Watershed Implementation Plan

Quittapahilla Creek Watershed

Prepared by: Quittapahilla Watershed Association
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Background of Quittapahilla Creek Watershed

The Quittapahilla Creek Watershed is located in Lebanon County, Pennsylvania. This area falls in the Susquehanna River Basin in the Great Ridge and Valley physiographic region. On average, this area receives about 120 cm of precipitation annually in the form of rain and snow. Average temperatures range from about -3 to 0 degrees C in winter to between 20-22 degrees C in summer.

The main body of water is the Quittapahilla Creek, flowing east to west with seven named tributaries, including Brandywine Creek, which flows from North to South, Snitz Creek, Beck Creek, Bachman Run, Killinger Creek, Ginrich Run and Buckholder Run all of which flow south to north. The Quittapahilla Creek and its tributaries are shown in Figure 1. The Quittapahilla Creek flows into the Swatara Creek and then to the Susquehanna River. The Susquehanna River empties in the Chesapeake Bay and is the Bay's greatest contributor of freshwater. Therefore, the area of impact for this watershed extends not only through parts of Pennsylvania, but also through parts of Maryland and Virginia as well.

The limestone type soil is nutrient rich and has supported a long agrarian heritage. Land use in this area is predominantly agricultural (~ 68%). Other areas are considered either developed (~13%) or declared open space such as forested or water bodies. Open space accounts for approximately 19% of the land. State Game lands account for much of the forested space and is dominated by deciduous trees and some coniferous and mixed species.

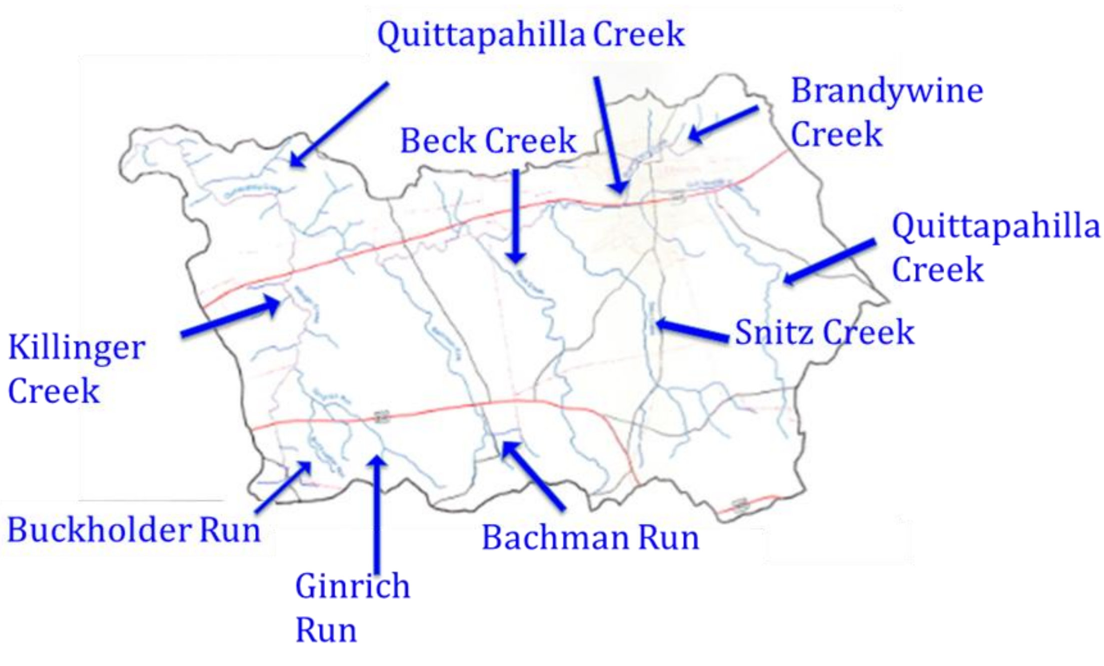

Figure 1. Map of the Quittapahilla Creek Watershed including the Quittapahilla Creek and named tributaries. (Adapted from: Powell, 2006).

Historic and Current Impairments

Originally, this area was inhabited by Native Americans. The word Quittapahilla is a Native American word meaning snake-harboring or eel-bearing. European settlers started to colonize this area in the early 1700's and acquired the land from Native Americans in 1732. After colonization, land use included grist and saw mills, logging, quarries and agriculture that directly affected the Quittapahilla Creek in the form of channel alterations and water quality impairments. In the 1700s and 1800s over 50 gristmills were present along the Quittapahilla Creek and several saw mills along the tributaries. Dams, used to construct millponds, were built for both the grist and saw mills. While the dams have been removed, some of the mill sites still remain adding to aggradation and creating barriers to fish movement.

Severe flooding in the 1800s led to the construction of the Hazel Dike in 1889 to protect the city of Lebanon from flood events. Hazel Dike converted much of the Upper Quittapahilla Creek to concrete flumes. Hurricane Agnes in 1972 spawned construction of more channel alterations in the form of concrete flumes and piping.

Irrigation for farmlands also added to channel alterations. Currently, the Quittapahilla Creek and its tributaries have all experienced channel alterations from about 17% at Killinger Creek to about 66% at Brandywine Creek. The main stem Quittapahilla has experienced approximately 20% alteration in its historic stream flow.

Historic land use patterns have influenced current land use in this watershed. As mentioned earlier, abandoned mills and dams are a source of impairment and restrict fish movement. Urban and storm water runoff and also the increase of impervious surfaces due to development are also a great concern. Urban and storm water runoff are regulated by the Federal Clean Water Act and the Pennsylvania Clean Streams law which requires permits for pollutant limits, monitoring, and reporting for wastewater discharges.

However, the activity that has had the most severe impact is nonpoint source pollution due to agriculture. Unrestricted livestock grazing along the tributaries has resulted in trampling of banks and vegetation leading to widening of channels via erosion. The focus of this plan is on the increase of sedimentation and nutrients, specifically nitrogen and phosphorus, and agricultural management strategies to restore water quality in the Quittapahilla Creek Watershed.

Early investigations by the PADEP and PA Fish Commission throughout the 1970's and 1980's reported that the waters were unable to support aquatic life, and stocking of trout was ceased. A Fish Commission report went so far as to call the Quittapahilla an "open sewer". After the Clean Water Act, regulations helped to improve conditions so that stocking could begin again in the late 1980s. The Clean Water Act of 1972 regulates pollutant discharges and water quality standards for the United States. Section 303(d) of the Clean Water Act states that impaired waters must be listed and that states, territories or tribes must set water quality standards based on the water's designated use (for example recreation or public drinking). The designated use of waters in the Quittapahilla Watershed is for aquatic life. Section 303(d) also requires that Total Maximum Daily Loads or TMDLs must be calculated for each impaired water body. Total Maximum Daily Loads is a "calculation of the maximum amount of a specific pollutant that a waterbody can receive and be able to meet water quality standards".

The Quittapahilla and its tributaries were listed as impaired waterbodies on both the 1996 and 1998 303(d) lists and also in the Pennsylvania Department of Environmental Protection's 305(b) report to Congress in 2000.

In 2000, the PADEP conducted an assessment of the Quittapahilla Creek watershed and found that out of 143 km of stream, only 2% or about 3 km were considered to be unimpaired waterways. And about 80% of those impaired streams were found to be affected by agriculture. Descriptions of impairments for each sub-watershed are described in depth in "Volume 2—Restoration and Management Plan" (Powell, 2006, p. 71-103 hardcopy, p. 81-116, electronic copy).

Total Maximum Daily Loads

The Quittapahilla Creek watershed as described in the TMDL Report as noted in the PA DEP report dated November 9, 2000 includes 8 sub-watersheds. However, the watershed was divided into 21 sub-watersheds for analysis in the Quittapahilla Creek Watershed Assessment dated September 2006 prepared by Clear Creeks Consulting and Skelly and Loy. The watersheds were subdivided in the later study to further refine the sources of impairments and update the load predictions based on newer landuse information. This updated model was then calibrated based on sampling data as described in "Volume 2—Restoration and Management Plan" (Powell, 2006)

The Figure 2 below is included to illustrate the comparison of the sub-watershed layout shown in both reports. Numbers 1 through 8 (black) represent the watersheds shown in the DEP TMDL Report; numbers 1 through 21 (red) illustrate the watersheds used for the Watershed Assessment. Table 1 summarizes the subwatershed comparisons.

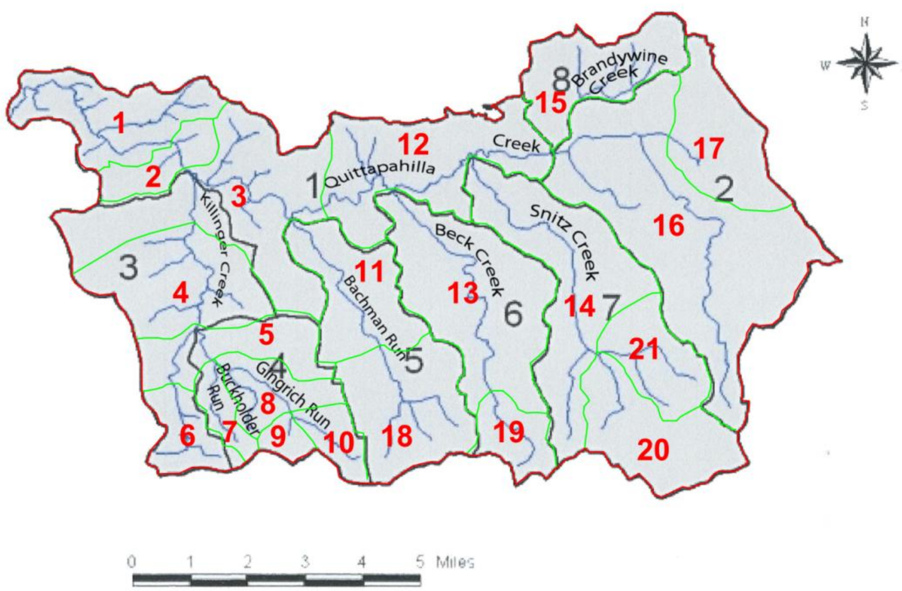

Figure 2. Comparison of subwatershed breakdown in PA DEP TMDL Report (2000) and Quittapahilla Watershed Assessment (2006)

Table 1. Comparison and breakdown of the watershed from each report

	Quittapahilla Creek TMDL Analysis report	**Quittapahilla Creek Watershed Assessment**
Watershed Name	**Watershed Number**	**Watershed Number**
Quittapahilla Creek Main Stem	1, 2 and 8	1, 2, 12 ,15, 16, 17 and 3[1]
Killinger Creek	3 and 4	3 and 4 through 10[2]
Bachman Run	5	11 and 18
Beck Creek	6	13 and 19
Snitz Creek	7	14,20 and 21

[1]Area includes 30% of sub-watershed Number 3
[2]Area includes 70% of sub-watershed Number 3

Watershed Modeling of Total Maximum Daily Loads

The method used to determine TMDL endpoints was the Reference Watershed Approach. In this approach two watersheds are compared; one that meets water quality standards and one that is considered impaired after completion of the biological assessment. Both watersheds must share similar characteristics such as land use, land cover, size, and geomorphology. The goal is to use the loading rates in the unimpaired streams as objectives for loadings in the impaired watershed. The 2000 DEP report uses the Conococheague Creek and Falling Branch tributaries as the reference watershed. The Conococheague watershed is located in Franklin County, southwest of the Quittapahilla Creek Watershed. The DEP determined that they would focus on 2 specific pollutants; sediment loadings in main stem Quittapahilla Creek and phosphorus loadings in the seven tributaries. Although nitrogen was also shown to be above optimum levels, phosphorus was determined to be the limiting nutrient in this region.

TMDLs were developed using the Generalized Watershed Loading Function or GWLF model. Given “variable-size source areas” such as forested, agricultural, or developed land, the GWLF model can simulate loadings of runoff, sediment, and nutrients. The GWLF model uses daily weather data and calculations of water balance. Monthly sediment and nutrient loadings can then be calculated.

Several inputs and measurements are needed for the GWLF model including daily temperature and precipitation values. These and other necessary values were calculated using the GIS software ArcView. The combined model is referred to as the AVGWLF model—the ArcView Version Generalized Loading Function model.

The AVGWLF model was used to calculate the sediment loadings for the Quittapahilla and Conococheague Creeks. It also calculated phosphorus loadings for the Falling Branch tributaries. The calculated loadings for phosphorus in the Conococheague Creek watershed in pounds per acre per year (lbs/ac/yr) are multiplied by the total acres of each sub watershed to get the TMDL value. For example, to calculate phosphorus loadings for the Bachman Creek sub-watershed we take the unit area loading rate in the reference watershed and multiply that by the total number of acres in the Bachman Run sub-watershed to determine the TMDL value.

