet pond. This displaced volume of water will be clear of sediments and will have resided in the pond long enough to remove nitrogen and phosphorus (unlike the nitrogen, phosphorus and sediment laden waters that will enter the proposed BMPs).

Potential Restoration Measures

- Geomorphic Approach

A geomorphic approach utilizing natural stability concepts is recommended for the restoration of unstable reaches along Quittapahilla Creek and its tributaries. This approach is system-oriented and works with, rather than against, the natural processes that shape and maintain stream channels. Restoration efforts are focused on: restoring a stable, self-maintaining channel form; reestablishing the critical interactions between the stream and adjacent riparian areas; restoring the natural functions of floodplains. This approach also recognizes that natural streams are composed of three distinct channels: a thalweg or low flow channel; a bankfull channel; and a floodplain, which conveys flows greater than bankfull. Finally, this approach emphasizes bio-engineered stream bank stabilization techniques that utilize natural materials (e.g., rootwads, logs, boulders, etc.) and live plantings.

- Level of Intervention

When implementing channel restoration or stabilization measures the level of intervention required is dictated by the severity of the problem. At the lowest level of intervention, restoration may involve simply eliminating the impacting activity and allowing natural recovery to proceed. For example, streams impact by livestock grazing will often recovery naturally after grazing has been eliminating by streambank fencing. At the opposite end of the intervention scale, extremely unstable conditions with a poor potential for natural recovery may require complete reconstruction of the stream channel to provide a stable channel pattern, profile, and cross-section and the utilization of bank stabilization techniques, and installation of flow diverting and grade control structures.

- Evaluation Methods

As described in the Findings Report, the Generalized Watershed Loading Function (GWLF) model with a GIS software (ArcView) interface (AVGWLF) developed by Pennsylvania State University was utilized to analyze water quality during the assessment phase of this study. The model allows for estimates of sediment and nutrient loadings derived from stream bank erosion.

As part of the assessment phase of the study estimates of sediment and nutrient loadings derived from stream bank erosion were calculated for each of the twenty one subwatersheds. It was assumed that the unstable reaches identified during the field reconnaissance and morphologic stream assessment account for 95% of the sediment and nutrient loadings derived from stream bank erosion, with the remaining 5% contributed by the stable reaches throughout all subwatersheds. This assumption formed the basis for evaluating the level of reductions in sediment and nutrient loadings that can be achieved with channel stabilization measures. The actual calculations of reductions were accomplished by determining the length of channel proposed for stabilization within given subwatershed. The percent reduction in this 95% pollutant loading was assumed to be equal to the length of restored channel as a percentage of the total length of channel within a given subwatershed.

- Proposed Restoration Measures

As noted previously, potential projects were identified from a list of subwatershed and main stem problem sites identified in Volume 1 of this report. These projects were selected for their potential for reducing loadings of sediment and other pollutants, correcting channel instability, and improving in-stream habitat problems. They include variety of project types at all levels of intervention. Low cost natural recovery type projects include stream bank fencing and livestock crossings and riparian buffer plantings. Stabilization type projects include bank grading and stabilization in urban areas, bank grading and stabilization with fencing in agricultural areas, and modifications to pond diversions. Full intervention restoration projects include stream restoration with reconstruction of channel geometry and installation of stabilization structures, dam and/or wall removal and channel restoration, channel restoration and creation of wetlands, modifications to culverts and/or bridge replacements. Some projects include unstable reaches that were identified as stormwater BMP sites. These sites present the Watershed Association with an either/or scenario. It is assumed that if the BMP is installed the restoration project would not go forward. However, if the BMP is not implemented than the channel restoration work would proceed.

Included in the project tables are recommended action items to be taken by the Watershed Association and their cooperating partners that are not reach specific projects, but critical to the overall restoration effort. Examples of these action items include working with the Royal Oaks Golf Course and Lebanon Country Club to modify riparian maintenance practices, working with the Millard Quarry to develop stormwater runoff control best management practices, and conducting feasibility studies of existing stormwater

management facilities along the main stem Quittapahilla Creek in the City of Lebanon to evaluate the potential for retrofitting or upgrading water quality management functions.