Loading Targets and Reductions

The PADEP 2000 report states that significant sedimentation and nutrient levels are due to agricultural activities. According to the DEP 2000 report, Total Maximum Daily Load (TMDL) requirements that would meet water quality objectives for the Quittapahilla Creek basin are 9,833,734 lbs/yr for sediment loading and 2,912 lbs/yr (Bachman Run), 3,067 lbs/yr (Beck Creek), 5,055 lbs/yr (Killinger Creek) and 4,068 lbs/yr (Snitz Creek) for phosphorus loadings (Figures 3 - 4 & Table 2).

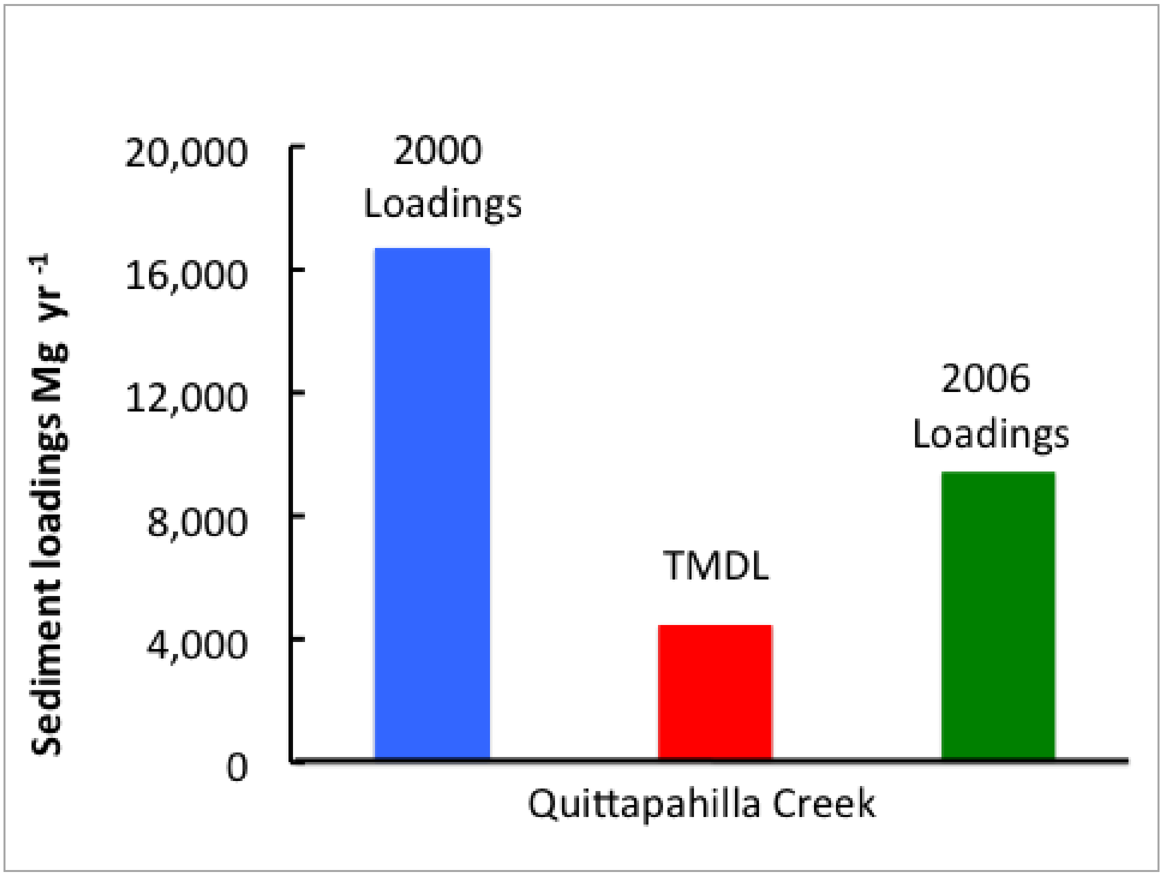

Figure 3. Sediment loadings in the Quittapahilla Creek Watershed in 2000 (PA DEP TMDL Study), 2006 (Watershed Assessment), and TMDL goal for sediment.

Clear Creeks Consulting (2006) has provided more current measurements for phosphorus and sediment loads. As of 2006, sediment loads were measured at 20,800,647 lbs/yr for the Quittapahilla Creek. Phosphorous loadings were found to have been 2,048 lbs/yr, 2,106 lbs/yr, 5,893 lbs/yr and 7986 lbs/yr respectively for Bachman Run, Beck Creek, Killinger Creek and Snitz Creek (Figures 3 - 4 & Table 2).

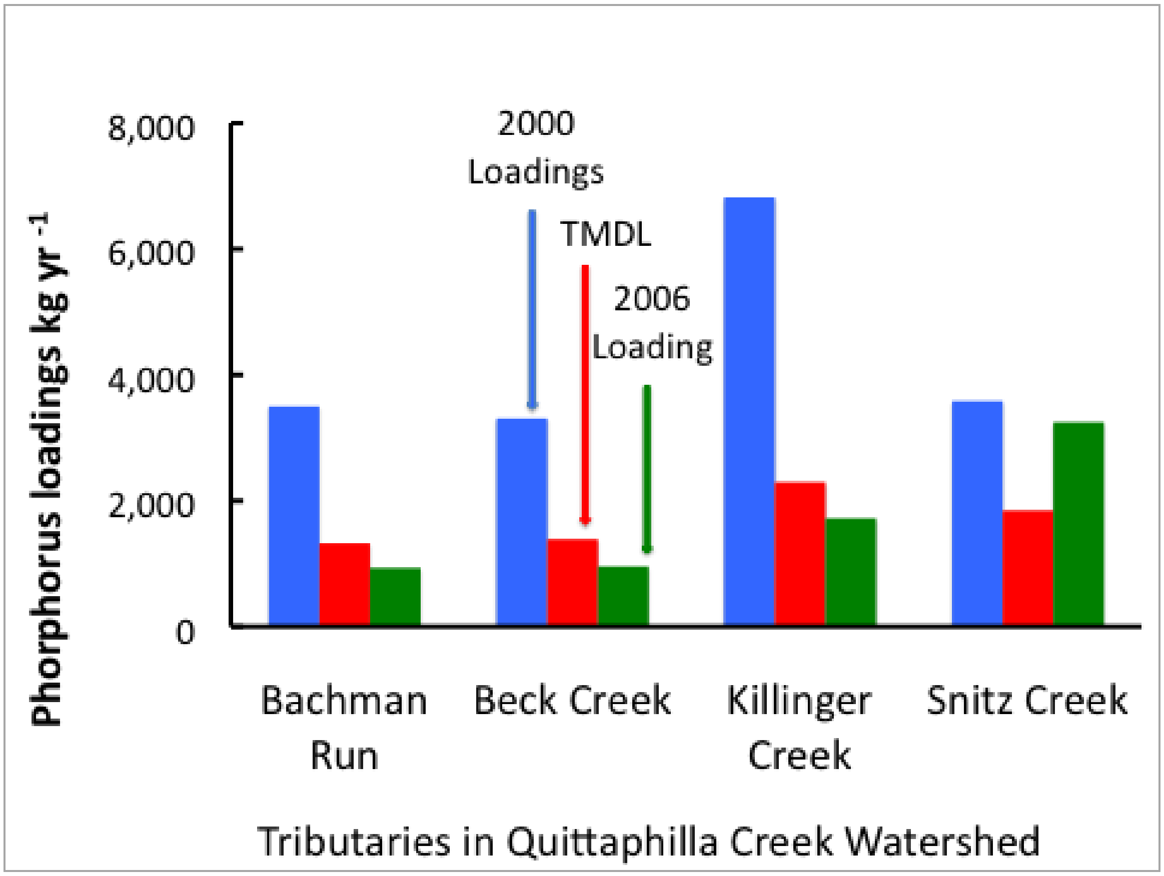

Figure 4. Phosphorus loadings in tributaries in Quittapahilla Creek Watershed in 2000 (PA DEP TMDL Study), 2006 (Watershed Assessment), and TMDL goal for phosphorus.

The sub-watershed breakdown (outlined in green on Figure 1 above) in the Watershed Assessment was used for modeling the estimated sediment and nutrient loading as well as estimating the effectiveness of the BMPs used to reduce these pollutants. Similarly, the eight watersheds outlined in black were developed in the TMDL Analysis to identify the sediment and nutrient loading within the watershed and establish the water quality objectives.

The water quality objectives for the Quittapahilla Watershed are listed in column H in Table 2 below. The tabulation also lists the TMDL loads which would result following implementation of the agricultural, urban, and stream stabilization/restoration BMPs identified in the Watershed Assessment in column G. These BMPs are further described in the following sections of this plan.

The estimated pollutant loadings in all sub-watersheds and the main stem would be reduced to levels lower that the values listed as goals in the analysis report if the proposed BMPs are implemented. Sediment in the Quittapahilla Creek would be reduced by approximately 36 per cent. Phosphorus would be reduced by approximately 62 per cent, 63per cent, 57 per cent and 67 percent respectively in Killinger Creek, Bachman Run, Beck Creek and Snitz Creek.

The DEP TMDL referenced above were developed using integrated version of the ArcView Version of the Generalized Watershed Loading Function (AVGWLF). The Generalized Watershed Function allows the simulation of runoff, sediment and nutrient loadings from agricultural, forested and developed land. The Water-shed Assessment dated 2006 applied AVGWLF to identify the water quality aspects for the study and then used PRedICT (The Pollution Reduction Impact comparison Tool) to identify agricultural BMPs and predict their effectiveness. This 2006 modeling was completed by Dr. Barry Evans of Pennsylvania State University.

As indicated on the map above, differences between the DEP Report and the Assessment Report are that the eight watersheds were used versus 21 watersheds in the Assessment and updated and calibrated landuse data was used. It should be noted that DEP has no plans to update the AGWLF Model for the Quittapahilla Creek Watershed. Therefore, modeling completed in the Watershed Assessment is considered the most up-to-date.

As shown in Table 2 below, applying the BMPs noted in the Assessment will result in improvements in the watershed to the extent that the goals set forth in the TMDL Report will be met.

Table 2. Water Quality Objectives Versus Reduction in Total Maximum Daily Loading

				A	B	C	D	E	(F)	(G)	H
		Quittapahilla Creek TMDL Analysis	**Quittapahilla Creek Watershed Assessment**	**DEP Estimated Loading**	**Watershed Assessment Estimated Loading**	**Load Reduction By Ag. BMPs**	**Load Reduction By Urban BMPs**	**Load Reduction By Stream BMPs**	**Estimated DEP Report Load Reduced by BMPs**	**Estimated TMDL Assessment Report Load Reduction by BMPs**	**TMDL Values For Water Quality Objectives**
Watershed Name	**Pollutant**	**Watershed Number**	**Watershed Number [2]**	**lbs\yr**	**lbs\yr**	**lbs\yr**	**lbs\yr**	**lbs\yr**	**lbs\yr**	**lbs\yr**	**lbs\yr**
Quittapahilla Creek Main Stem	Sediment	1, 2 and 8	1, 2, 12 ,15, 16, 17 and 3	36,740,900	20,800,647	11,934,099	1,546,902	1,041,586	22,218,313	6,278,060	9,833,734
Killinger Creek	Phosphorous	3 and 4	3 and 4 through 10	15,028	5,893	3,968	N/A	[1]6	11,054	1,919	5,055
Bachman Run	Phosphorous	5	11 and 18	7,724	2,048	984	N/A	2	6,738	1,062	2,912
Beck Creek	Phosphorous	6	13 and 19	7,302	2,106	801	N/A	1	6,500	1,304	3,067
Snitz Creek	Phosphorous	7	14,20 and 21	7,903	7,986	6,460	N/A	3	1,440	1,523	4,608

The following summarizes the derivation of the values shown in Table 2:

- Column A: The values are from the DEP TMDL document from 2000.
- Column B: These values are the current loading found in Volume 2 of the Watershed Assessment on Table 3.4.
- Column C: These values represent the reduction of loads associated with the implementation of the BMPs associated with agricultural activities. Note that these values are based on the loading predicted in the Watershed Assessment and not the DEP TMDL report.
- Column D: These values represent the reduction of the sediment load resulting from the implementation of the urban BMPs. Note that these values are based on the loading predicted in the Watershed Assessment and not the DEP TMDL report.
- Column E: Implementation of the stream BMPs would reduce the loading values associated with stream bank erosion. Note that these values are based on the loading predicted in the Watershed Assessment and not the DEP TMDL report.
- Column F: Values in this column are the predicted loading following the implementation of all BMPs and are derived based upon the following equation; F= A-C-D-E. Note this column presents a comparison of the loading values predicted in the DEP TMDL report and the BMP reductions predicted in the Watershed Assessment. Therefore, it is not considered a valid comparison.
- Column G: Values in this column are the predicted loading following the implementation of all BMPs and are derived based upon the following equation; G= B-C-D-E. Note that this column presents a comparison of the loadings and BMP reductions predicted in the Watershed Assessment. Therefore, it is considered a valid comparison.
- Column H: The values represent loading goal established in the TMDL Report.

Existing and Future BMPs

In 1997 a group of concerned citizens formed the Quittapahilla Watershed Association or QWA. Their mission is to improve the "water quality of the watershed" and make the "community aware of the watershed's importance." Since their conception, they have worked with businesses, community officials, landowners, state and federal agencies, and conservationists to achieve their goal. In 2001, with funding from a DEP Growing Greener Grant, the QWA was able to hire a private consulting firm, Clear Creek Consulting to conduct a thorough watershed assessment (Powell, 2006, Volume 1) and provide recommendations for restoration and management (Volume 2). The second volume also prioritized areas of the sub-watersheds so the QWA could focus their efforts and their limited funding on these areas. From 2001 – 2006 the QWA had already begun implementing some BMPs throughout the watershed, working specifically to address agricultural activities. Figures 5 and 6 illustrate the Best Management Practices implemented by the QWA prior to 2006, as described by Powell (2006). Figure 5 depicts the BMPs most used by the QWA, but other BMPs have been implemented such as livestock crossings.

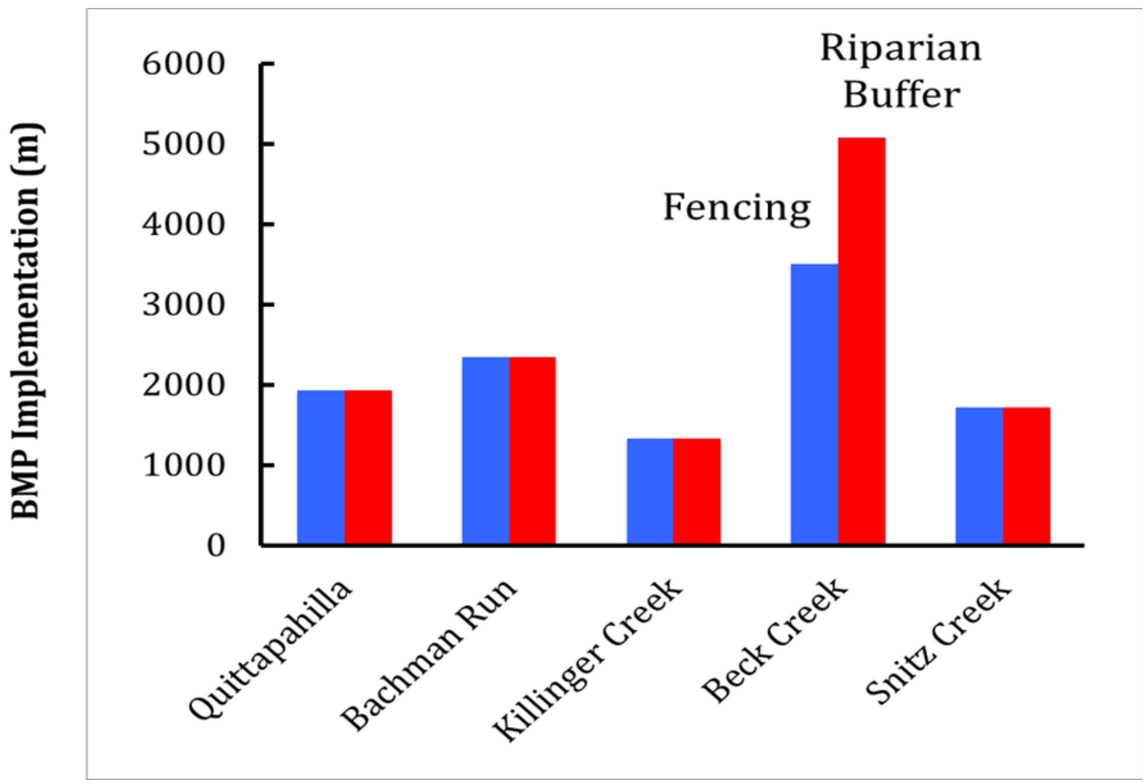

Figure 5. Amount (m) of riparian buffer and streambank fencing implemented by the QWA in the Quittapahilla Watershed between 2000 and 2006.

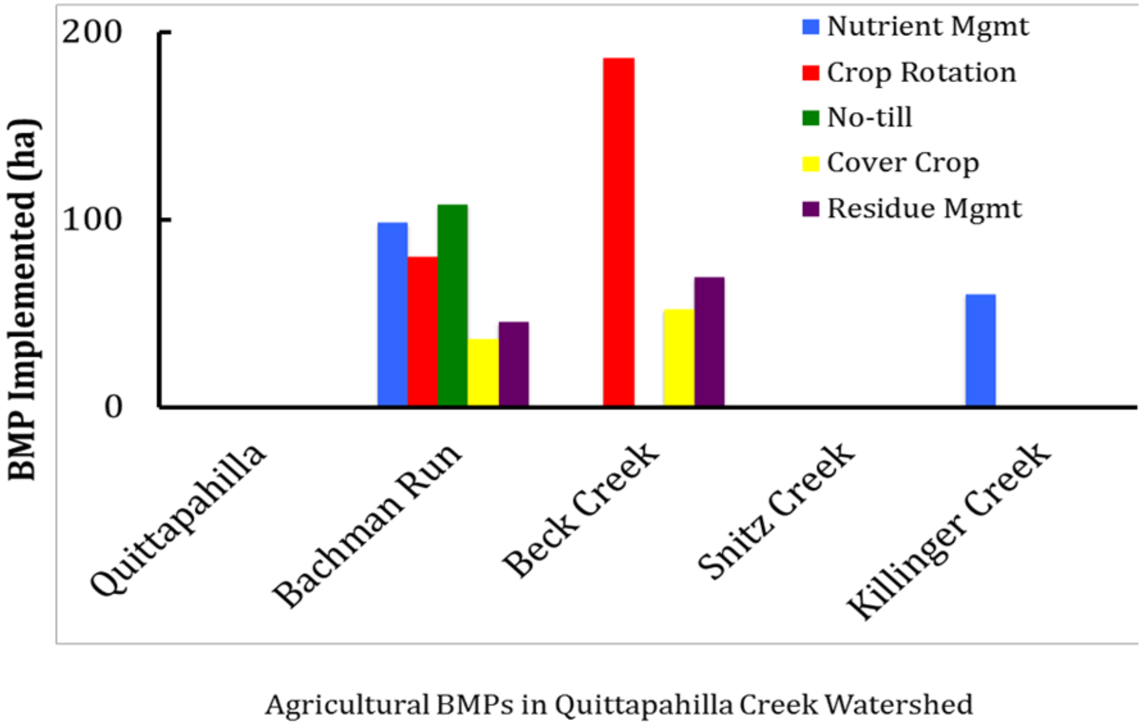

Figure 6. Graph of agricultural BMP implementation (ha) by QWA through 2006.

Volume 2 of the Quittapahilla Creek Watershed Assessment (Powell, 2006) describes future recommended BMP implementation and restoration projects. The recommended BMPs and restoration projects are generally separated into agricultural, urban, and stream stabilization/restoration BMPs. The following sections briefly describe each. Volume 2 of the Quittapahilla Creek Watershed Assessment (Powell, 2006) provides details for specific projects.

Agricultural BMPs

Agriculture contributes the majority of sediment and nutrient pollution to the Quittapahilla Watershed. Therefore, identify agricultural BMPs that could reduce these pollutants is considered critical to the implementation of this plan. The following section describes how agricultural BMPs were evaluated and selected for this plan.

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.

The tool includes pollutant reduction coefficients for nitrogen, phosphorus and sediment, and also has built-in cost information for an assortment of pollution mitigation techniques. A rather simple cost-accounting approach is used to estimate load reductions and their associated costs. The user initially specifies desired conditions such as the number of acres of agricultural BMPs to be used, the number of septic systems to be converted to centralized wastewater treatment, miles of riparian buffers, percentage of urban areas to be treated by wetlands and detention basins, etc. Based on this information, built-in reduction coefficients and unit costs are utilized to calculate resultant nutrient and sediment load reductions and scenario costs.

Although options exist for the analysis of various pollution mitigation strategies in PRedICT, for the purposes of this study only selected agricultural BMPs were evaluated using this methodology. Other mitigation strategies such as urban BMPs and stream stabilization activities were evaluated using other methods.

Agricultural BMP Options in PRedICT

Within PRedICT, BMP systems rather than individual BMPs are more often used as the basis for agricultural load reductions. This is because, as recognized by the Chesapeake Bay Program, BMPs are typically used in combination rather than individually to mitigate on-farm loss of soil and nutrients. Following this usage, the Pennsylvania Department of Environmental Protection has developed a guidance document that describes the different BMP systems that are recognized and eligible for funding through the State Conservation Commission (PaDEP, 2000) to mitigate water quality problems in agricultural areas. While not necessarily identical, the BMP systems used in PRedICT are based on the more generic and widely-used BMPs described in the latter document. Moreover, in the current version of PRedICT, BMP usage and descriptions were revised to more closely follow comparable mitigation strategies used within the Chesapeake Bay Model (USEPA, 1995). The agricultural BMP options used in the current version of PRedICT are given in Table 3

Pollutant Reduction Efficiencies

While hundreds of studies have been completed over the past 25 years on the efficiencies of BMPs for reducing various pollutants (primarily sediment and nutrients), most of these studies have focused on the more frequently-used BMPs. Additionally, standard terminology and procedures in describing the BMPs and the reductions achieved have not been uniformly applied.

Within PRedICT, information on pollutant reduction efficiencies have been drawn primarily from four different sources, including Dillaha, Yagow and Pease (2000), Ritter and Shirmohammadi (2001), Susquehanna River Basin Commission (1998), and U.S. EPA (1990). The first and fourth documents are exhaustive literature reviews of the results of hundreds of BMP efficiency studies conducted across the country over the last 25 years. In both documents, synopses of reduction efficiencies are reported for about two dozen BMPs, which sometimes overlap in terms of terminology and procedures, and sometimes do not. The Susquehanna River Basin Commission document reports the results of a study evaluating pollutant mitigation strategies in the Susquehanna River Basin and the associated potential nutrient reduction. The results are based on the use of non-point source-related reduction efficiency values utilized in the EPA's Chesapeake Bay watershed model (U.S. EPA, 1995). Finally, Ritter and Shirmohammadi (2001) is a recently released textbook that, among other things, presents the results of a number of recent BMP studies completed by various researchers around the country.

Table 3 - Agricultural BMP options used in *PRedICT*

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	

Composite pollutant reduction values for the generic BMP options used in *PRedICT* are presented in Table 4. These values essentially reflect the average values for the individual BMPs that comprise each BMP option. As can be seen in the table, efficiency values are provided for nitrogen, phosphorus, and sediment. Due to the nature of the studies used in deriving the individual BMP values (i.e., they were primarily "runoff plot" studies), the efficiency values shown are only used to estimate reductions in surface runoff loads. This is very important with respect to evaluating reductions in nitrogen loads since, at the watershed level, much of the non-point source load can be contributed via the sub-surface movement of nitrates in agricultural areas. In addition to surface runoff-based load reductions, adjustments to loads are also made within *PRedICT* to groundwater contributions based on the particular BMP option utilized.

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).

Within PRedICT, only the costs associated with initial BMP implementation and construction are considered; long-term operational and maintenance costs are not included. These costs are shown in Table 5. In calculating the cost for any given BMP system, the separate costs for each individual BMP are calculated and subsequently summed according to the set of individual BMPs comprising each system.

Table 4 - Estimated BMP reduction efficiencies (%) by pollutant type. Notes on Table Usage:

BMP SYSTEM/TYPE	Nitrogen	Phosphorus	Sediment
BMP 1	25	36	35
BMP 2	50	38	64
BMP 3	23	40	41
BMP 4	95	94	92
BMP 5	97	92	98
BMP 6	70	28	-
BMP 7	43	34	13
BMP 8	44	42	71

- Values represent estimated reductions in surface runoff-associated loads only.
- Values represent percent reductions. For example, 36% of the surface P load can be reduced by implementing BMP 1.
- No value is reported for sediment for BMP 6 since this BMP (nutrient management) is typically not used for sediment reduction.
- The reduction values given for BMP 6 assume a “balanced” approach to reducing N and P loads. Otherwise, a value of 75 is recommended if the reduction of either pollutant is addressed at the expense of the other in the nutrient management plan. It is rare that a value of 75 would be used to reduce both nutrients at the same time.