- Preliminary Cost Estimates

Preliminary cost estimates for design, permitting and construction of the storm water wetland facilities and stream restoration/stabilization projects were developed as part of this study.

Design and Permitting costs include: consultant's professional fees for surveying, base map preparation, stream assessment, wetland delineation, biological monitoring, hydrology & hydraulic analysis, final design plans, construction documents, final design report, engineer's certification, permit application and agency meetings, and all expenses.

Construction Cost includes: consultant's professional fees for geotechnical studies, construction inspection for SWM ponds, construction management for stream restoration projects, as-built surveys, and all expenses; as well as the Construction Contractor's Costs including: mobilization, clearing & grubbing, construction stakeout, sediment control and dewatering, earthwork, SWM Pond control structures, rock for and installation of in-stream structures, erosion control matting, seeding & mulching, and landscaping.

Long-Term Management Strategies

There are numerous tools available for managing and protecting Quittapahilla Creek and its tributaries from the adverse effects of human activities. In general terms, these tools can be classified as planning tools, regulatory tools, best management practices, and educational tools. In this section of the report we will be discussing the planning and regulatory tools applicable to the Quittapahilla Creek watershed.

- Planning Tools

The Comprehensive Plan currently being prepared by Lebanon County in cooperation with the City of Lebanon and the surrounding boroughs is a document that assesses the current social, economic, and environmental conditions in the region, and proposes changes to the management of growth and development in order to meet specific goals. Draft outlines of the document indicate that a major theme of the Plan is the control of suburban sprawl and a move toward sustainable development. From an environmental perspective, the Plan promotes economic opportunity while protecting and restoring the natural environment upon which the community's well-being and quality of life depends. In relation to the protection of Quittapahilla Creek and its tributaries, the final Plan should identify as minimum the following objectives:

  - Protected watersheds, wetlands, and streams resulting in reduced pollution runoff, soil erosion and flooding, and clean, high quality water to meet the domestic, economic and recreational needs of the community.

- Environmentally sensitive development, which respects natural areas and enhances the quality of the built environment.

In order to meet these objectives, the Plan should outline policies and action agendas for the future, which include:

- Policies

  - Using the information collected during this watershed assessment as a baseline, continue to monitor water quality and stream conditions to determine the effectiveness of regulations and recommend changes as needed.
  - Promote the utilization of building methods that emphasize reducing the amount of impervious surface.
  - Promote more environmentally sensitive and aesthetically pleasing stormwater management systems.
  - Educate landowners and businesses about the benefits of best management practices for stormwater protection.
  - Enforce floodplain regulations more effectively.
  - Consider the adoption of guidelines and/or regulations to manage development in environmentally sensitive areas.
  - Integrate natural areas such as streams and wetlands into the site design of development projects and ensure that these areas are protected during development.

- Action Agenda

  - Implement the urban stormwater best management practices and restoration projects identified in this restoration and management plan.
  - Promote a system of vegetative buffers along streams to filter pollutants.
  - Implement a countywide stormwater management program that incorporates best available technology for controlling the quality and quantity of stormwater runoff.
  - Review and amend, as necessary, the erosion control ordinance.
  - Develop an environmental checklist for ensuring compliance with existing regulations.
  - Consider an environmental review procedure, which includes assessing the environmental effects of development proposals.
  - Study existing environmental protection practices for effectiveness.

- Recommended Policies and Programs

The plan recommends that local policies and programs be developed to focus on: timber harvest permits and best management practices; agricultural land management plans and best management practices; conservation easements for preservation of land within the floodplain and stream corridor; land acquisition of parcels that have been identified for conversion to wetlands or stormwater management facilities; and stream/floodplain

corridor -land use covenants that establish protective covenants on new lots and parcels at the time of subdivision approval. These covenants would establish riparian buffers that include wetland and floodplain areas and require a minimum buffer width from top of stream bank.