Table 5 - Costs by Best Management Practice type.

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

Potential Agricultural BMP Implementation within the Quittapahilla Watershed

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.

As described in the Findings Report, a number of mitigation measures have already been implemented in various sub-watersheds of the Quittapahilla Creek watershed. In these cases, simulations were performed under the assumption that BMPs will be implemented in the remaining “untreated” agricultural areas. In the other sub-watersheds, simulations were done under the assumption of “full” BMP implementation in agricultural areas.

The results of the BMP scenario evaluations made using *PRedICT* are shown in Table 6. As can be seen from this table, total reductions of 45%, 64%, and 57% were estimated for nitrogen, phosphorus, and sediment, respectively, if BMPs were implemented in the remaining agricultural areas. These reductions, of course, are only estimates since actual reductions would depend on the actual suite of BMPs implemented, how well they were installed, and the degree to which they are maintained after installation. However, it does provide some insight into the types of load reductions that might be possible with this type of mitigation measure.

Table 6 – Nutrient and sediment load reductions based on potential agricultural BMP implementation.

Shed No.	Area (ac)	N (current)	N (max BMPs)	N Reduction	% N Red	P (current)	P (max BMPs)	P Reduction	% P red	S (current)	S (max BMPs)	S Reduction	% S red	Cost
1	2495	23333	19217	4117	0.18	900	437	463	0.51	843413	385458	457954	0.54	$369,635
2	857	12458	10081	2377	0.19	452	135	318	0.70	465255	134287	330968	0.71	$146,042
3	4419	235776	61691	174085	0.74	6787	1360	5427	0.80	3143889	1363819	1780070	0.57	$670,024
4	2628	49233	42713	6520	0.13	1292	591	701	0.54	1274490	460479	814011	0.64	$498,860
5	1635	39066	30570	8496	0.22	1100	397	703	0.64	1187613	246060	941553	0.79	$347,631
6	968	41064	6478	34585	0.84	481	123	357	0.74	332735	162504	170230	0.51	$99,017
7	529	5746	4304	1442	0.25	223	84	139	0.62	211680	51507	160173	0.76	$87,731
8	1109	20167	16202	3965	0.20	556	216	340	0.61	629087	143927	485160	0.77	$206,568
9	299	820	558	262	0.32	62	33	29	0.46	85995	23424	62571	0.73	$6,032
10	598	4106	3409	697	0.17	143	73	71	0.49	187866	53698	134168	0.71	$33,896
11	2285	45994	42210	3784	0.08	981	587	395	0.40	744188	457641	286546	0.39	$468,590
12	3767	57204	49090	8114	0.14	1762	811	950	0.54	1844483	827936	1016547	0.55	$584,381
13	4298	102515	93576	8939	0.09	1960	1200	761	0.39	1122786	708874	413912	0.37	$911,830
14	4080	275733	49943	225790	0.82	6681	836	5845	0.87	1613840	799235	814604	0.50	$547,810
15	2213	40431	12979	27452	0.68	750	291	459	0.61	592263	374114	218149	0.37	$242,703
16	7291	120660	106067	14593	0.12	3925	2516	1409	0.36	3293829	1607178	1686651	0.51	$915,585
17	2225	33381	28537	4844	0.15	878	390	487	0.56	714641	205621	509020	0.71	$303,281
18	2650	42243	35560	6683	0.16	1067	478	589	0.55	1113084	337771	775313	0.70	$421,059
19	906	4284	3914	370	0.09	146	106	40	0.27	91287	48144	43143	0.47	$60,467
20	2302	9704	8586	1118	0.12	476	329	148	0.31	466358	256109	210249	0.45	$62,104
21	1526	37143	33364	3779	0.10	829	362	467	0.56	841869	218762	623107	0.74	$256,376
Totals	49081	1201064	659050	542013	0.45	31450	11354	20096	0.64	20800647	8866548	11934099	0.57	$7,238,622

Notes:

"Shed No." = sub-watershed number, "ac" = acres, "N" = nitrogen, "P" = phosphorus, "S" = sediment, "current" = existing load, "max BMPs" = load based on maximum agricultural BMP implementation

All loads are in pounds per year

Prioritization of Agricultural Best Management Practices

As Table 4 shows 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.

Table 6 indicates that 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 with reductions in nitrogen and phosphorus loadings of 84% and 74%, 82% and 87%, 74% and 80%, and 68% and 61%, respectively.

Table 6 indicates that 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 with reductions in sediment loadings of 79%, 77%, 76%, 74%, 73%, 71%, 71%, 71%, 70%, and 64%, respectively.

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.

Urban BMPs

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. It should be noted that the BMP's recommended in this study are intended to address existing stormwater runoff conditions. Runoff from future development should be controlled with management strategies required as part of the land development review process. 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 7 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.

Table 7 Comparison of Post-Construction Best Management Practices (Source: USEPA, Office of Water Website)

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

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:

- Reproduce Predevelopment Hydrologic Conditions

The historical concern in stormwater management has been to reduce the frequency and severity of downstream floods and stream channel erosion caused by runoff. In most areas, this goal is achieved by controlling the peak discharge computed for a specific design storm to predevelopment levels. BMPs designed to control small to intermediate storm events can be effective at reducing stream channel erosion.

- Provide Moderate Pollutant Removal Capability

In recent years, BMP designs have been developed to enhance pollutant removal during storms, and thereby improve the quality of stormwater runoff delivered to the receiving waters. BMPs differ markedly in the pollutant removal mechanisms they employ, and consequently, their performance in removing different pollutants can vary significantly. However, removal rates can be enhanced by increasing the volume of runoff effectively treated by the BMP, or by adding extra design features. Another important consideration in selecting the appropriate BMPs is which urban pollutants are to be targeted for removal in the watershed.

- Constraints

Many BMPs are constructed on sites for which they are not suitable. As a consequence, some BMPs experience chronic maintenance problems or nuisance conditions, and in extreme cases, may no longer function as designed. To prevent these sorts of problems from occurring, it is important to understand the physical restrictions associated with each type of BMP. In addition, field tests should be conducted to verify the physical conditions of a proposed BMP site.

- Cost-Effectiveness

The construction costs for different BMP options can vary substantially, even on similar sites. This is due to inherent differences in the methods and materials used for BMPs, as well as certain economies-of-scale. Since the cost of BMPs that are implemented by municipalities are eventually passed on to the public, cost-minimization should be a priority. This can be achieved by identifying the BMPs that meet your watershed restoration and management goals for the lowest initial cost and lowest long-term maintenance costs.

- Acceptable Future Maintenance Burden

BMPs can only continue to be effective if they are regularly inspected and maintained. Maintenance tasks for most BMPs include both low cost routine tasks and more expensive non-routine tasks, such as rehabilitation or sediment removal. Maintenance costs for BMPs can be significant. Over a twenty-year period they will often equal or exceed the initial construction cost. The cost and responsibility for maintenance is passed on to the public.

Consequently, it is critical to vest responsibility for maintenance: how and when tasks will be performed, how it is to be financed, and who will inspect the BMP. In most cases, the maintenance burden of a BMP is determined by the initial design and construction of the facility. If maintenance requirements are addressed during the design and construction phases, both the scope and cost of future maintenance activities can be sharply reduced.

- Neutral Impact on the Environment

Urban BMPs nearly always represent a significant modification to both the natural environment and the adjacent community. As such, BMPs can either enhance or degrade the amenity values that both provide. Comparatively small investments in design, landscaping, and maintenance can make a BMP an attractive feature of a community, or at least an unobtrusive one. Without such efforts, many BMPs appear unsightly or discordant, provide no habitat or recreational opportunities, and are plagued by nuisance problems. The importance of enhancing the amenity values of a BMP cannot be overemphasized, as community perceptions about a BMP are generally formed by the amenities they do or do not provide. These perceptions, in turn, strongly influence their acceptance of and support for these BMPs, which is critical if the community is expected to pay for maintenance.

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 were conceptually designed using GIS topography with the goal of achieving maximum amount of attenuation volume based upon the physical characteristics of the sites. Elevation-Storage tables were constructed to analyze the storage capacity for each of the proposed BMPs. Existing sub-watersheds were analyzed with the USGS National Flood Frequency Program to obtain target peak discharges consistent with rural peak discharges for the one- and two-year storm events. Elevation-Discharge tables were then constructed from values obtained for the target peak discharges for the one- and two-year storm.

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.

Urbanized versus Pre-Urbanized Condition

To estimate the improvements which would be realized from the extended wet detention pond BMPs, three conditions must be modeled: pre-urbanization; unimproved post-urbanization; and, improved post-urbanization.

Soil mapping and land use mapping post-date the establishment of the City of Lebanon. Therefore, these parameters are unavailable for the estimation of pre-urbanization conditions with the HEC-HMS watershed model. To estimate the pre-urbanization conditions, the runoff curve number for three specific watersheds was lowered to simulate an undeveloped condition as summarized in Table 3.6.

Table 8 - Runoff Curve Numbers developed for three specific watersheds to simulate undeveloped conditions

SUBWATERSHED (HEC-HMS MODEL)	CALIBRATED CN (URBANIZED CONDITION)	CN USED FOR ESTIMATING THE PRE-URBANIZED CONDITION
Brandywine	74	64
Lebanon	81	64
Mid-Quitty	64	60

The HEC-HMS model was then run using the pre-urbanization parameters to establish a baseline for studying the effects of the proposed BMPs on the bankfull discharge. A graphical comparison of the calibrated urbanized and pre-urbanized hydrologic models is represented in Figure 7.

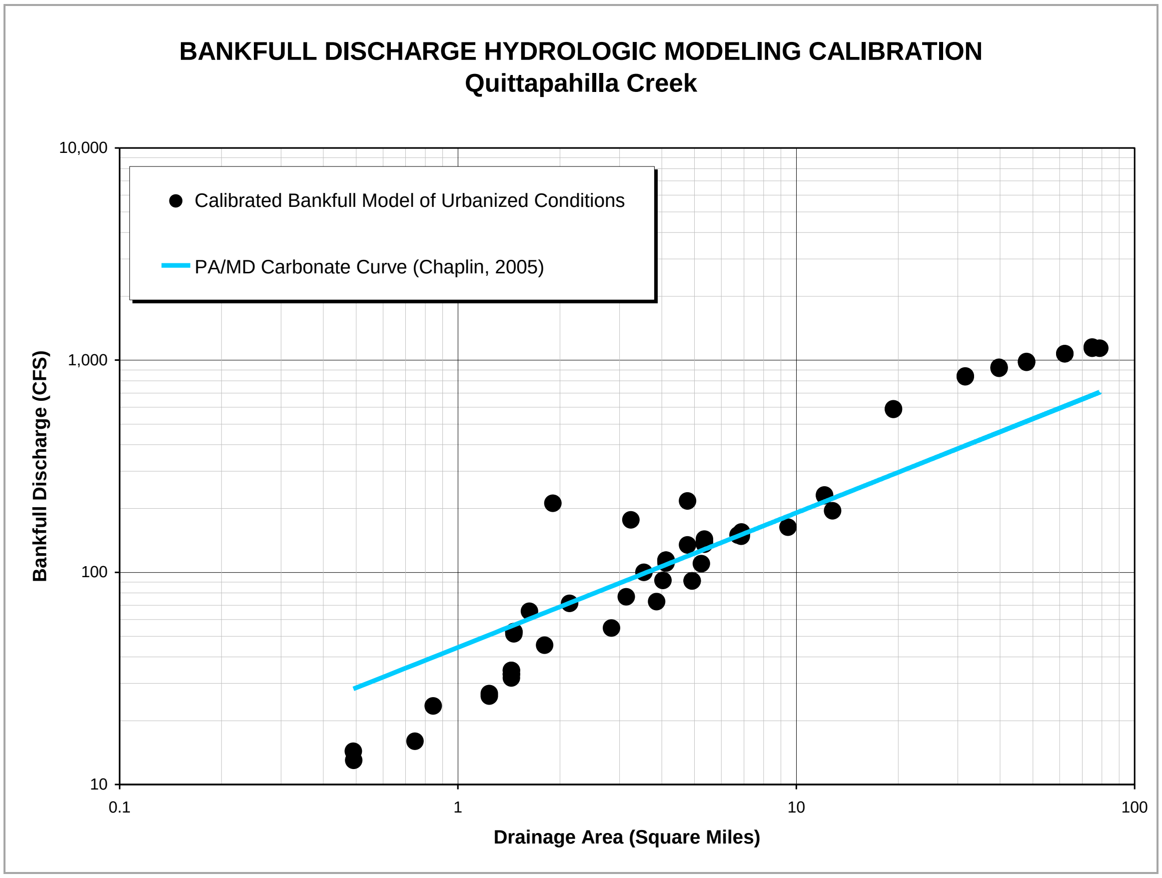

Figure 7 - Comparison of modeled bankfull discharges in the urbanized and pre-urbanized conditions. The model has been calibrated to the PA/MD carbonate geology regional curve.

Impact of BMPs on the Bankfull Discharge

As noted, a major objective for implementing the extended wet detention pond BMPs within the greater Lebanon area is to counteract increases in the bankfull discharge that have resulted from urbanization. Ideally, the implementation of the BMPs would reduce the bankfull discharge down to pre-urbanization levels. As seen in Figure 8, the BMPs would be successful at reducing the bankfull discharges by approximately 20 to 30% along the main stem of Quittapahilla Creek.

Verification of No Hydrograph Interference

In addition to analyzing the beneficial hydrologic impacts of the proposed BMPs on the bankfull discharge, the effects of the BMPs on the 100-year discharges was studied to verify that BMPs would not create hydrograph interference. All reaches and junctions within the HEC-HMS model were analyzed, and it was found the proposed improvements will not create any increases in the 100-year discharge within the Quittapahilla Creek watershed.

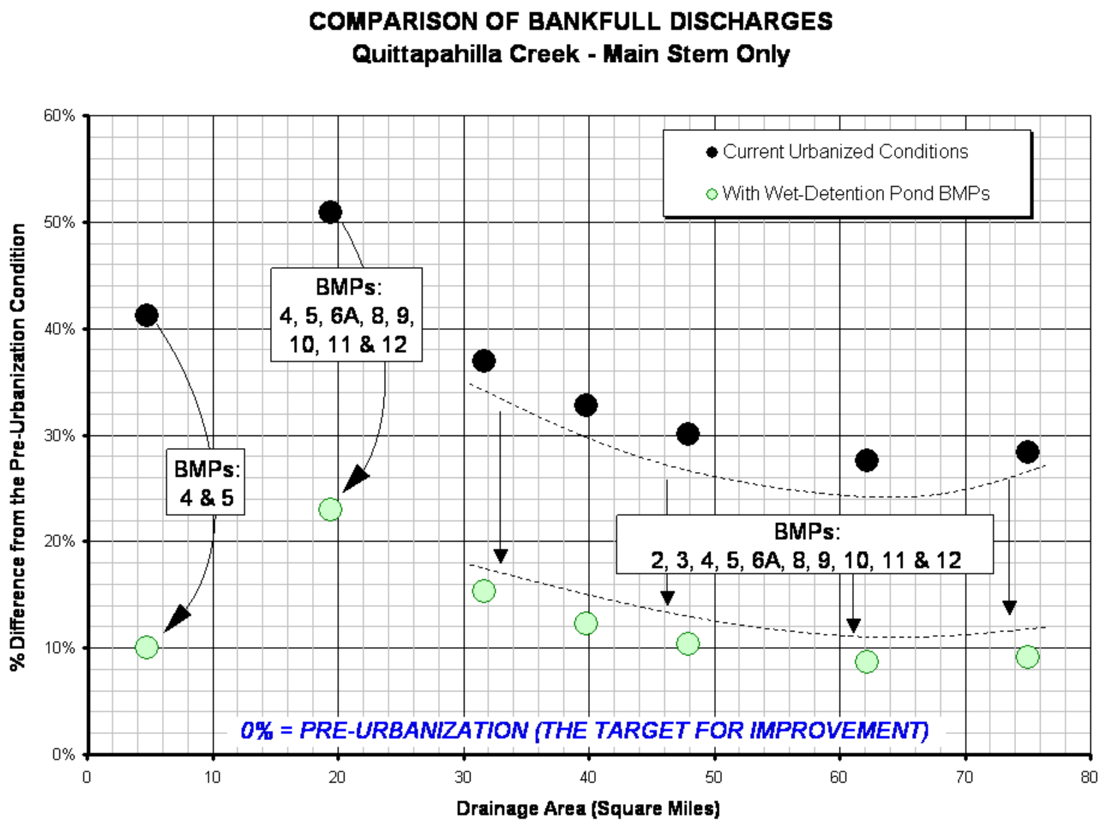

Figure 8 - Comparison of bankfull discharges following urbanization and reduced bankfull discharges following the installation of the proposed BMPs.

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).

Method of Calculating Pollutant Load Reductions

Pollutant reduction potential of the proposed BMPs was analyzed in accordance with the methods outlined in Stormwater Best Management Practices (North Carolina Department of Environment and Natural Resources, April, 1999.). The estimation of the pollutant reduction potential of the BMPs is based upon the ratio of the permanent wet pool surface area (SA) to the uncontrolled upstream drainage area (DA). Optimally, an 85% reduction in sediment pollutant load is achieved when a certain SA/DA ratio is met for a specific wet pond depth. The SA/DA ratios and computed pollutant removal efficiencies for each of the proposed BMPs is listed in Table 9.

Table 9 – SA/DA Ratios and Pollutant Removal Efficiency for each proposed BMPs

BMP	SA/DA	ESTIMATED POLLUTANT REMOVAL EFFICIENCY
2	0.06%	6%
3	0.03%	3%
4	0.08%	11%
5	0.47%	85%
6A	2.63%	85%
8	0.29%	17%
9	0.06%	8%
10	0.19%	27%
11	0.57%	51%
12	0.07%	17%

Pollutant Load Reductions

The pollutant removal efficiencies listed above are specific to each BMP and its direct watershed area. The combined effect of the pollutant removal properties of each BMP was analyzed to determine the level of nitrogen, phosphorus and sediment reduction that would be seen along the main stem of Quittapahilla Creek. These combined efficiencies are shown in Table 10. Load reductions (shown in Table 2 above) associated with each BMP were calculated by multiplying the percent removal by the estimated upstream pollutant load which was modeled using AGWLF.

Table 10 – Pollutant Removal Efficiency achieved by the combined effect of Proposed Urban Best Management Practices

BMPs	LOCATION	NITROGEN REDUCTION POTENTIAL	PHOSPHORUS REDUCTION POTENTIAL	SEDIMENT REDUCTION POTENTIAL
8, 9, 10 & 11	Subwatershed 15	16%	33%	38%
4, 6A & 12	Subwatershed 16	9%	18%	21%
5	Subwatershed 17	17%	34%	39%
3	Main Stem	1.3%	2.6%	3.0%
2	Main Stem	2.6%	5.2%	6.0%

Proposed Urban Stormwater Best Management Practices

An extended detention stormwater wetland as shown in Figures 9, 10 and 11 was conceptually designed for each BMP site location to reduce peak discharges for the storm events that produce bankfull flows and reduce pollutant loading from the subwatersheds draining to these stream reaches. The Quittapahilla Creek Watershed Assessment Volume 2 presents conceptual designs for the proposed BMPs, outlines the hydrologic and water quality benefits associated with the implementation of the BMPs, and provides preliminary cost estimates for design, permitting and construction of each BMP.

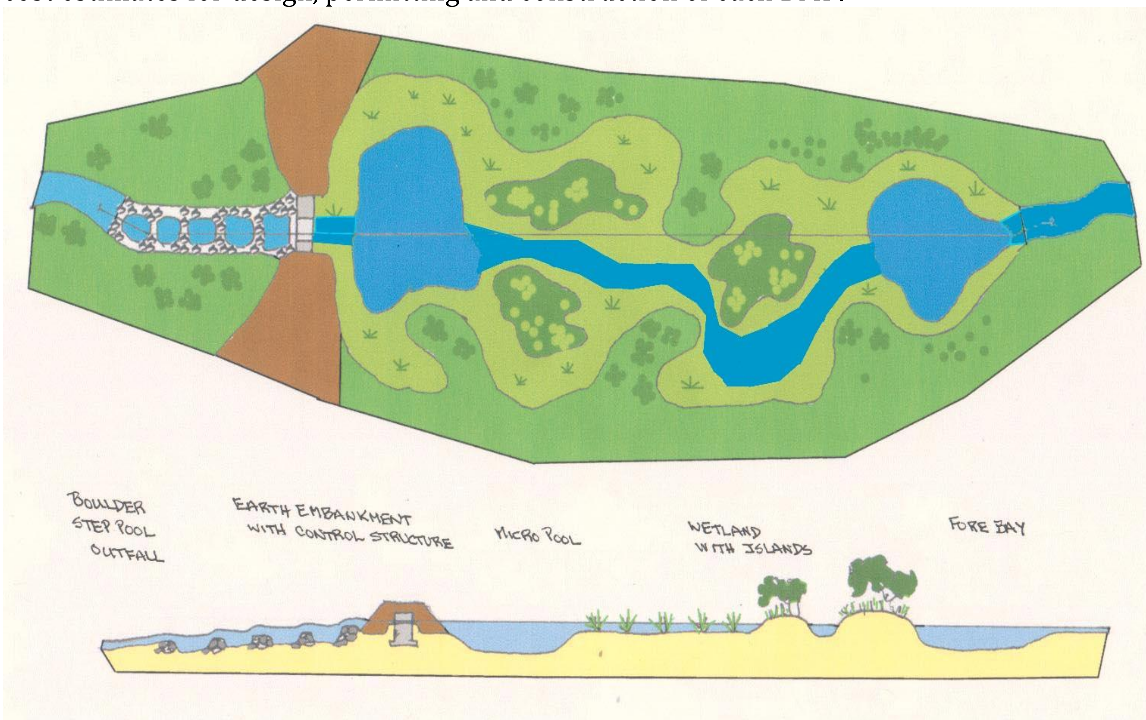

Figure 9 – Typical Stormwater Wetland in plan view (upper) and profile (lower)

A typical stormwater wetland design provides a 3-5ft deep permanent pool with additional temporary storage area above the permanent pool for attenuating stormwater runoff for storm events that produce bankfull flows.

Figure 10 – Stormwater wetlands in a residential subdivision

Figure 11 – Extended detention wet pond in a residential subdivision

Conceptual designs and projected cost associated with each urban BMP are included in the Watershed Assessment Volume 2. Anticipated cost for implementation of all Urban BMPs is $3,170,368

Stream Stabilization/Restoration Measures

Traditional Approaches

The traditional restoration effort is project-oriented rather than system- or process-oriented. The project-oriented approach focuses on the obvious eroding stream banks or aggrading streambeds, and flood waters overtopping stream banks. It often fails to recognize the natural processes that shape and maintain stream channels, the interactions between the channel and adjacent riparian areas, and how these processes and interactions are affected by channel and floodplain maintenance practices and land use in the watershed.

The traditional approach is commonly associated with engineered channels, that is, a relatively straight, wide, trapezoidal channel, with a uniform profile designed to convey all flows (baseflow, bankfull flow, and flood flow). The channel banks are often armored with rip-rap or gabions (concrete revetment in more urbanized areas) in an effort to maintain this engineered form, and grade control structures may be installed to maintain bed stability. This engineered approach invites long-term problems due to the negative feedback mechanisms inherent in all stream systems. These channels are generally devoid of habitat.

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; modifying channel and floodplain maintenance practices that are inconsistent with these objectives; and minimizing the effects of land use by relocating structures from high hazard areas, and adopting land use controls throughout the watershed that are based on landscape capabilities. 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 recover 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.

Figure 12 – Stream in agricultural watershed impacted by livestock grazing.

Figure 13 – Same stream after fencing installed to limit livestock access.

Figure 14 – Stream in a residential area where landowner mowed to top of stream banks

Figure 15 – Same stream two growing seasons after mowing practices were modified

Designing the Stable Channel Form

- Empirical Relationships

Early studies in fluvial geomorphology established that relationships exist between various stream characteristics (i.e., channel width and meander geometry, meander geometry and longitudinal profile) and that streams respond in a predictable manner to changes in one or more of these characteristics.

- Reference Reach Concept

In theory a stream that has adjusted its channel geometry to accommodate the range of flows and sediment load delivered to it by its watershed and has remained stable over time provides an excellent model for how we want our project reach to look and function. Because these characteristics can be measured in the field, the goal of the geomorphic approach to channel restoration is to approximate a range of appropriate stream channel features, utilizing data gathered from stable reference streams in similar geomorphologic and hydrologic settings.

Channel Stabilization Techniques

- Grade Control

Grade control will be provided by the construction of cross vanes, boulder drop structures, or boulder steps at appropriate locations along the restored reaches. Construction of these features is in no way similar to weirs or check dams utilized in a standard engineered channel. The features have very specific design criteria including site location, plan form, cross-section and profile.

- Stream Bank Stabilization and Flow Diverting Techniques

Selecting stream bank stabilization and flow diverting techniques that complement the restored stable channel form should emphasize stability, habitat and aesthetics. Techniques that utilize rootwad and boulder revetment, cross vanes, rock vanes, log-boulder J-Hooks, boulder-drop structures, and boulder step-pools, look natural and are especially effective at providing structural stability. The objective of installing flow diverting structures is to reduce the shear stress on the stream banks by slowing and diverting the flow away from the banks and into deep water on bends or the center of the channel in crossover reaches.

- Live Plant Material

These techniques are supplemented by a variety of other innovative approaches (e.g., soil fabric lifts; toe benches with sod or willow mats, fascines, brush mattresses, willow posts, and soil/fabric lifts). Using plant materials appropriate for the soil and hydrologic conditions and adapted to the regional weather extremes is key to the long-term success of the project. Local or regional suppliers of native plants will be the best source of materials.

Floodplain and Wetland Restoration

The restoration objectives for Quittapahilla Creek and its tributaries include floodplain and wetland restoration and creation where practical. To increase flood storage, provide water quality treatment of urban and agricultural runoff, and create wildlife habitat some floodplain areas would be excavated and/or expanded depending on landowner acceptance. Approaches could involve: 1) expansion and enhancement of wetlands in natural drainage ways in the floodplain where relic channels already support wetland conditions; 2) excavation of floodplain areas adjacent to restored stream reaches; 3) excavation of floodplain areas in conjunction with modifications to the upstream side of culverts to create shallow impoundments; 4) construction of berms perpendicular to and across the floodplain to create shallow impoundments; 5) lowering of floodplain elevations to encourage more frequent flooding of adjacent riparian areas.

Figures 16 & 17 – Unstable stream reach (top) and same reach immediately after stabilization with log/boulder step-pools and toe benches (bottom)

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. Stream bank erosion is calculated using a "stream power" approach similar to that described by Dietrich et al. (1999) and Prosser et al. (2001).

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.

For example, in the Brandywine Creek Subwatershed - 15 the total stream length is 28,050 feet. Approximately 15,180 feet (54% of the total channel length) was identified as unstable channel during the field reconnaissance. The total sediment load estimated to be derived from stream bank erosion for the Brandywine is 158,760 lbs per year. It is assumed that erosion along the unstable reaches account for 95% of that total sediment load or 150,822 lbs per year. Stabilizing the unstable reaches should reduce this loading by 54% or 81,443.9 lbs per year.

Table 11 shows the estimated pollutant loadings derived from stream bank erosion for each subwatershed. Table 11 shows the estimated reductions in pollutant loadings that will be achieved by implementing the recommended restoration and stabilization measures. Table 12 shows that nitrogen, phosphorus and sediment loadings that derive from stream bank erosion could be reduced by 42.8%, 42.8% and 43.9%, respectively by implementing the recommended stream stabilization measures. The subwatersheds that show the highest pollutant loading reductions include 1-Lower Main Stem, 12,-Middle Main Stem, 13-Lower Beck Creek, 14-Lower Snitz Creek, 16-Upper Quittapahilla Creek, 17-Upper Quittapahilla Creek, and 19-Upper Beck Creek.

Table 11 - Estimated pollutant loadings derived from stream bank erosion by subwatershed

SUBSHED	TOTAL N	95% N	TOTAL P	95% P	TOTAL S	95% S
1	8.2	7.8	3.5	3.3	158,760	150,822
2	1.1	1.05	0.4	0.38	22,712	21,576
3	13.2	12.5	5.7	5.4	263,057	249,904
4	9.7	9.2	4.2	4.0	193,379	183,710
5	2.2	2.1	1.1	1.05	45,864	43,571
6	4.4	4.2	2.0	1.9	87,318	82,952
7	0.4	0.38	0.2	0.19	7,497	7,122
8	1.5	1.4	0.7	0.67	32,414	30,793
9	0.2	0.19	0.0	0.0	2,646	2,514
10	0.7	0.67	0.2	0.19	14,112	13,406
11	3.3	3.1	1.3	1.2	63,945	60,748
12	26.5	25.2	11.7	11.1	527,877	501,483
13	8.2	7.8	3.3	3.1	151,704	144,118
14	20.1	19.1	8.4	8.0	386,757	367,419
15	12.3	11.7	5.5	5.2	246,960	234,612
16	6.4	6.1	2.9	2.76	125,685	119,400
17	2.0	1.9	0.9	0.86	41,234	39,172
18	4.9	4.7	2.2	2.1	96,800	91,960
19	0.4	0.38	0.2	0.19	8,600	8,170
20	1.1	1.05	0.4	0.38	20,286	19,272
21	2.6	2.5	1.1	1.05	52,479	49,855

Table 12 – Estimated pollutant loading reduction achieved by implementing stream stabilization measures

SUBSHED	TOTAL STREAM LENGTH	UNSTABLE STREAM LENGTH	PERCENT REDUCTION	95% N (LBS/YR)	REDUCED LOADING N (LBS/YR)	95% P (LBS/YR)	REDUCED LOADING P (LBS/YR)	95% S (LBS/YR)	REDUCED LOADING S (LBS/YR)
1	46,580	32,720	0.70	7.8	2.34	3.3	0.99	150,822	45,247
2	13,200	3250	0.25	1.05	0.79	0.38	0.29	21,576	16,182
3	34,220	18,480	0.54	12.5	5.75	5.4	2.48	249,904	114,956
4	18,150	7930	0.44	9.2	5.15	4.0	2.24	183,710	102,878
5	11,880	2400	0.20	2.1	1.68	1.05	0.84	43,571	34,857
6	13,992	1320	0.09	4.2	3.78	1.9	1.71	82,952	74,657
7	12,210	1650	0.14	0.38	0.33	0.19	0.16	7,122	6,125
8	10,560	4455	0.42	1.4	0.81	0.67	0.39	30,793	17,860
9	3,630	150	0.04	0.19	0.18	0.0	0	2,514	2,413
10	7,920	660	0.08	0.67	0.62	0.19	0.17	13,406	12,334
11	19,470	8,250	0.42	3.1	1.80	1.2	0.70	60,748	35,234
12	29,550	18,225	0.62	25.2	9.58	11.1	4.22	501,483	190,564
13	26,400	18,880	0.72	7.8	2.18	3.1	0.87	144,118	40,353
14	36,300	24,080	0.66	19.1	6.49	8.0	2.72	367,419	124,923
15	20,130	9,095	0.45	11.7	6.44	5.2	2.86	234,612	129,037
16	4,650	4,650	1.0	6.1	0	2.76	0	119,400	0
17	4,200	3,200	0.76	1.9	0.46	0.86	0.21	39,172	9,401
18	25,080	11,920	0.48	4.7	2.44	2.1	1.09	91,960	47,819
19	16,500	10,470	0.63	0.38	0.14	0.19	0.07	8,170	3,023
20	15,840	7,010	0.44	1.05	0.59	0.38	0.21	19,272	10,792
21	10,560	5,680	0.54	2.5	1.15	1.05	0.48	49,855	22,933
TOTAL				123.0	52.7	53.0	22.7	2,372,724	1,041,586

Proposed Restoration Measures

Potential projects were identified from a list of subwatershed and main stem problem sites identified in Quittapahilla Creek Watershed Assessment. 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 tables in the Quittapahilla Creek Watershed Assessment 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.

The tables included in the Quittapahilla Creek Watershed Assessment describe the restoration/stabilization projects recommended for implementation in the Quittapahilla Creek watershed and the accompanying figures show the location of the proposed projects. The projects listed do not include the proposed Urban SWM BMP facilities.

Estimated Costs of Proposed BMPs

Detailed cost estimates are available for review in Volume 2—Restoration and Management Plan (Powell, 2006, p. 119-126). The total preliminary cost for implementing all recommended stream stabilization/restoration projects is approximately $15,981,671.00 or about $74 per linear foot.

Prioritization

Prioritization of restoration and BMP sites were determined based on need and project potential to reduce pollutant loadings. These prioritized sites are listed in Table 13. Ranking is from highest to lowest priority. Methods for determining these sites are described in detail in Volume 2—Restoration and Management Plan (Powell, 2006,p. 114- 116, hardcopy; p. 126-129 electronic copy). Figure 18 illustrates the location for these prioritized sites.

Table 13. Prioritized restoration and BMP sites in the Quittapahilla Creek Watershed (Powell, 2006 p. 128, electronic copy).

Ranking	Subwatershed #	Subwatershed Name
1	12	MS Quittapahilla Creek confluence Beck & Snitz
2	14	Lower Snitz Creek
3	3	MS Quittapahilla Creek confluence Killinger Creek
4	16	Middle Quittapahilla Creek
5	15	Brandywine Creek
5	1	MS Mouth of Quittapahilla Creek
6	13	Lower Beck Creek
7	4	Middle Killinger Creek
8	18	Upper Bachman Run
9	17	Upper Quittapahilla Creek
10	21	East Fork Tributary to Snitz Creek
11	11	Lower Bachman Run
12	8	Middle Gingrich Ru
13	5	Upper Killinger Creek and Gingrich Run
14	20	Upper Snitz Creek
15	6	Upper Killinger Creek
16	19	Upper Beck Creek
17	10	Upper Gingrich Run
18	7	Buckholder Run
19	2	MS Lower Quittapahilla Creek
20	9	Tributary to Gingrich Run

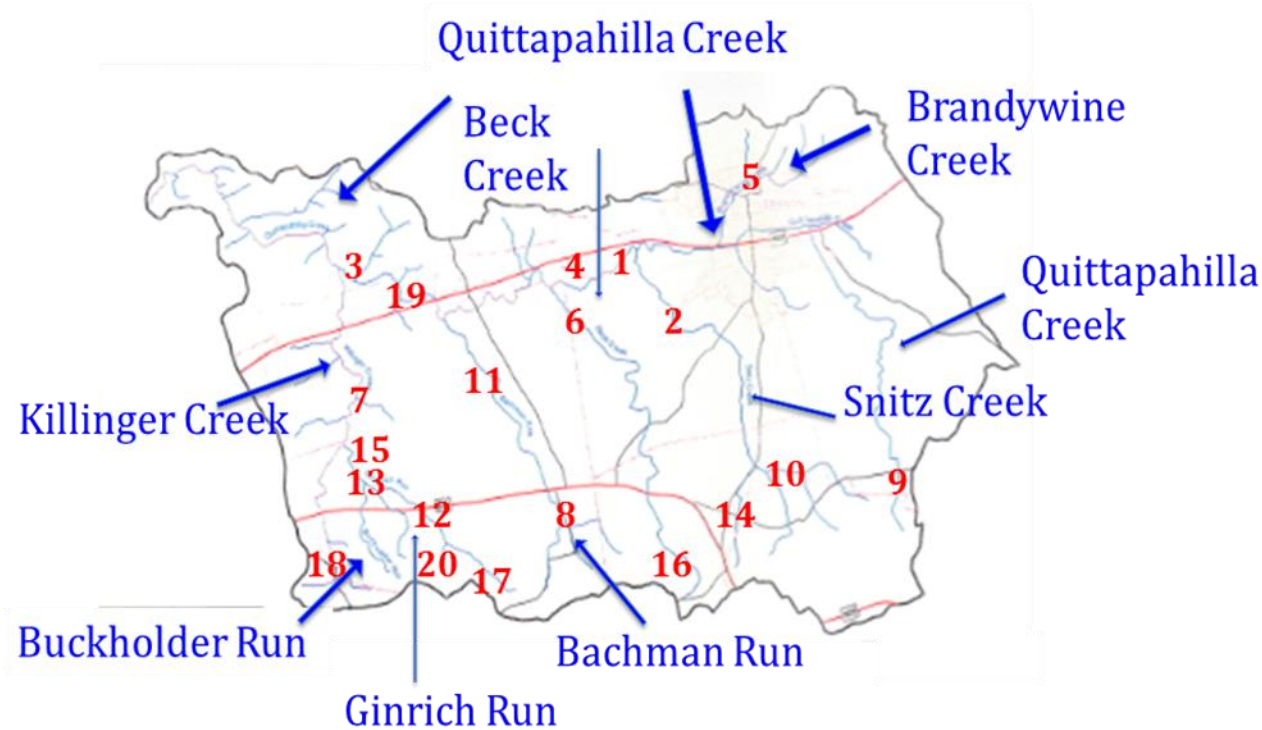

Figure 18. Map of prioritized sites (1-20) in the Quittapahilla Creek Watershed (Adapted from Powell, 2006).

Accomplishments of Quittapahilla Watershed Association

Since their conception in 1997, the QWA has been awarded many grants including two DEP Watershed Restoration Grants that allowed them to fence over 35,000ft of stream bank and plant riparian buffers on eleven farms. Two DEP Growing Greener grants have allowed the QWA to construct over 19,000 ft of stream bank fencing and plant riparian buffers on eleven farms from 2000-2002. A Department of Community & Economic Development Grant was awarded to the QWA and utilized to develop a wetland and educational opportunities for four school districts and Lebanon Valley College in 2000-2001. The QWA has also been successful in stabilizing 4000 ft in the Quittapahilla Creek Nature Park (1998-2000). Other grants have been awarded to this organization in order to complete ecological assessments. In 2010 a wetland to remove phosphorus and sediment was created and 3300 ft of stream bank was stabilized. These were also completed with funding provided by DEP Growing Greener Grants.

Due to these many achievements, the QWA was awarded the Governor's Watershed Stewardship Award in 2001 and the Watershed Protection Award in 2002 from the Pennsylvania Association of Conservation Districts. Along with the implementation of BMPs, the QWA has also collected over 6,000 lbs of trash along the streams in this watershed.

Implementation Schedule

Available funding and landowner and county cooperation limit implementation of potential Best Management Practices. Lack of landowner investment can also hinder implementation of BMPs. The number of projects that can be implemented will be dependent upon funding, cooperation, and scale of the project.

The QWA has completed an assessment, project design, and permitting of the Quittapahilla Park Stream Restoration project. This project is expected to be completed within the next two years (given funding). Implementation will be monitored and tracked by the Quittapahilla Watershed Association. The following sections described proposed implementation schedules and approaches for the agricultural, urban, and stream stabilization/restoration BMPs.

Agricultural BMP

Several agricultural BMPs are proposed as part of the Watershed Plan. These include cropland protection, conservation tillage, strip cropping/contour farming, conversion of agricultural land to forest, conversion of agricultural land to wetland, nutrient management, grazing land management, and terraces/diversions. These BMPs will be implemented primarily by the Lebanon County Conservation District (LCCD), Natural Resource Conservation Service (NRCS), and the Chesapeake Bay Foundation (CBF) working with local farmers to educate, fund, and implement these agricultural BMPs. Several BMPs have already been implemented as can be seen in Figures 5 and 6 of this Plan.

It is estimated that all eligible landowners can be contacted within the next 5 years (or by 2017) to determine which landowners are willing to install these agricultural BMPs. Project Implementation is expected to span additional 10-years beyond the landowner contacts. The LCCD and NRCS have specific expertise in the use of BMPs directly related to crop production such as no-till farming and nutrient management. Therefore, it is anticipated that these agencies will be the primary drivers for installation of these BMPs.

The Quittapahilla Watershed Association can assist by providing landowner education on the conversion of agricultural land to forest or wetlands. This land conversion can be accomplished with NRCS CREP funds, which provide funding to convert lands near waterways to riparian corridor. The QWA has already held a CREP meeting in coordination with the Chesapeake Bay to educate local landowners on the opportunities. The QWA plans to have an annual CREP meeting for local landowners in coordination with the CBF upon approval of the WIP for approximately 5 years (Meetings in 2013 through 2017). When speaking with local landowners, QWA members will actively solicit participation in riparian buffer planting and stream fencing programs.

Urban BMPs

Ten specific urban stormwater BMPs were identified in the Watershed Assessment. These BMPs can be described as extended wet detention ponds and would reduce pollutants loads as well as providing hydrologic improvements within the watershed.

Conceptual design of BMP3, which was funded by a DEP Growing Greener Grant, has already been completed. Due to the significant cost of design, permitting, and construction of these large scale BMPs it is anticipated that the QWA will be able to complete one BMP every 3 years. Therefore, all urban BMPs could be installed by 2042.

Stream Stabilization and Restoration

Several stream stabilization and restoration measures are proposed throughout the watershed. These projects include stream restoration, channel stabilization, wetland creation, dam removal, stream bank fencing, and riparian buffer planting. The number of projects in each sub watershed is listed below.

Beck Creek - 19
Bachman Run - 16
Brandywine Creek - 8
Buckholder Run – 1
Gingrich Run – 5
Killinger Creek - 11
Snitz Creek - 24
Unnamed Tributary - 5
Upper Quittaphailla Creek - 10
Main stem of Quittapahilla Creek -29

The total number of stream projects identified in this WIP is 128. Approximately 25 of the smaller projects including stream bank fencing and buffer plantings can be completed by the QWA without the assistance of an engineering consulting firm. It is anticipated that the QWA can implement 2 of these projects annually. Therefore, all of the small projects could be completed by 2040.

Approximately 103 of the projects will require an engineering consulting firm to provide survey, engineering, permitting, and contract document preparation. These same 103 projects will require a construction contractor to build the projects. It is anticipated that two of these projects can be completed concurrently every 3 years. It is also anticipated that several of these projects will not be completed due to lack of landowner cooperation. Projects will be completed in the priority determined in Table 13 of the WIP and will take many years to complete.

Milestones

The Association anticipates an annual WIP progress review. The following will be addressed in the annual review: project implementation status (total percent complete), review of water quality monitoring, current funding/grant status, public participation review, and schedule.
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Funding Sources

The Quittapahilla Watershed Association has identified several potential funding sources. These include the following.

EPA Section 319 Program

Congress amended the Clean Water Act (CWA) in 1987 to establish the section 319 Nonpoint Source Management Program because it recognized the need for greater federal leadership to help focus State and local nonpoint source efforts. Under section 319, State, Territories, and Indian Tribes receive grant money which support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects. (http://www.epa.gov/owow_keep/NPS/cwact.html#apply)

The QCWA plans to utilize this funding source to provide primary design, permitting, and construction dollars to complete Urban BMP and stream stabilization measures in the watershed.

Pennsylvania Growing Greener Grant

Growing Greener remains the largest single investment of state funds in Pennsylvania's history to address Pennsylvania's critical environmental concerns of the 21st century.

Growing Greener has helped to slash the backlog of farmland-preservation projects statewide; protect open space; eliminate the maintenance backlog in state parks; clean up abandoned mines and restore watersheds; provide funds for recreational trails and local parks; help communities address land use; and provide new and upgraded water and sewer systems.

The funds are distributed among four state agencies: the Department of Agriculture to administer farmland preservation projects; the Department of Conservation and Natural Resources for state park renovations and improvements; the Pennsylvania Infrastructure Investment Authority for water and sewer system upgrades; and the Department of Environmental Protection for watershed restoration/protection, abandoned mine reclamation, and abandoned oil/gas well plugging projects.
(http://www.depweb.state.pa.us/portal/server.pt/community/growing_greener/13958/what_is_growing_greener_/588899)

The QCWA plans to utilize this funding source to provide primary design, permitting, and construction dollars to complete Urban BMP and stream stabilization measures in the watershed.

NRCS Conservation Reserve Program

The Conservation Reserve Program (CRP) is a voluntary program for agricultural landowners. Through CRP, participating landowners can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers .

The Commodity Credit Corporation (CCC) makes annual rental payments based on the agriculture rental value of the land, and it provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. Participants enroll in CRP contracts for 10 to 15 years.
(http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp)

The QCWA will direct local farmers and landowners to these programs to get the identified agricultural BMPs implemented throughout the watershed.

NRCS Conservation Reserve Enhancement Program

The Conservation Reserve Enhancement Program (CREP) is a voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water.

The program is a partnership among producers; tribal, state, and federal governments; and, in some cases, private groups. CREP is an offshoot of the country's largest private-lands environmental improvement program - the Conservation Reserve Program (CRP).

Like CRP, CREP is administered by USDA's Farm Service Agency (FSA). By combining CRP resources with state, tribal, and private programs, CREP provides farmers and ranchers with a sound financial package for conserving and enhancing the natural resources of farms.

CREP addresses high-priority conservation issues of both local and national significance, such as impacts to water supplies, loss of critical habitat for threatened and endangered wildlife species, soil erosion, and reduced habitat for fish populations such as salmon. CREP is a community-based, results-oriented effort centered on local participation and leadership. (http://www.fsa.usda.gov/FSA/newsReleases?area=newsroom&subject=landing&topic=pfs&newstype=prfactsheet&type=detail&item=pf_20110301_consv_en_crppa.html)

The QCWA will direct local farmers and landowners to this program to get the identified agricultural BMPs implemented throughout the watershed.

National Fish and Wildlife Foundation Small Watersheds Grants

The Chesapeake Bay Small Watershed Grants Program empowers local communities to protect and restore tributary watersheds while building citizen stewardship of natural resources. Since 1999, the program has provided over $28 million to support 635 projects throughout the Bay watershed. These grants leveraged an additional $57 million from other funding sources, resulting in over $85 million for efforts to sustain healthy waters, habitats, and wildlife. Conservation results include over 150,000 acres of protected farm and forestland, 194 miles of rivers and streams opened to fish passage, and over 1.1 million acres of habitat restoration (including riparian buffers, oyster reefs, upland forest, and wetlands).

The Small Watershed Grants Program is administered by the National Fish and Wildlife Foundation in cooperation with the Chesapeake Bay Program. The Chesapeake Bay Program is a partnership among Virginia, Maryland, Pennsylvania, the District of Columbia, the Chesapeake Bay Commission, and the federal government. It was formed in 1983 as a result of the first Chesapeake Bay Agreement. The partnership has set a number of Bay protection and restoration goals, and it works to mobilize the resources of government and the private sector to achieve the goals. The Chesapeake Bay Program operates as a voluntary, collaborative resource management program. It has set goals related to fisheries, submerged grasses, wetlands, toxins, sustainable development, nutrient reduction, and public participation.

Major funding for the program is provided by the U.S. Environmental Protection Agency, the U.S. Forest Service, the D.C. Department of the Environment, Altria, FedEx, and Wells Fargo. (http://www.nfwf.org/AM/Template.cfm?Section=Home&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=25630)

The QCWA plans to utilize this funding source to provide matching design, permitting, and construction dollars to complete Urban BMP and stream stabilization measures in the watershed.

Pennsylvania Fish and Boat Commission Cooperative Habitat Improvement Program

The Pennsylvania Fish & Boat Commission recognizes the need for riparian and aquatic improvements and restoration in and along the waters of Pennsylvania and the desire of private and public organizations to participate in such projects. The Cooperative Habitat Improvement Program provides the opportunity for assistance, support and guidance to those organizations or individuals willing to enhance and restore particular waterways that will benefit from such projects.

The Pennsylvania Fish & Boat Commission has established this cooperative program, which provides technical assistance in planning, supervision of construction and a limited amount of financial assistance for materials to an agency or group holding an approved project on a qualified watershed. The program strives to accomplish the following:

- Improve, restore and enhance the aquatic and riparian habitats of Pennsylvania's waterways.

- Provide organized conservation groups, agencies, private individuals and landowners the opportunity to gain a working knowledge of the environmental relationships involved with Pennsylvania's aquatic resources.

- Promote a closer working relationship among the Commission, other agencies, anglers and boaters, landowners and the general public.

- Protect, enhance, conserve and expand angling, boating and aesthetic values of Commonwealth waters.

  (http://fishandboat.com/water/habitat/coophab_pfbc900.pdf)

The QCWA plans to utilize this program to install small stream stabilization measures in the watershed.

Coldwater Heritage Partnership Planning and Implementation Grants

The Coldwater Heritage Partnership (CHP) is a collaborative effort between the PA Fish & Boat Commission, PA Department of Conservation and Natural Resources, Western Pennsylvania Watershed Protection Program and Pennsylvania Trout.

The purpose of the Coldwater Heritage Partnership (CHP) is to provide leadership, coordination, technical assistance, and funding support for the evaluation, conservation and protection of Pennsylvania's coldwater streams.

The program provides two grant opportunities, which help to protect and conserve the health of Pennsylvania's coldwater ecosystems. The two grant opportunities are:

- Planning Grant- designed to help develop a conservation plan that identifies the values and threats that impact the health of the coldwater ecosystems that have naturally reproducing trout. The collected information can be used as a catalyst for more comprehensive planning or for development of watershed improvements projects. Planning grants average around $6,000.

- Implementation Grant- designed to provide funding to projects recommended in a completed conservation plan or report. Potential projects must enhance, conserve or protect the coldwater stream for which the coldwater conservation plan was originally completed. Implementation grants average around $10,000.

  (http://www.coldwaterheritage.org)

The QCWA plans to utilize this program to install small stream stabilization measures or as matching funds for larger stream stabilization measures in the watershed.

<u>Tulpehocken & Quittapahilla Watershed Grant Program</u>

Tulpehocken and Quittapahilla Creek Watershed grants are given for stream restoration, habitat enhancement, and recreational enhancement activities on streams located in the Tulpehocken and Quittapahilla Creek watersheds. This funding is available through a settlement agreement between the Pennsylvania Fish and Boat Commission and AES Ironwood, L.L.C. related to the operation of an electric generation facility located in South Lebanon Township, Lebanon County.

Only project proposals located within the Tulpehocken and/or Quittapahilla Creek watersheds are considered. The monies can be used for stand-alone projects or to supplement other funding for larger projects that are designed to improve aquatic habitat, water quality, or recreational use. Examples of acceptable activities include fishery habitat restoration or enhancement; fish stocking; fishing access; maintenance or creation of facilities to encourage, improve or expand recreational use of the fishery; or studies related to these issues.

The program will continue on a regular basis throughout the life of the AES Ironwood Power Plant. (http://www.fish.state.pa.us/newsreleases/2008/tulpe_quitta.htm)

This grant program is not currently accepting proposals for new projects but is expected to open again sometime in the future. At such time, the QCWA plans to utilize this program to install small stream stabilization measures or as matching funds for larger stream stabilization measures in the watershed.

<u>American Water’s Environmental Grant Program (who is American Water?)</u>

Established in 2005, the American Water annual Environmental Grant Program offers funds for innovative, community-based environmental projects that improve, restore or protect the watersheds, surface water and/or groundwater supplies in our local communities. To qualify for Environmental Grant funding, a proposed project must be:

- Located within an American Water service area
- Completed between May and November of the grant funding year
- Be a new or innovative community initiative, or serve as significant expansion to an existing program.

(http://www.amwater.com/corporate-responsibility/environmental-sustainability/environmental-stewardship-and-innovation/environmental-grant-program.html)

The QCWA plans to utilize this funding source to provide matching design, permitting, and construction dollars to complete Urban BMP and stream stabilization measures in the watershed.

Project match funding from the Doc Fritchey Chapter of Trout Unlimited

The Doc Fritchey Chapter is proud to be fulfilling Trout Unlimited's mission in Dauphin and Lebanon counties. The organization works to conserve, protect and restore the coldwater resources of south central Pennsylvania (http://www.dftu.org). Doc Fritchey Trout Unlimited has been a historic partner of the QCWA and has volunteered hours and provided financial support to complete projects in the Quittapahilla Creek Watershed.

The QCWA plans to utilize small contributions from Trout Unlimited to provide matching design, permitting, and construction dollars to complete Urban BMP and stream stabilization measures in the watershed. The QCWA also anticipates that Trout Unlimited will provide matching in-kind services that can be used to meet grant matching goals.

American Rivers and NOAA Community-Based Restoration Program River Grants

Since 2001, American Rivers and the National Oceanic and Atmospheric Administration (NOAA) Community-based Restoration Program have provided financial and technical assistance for river restoration projects benefiting diadromous fish species in the Northeast (CT, MA, ME, NH, RI, VT), Mid-Atlantic (DC, DE, MD, NJ, NY, PA, VA), Northwest (ID, OR, WA) and California. [Diadromous fish migrate between freshwater and saltwater during their life cycle. Examples include alewife, American shad, American eel, salmon, steelhead and shortnose sturgeon.] (http://www.americanrivers.org/initiatives/grants/noaa)

The QCWA plans to utilize this funding source to provide matching design, permitting, and construction dollars to complete stream stabilization measures that include in-stream obstruction removal.

Public Information and Participation

The Quittapahilla Watershed Association (QWA) is the primary watershed organization for the Quittapahilla Creek. The Doc Fritchey Chapter of Trout Unlimited (DFTU) and the Lebanon Valley Conservancy (LVC) are active non-profit partners of the Association. There are, however, several other entities with which QWA will partner to implement this plan. These include the Lebanon County Conservation District, Natural Resources Conservation Service, the PA Department of Environmental Protection, and the Chesapeake Bay Foundation (CBF). As such, it is expected that much of the first steps taken in implementing the Watershed Implementation Plan will be done by the QWA with support from the other organizations.

All of these entities will play a critical role in implementation of the restoration projects set forth in this plan. As this plan addresses agricultural sources, the assistance of farm agencies such as those listed above is invaluable. These agencies have established relationships with area farmers, have the expertise to provide necessary technical assistance and have the staff and resources to facilitate the implementation of agricultural BMPs to improve water quality.

The QWA is privileged to have a strong working relationship with the Lebanon County Conservation Districts and CBF, and anticipates a successful and growing partnership with all area farm agencies that will aid in implementation of this plan.

Watershed municipalities are also considered critical partners for the plan implementation. The Association plans to make WIP presentations to local municipalities. This presentation will include a request for assistance with the planning an implementation of proposed projects. These projects may also be used to meet TMDL implementation goals which are incorporated into municipal separate storm sewer system (MS4) NPDES permit goals of the municipalities.

The Doc Fritchey Chapter of Trout Unlimited is a Dauphin and Lebanon County-wide volunteer watershed organization. This group has approximately 400 members who are interested in improving the coldwater fisheries in their coverage area, which includes the Quittapahilla Creek. As such, DFTU is well positioned to identify landowners and other individuals and organizations who may be interested in the implementation of the potential stream improvement projects identified in this restoration plan. After approval of this plan, the QWA will inform the DFTU stream steward to request volunteer, financial, and landowner assistance to implement the Watershed Implementation Plan at their monthly meetings.

The QWA is actively engaged in outreach and publicity work to educate landowners about watershed protection and restoration issues. QWA members speak at local civic organizations and schools, sponsor guest presentations, and run display booths at local events such as community fairs and fund raising dinners. The QWA will continue to use these community outreach and educational events as tools to develop partnerships with landowners on potential projects. Recently, the QWA help an event for local landowners in which speakers from the Chesapeake Bay Foundation presented on the NRCS CRP and CREP programs. The QCWA will continue to hold these public meetings with a focus on watershed landowners to the table to complete the Implementation Plan Goals.

The QCWA also maintains a website at quittapahillawatershedassociation.org. The website provides information regarding the QCWA many existing restoration projects, and this restoration plan project. Upon finalization of the plan, the QCWA will update its website to provide more information regarding the restoration plan and the opportunities for Quittapahilla Creek landowners to partner with QCWA on restoration projects.

The QCWA holds monthly meetings in Annville, PA which lies in the center of the Quittapahilla Creek Watershed. The public is invited to attend all meetings. Following approval of the plan, the public will be invited to attend meetings to discuss the Watershed Plan and how the public and landowners can assist. To spur attendance, the QCWA will announce Implementation Plan meetings via newspaper, radio, and project partner websites. Also, any plans to implement proposed BMPs or restoration projects will be announced via newspapers, websites, and meetings which are available to the public. Opportunities for public moment will occur during these public meetings.

Water Quality Monitoring

The QWA intends to reach target Total Maximum Daily Loads as reported by the DEP. Implementation of all recommended BMPs and ecological restoration plans in high priority subwatersheds could result in meeting reduction goals for nutrients and sedimentation. Water quality monitoring will measure total nitrogen, phosphorus, and sediment and will occur monthly. Water monitoring will occur in designated sites along the Quittapahilla Creek and its tributaries including, Brandywine Creek, Snitz Creek, Beck Creek, Bachman Run, Killinger Creek, Buckholder Run, and Ginrich Run. Table 24 and Figure 7, below, display these anticipated monitoring sites. The QWA will also complete benthic macroinvertebrate analysis along these sites yearly. The monitoring will be completed by faculty in the Biology Department at Lebanon Valley College in Annville, PA. Annual reporting of the sampling effort is anticipated.

Table 14. Anticipated monitoring sites in the Quittapahilla Creek Watershed.

Site Number	Name
1	Upper Quittapahilla Creek
2	Middle Quittapahilla Creek (before water treatment facility)
3	Middle Quittapahilla Creek (after water treatment facility)
4	Lower Snitz Creek
5	Lower Beck Creek
6	Lower Bachman Run
7	Ginrich Run
8	Buckholder Run
9	Killinger Creek
10	Brandywine Creek
11	Upper Bachman Run
12	Upper Beck Creek
13	Upper Snitz Creek
14	Lower Quittapahilla Creek

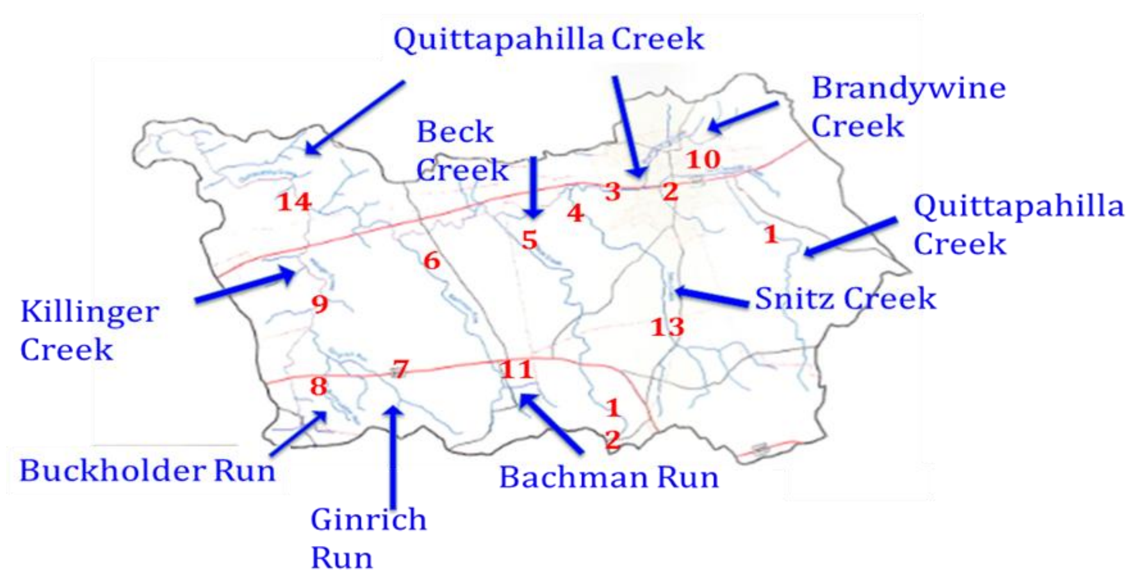

Figure 19. Map displaying anticipated monitoring sites in the Quittapahilla Creek Watershed (Adapted from Powell, 2006).

The Quittapahilla Creek Watershed currently has seven candidate streams up for reassessment by the DEP. Upon, completion of this reassessment, the QWA and LCCD will have a better understanding of where to focus future conservation and restoration efforts.

Monitoring Implementation

The specific BMP types and sites identified in this report and in the Quittapahilla Creek Watershed Assessment set forth precise goals for BMP implementation. Acres and number of agricultural BMPs will be monitored. Total number and size of urban BMPs and total length of stream stabilization/restoration measures will be monitored. Since this report and the Watershed Assessment provides a prediction of load reductions associated with each BMP, the estimated load reduction associated with plan implementation over-time will be straightforward. Load predictions will be compared to monitoring data to see if the predicted water quality improvements are coming to fruition.

Interim water quality measures that will be monitored throughout the WIP implementation included reductions in sediment and nutrient levels in the water quality samples. Another indicator of particular interest to the watershed association is improvement in aquatic macroinvertebrate and trout populations. These will be monitored by the Association as well as the Department of Environmental Protection and Pennsylvania Fish and Boat Commission in their periodic water quality/biologic assessments. It is anticipated that both the quantity and quality of aquatic macroinvertebrates will increase. Additionally, it is a goal of this project to see an increase in wild trout reproduction following implementation. It is a goal of the Association to get the Quittapahilla Creek and tributaries designated as streams that support natural reproduction of trout.

Since agricultural issues make up the majority of pollutant loadings and agricultural BMP implementation is expected to be completed within 15 years, a significant reduction in pollutant loadings (>50%) is expected in this timeframe. Urban and stream restoration BMP implementation is supposed to extend beyond this timeframe but several projects of these types of BMPs should be completed at the 15 year mark. If significant water quality improvement has not been realized in this time-frame, a re-assessment and new paradigm for restoration and water quality improvement will need evaluated by the Association.

Public Participation goals will be review annually by the Association to ensure that the public, interested stakeholders and local government is actively engaged in the WIP implementation process. Once measure of success is the number of individuals that attend the monthly meetings that will focus on the WIP implementation. The Association's goal is to increase attendance and participation in the meetings by 100% by year two of the WIP implementation.

Remedial Actions

Restoration of ecosystem function and structure is a long process. Successful recovery of this watershed (i.e. meeting TMDL endpoints) will take years to achieve. The QWA will continue to monitor streams throughout this watershed to determine which actions have been successful in reducing pollutants, where further action is needed, and where there has been little success. In each case, the QWA will adjust and adapt implementation and management plans as necessary to achieve their goals and objectives.

References

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