LITTLE LEHIGH CREEK WATERSHED

ACT 167

STORMWATER MANAGEMENT PLAN

WATER QUALITY UPDATE

This is the text prepared by the Lehigh Valley Planning Commission staff on behalf of Lehigh County and Berks County. It contains revisions, as necessary, based on comments received from the Little Lehigh Creek Watershed Advisory Committee, the Little Lehigh Creek Municipal Engineers Committee, the Little Lehigh Creek Legal Advisory Committee, the affected municipalities, the LVPC, general public, Lehigh County and the Department of Environmental Protection.

The Pennsylvania Stormwater Management Grant Assistance Program, administered by the Department of Environmental Protection, financed the preparation of this report. This grant program provides for seventy-five percent (75%) State funding with a twenty-five percent (25%) local match provided by Lehigh County.

Final Plan May 2004
Adopted by Lehigh County July 2004
Approved by DEP January 19, 2005

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May 2004

PREAMBLE

As written by
Little Lehigh Watershed Coalition, Inc.[1]

The Little Lehigh Creek is the beneficiary of a healthy Little Lehigh Watershed and is a recreationally valuable watercourse. Portions of the Little Lehigh Creek are designated a High Quality, Cold Water Fishery according to Pennsylvania Code Title 25, Environmental Protection, Chapter 93, Water Quality Standards. The Pennsylvania Fish and Boat Commission has designated a portion of the Little Lehigh Creek as a Class A – Wild Trout Stream and one mile stretch as Heritage Trout Waters, significant in that only twenty miles of streams within the Commonwealth have received this distinction.

The waters of the Little Lehigh support a trout hatchery and flow through a nonprofit wildlife sanctuary and refuge. Passing a registered Native America archaeological site, it enters the Lehigh Parkway, part of the Delaware-Lehigh State Heritage Park and the Delaware-Lehigh National Heritage Corridor. It flows along the Lehigh Parkway Heritage Trail, Trail No. 689 of the National Trail System. In addition, the Little Lehigh Creek is one source of potable water produced by the City of Allentown each day for the use of residents living in or near the third largest City in the Commonwealth and the commercial use of a number of companies and corporations in the watershed.

Given the significance of the Little Lehigh Creek (and its watershed) it is the intention of the Counties of Lehigh and Berks through this Little Lehigh Creek Watershed Storm Water Management Plan Update, in part, to encourage those actions that serve to protect this valuable natural resource.

This preamble is not designed to compel any municipality to take any specific action, including adoption of a standard ordinance. It is offered and intended to acquaint and remind all members of planning boards and commissions, zoning hearing boards, supervisors and commissioners, engineers, and solicitors of municipalities located in the Little Lehigh Watershed of the considerable statewide importance of the Little Lehigh Creek's high quality waters.

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CHAPTER 1. INTRODUCTION

The Pennsylvania Stormwater Management Act, Act 167 of 1978, provides the framework for improved management of the storm runoff impacts associated with the development of land. The purposes of the Act are to encourage the sound planning and management of storm runoff, to coordinate the stormwater management efforts within each watershed and to encourage the local administration and management of a coordinated stormwater program. The Act also specifies the need to periodically update plans. This guarantees a dynamic system of runoff control sensitive to changing study area characteristics and changing regulatory requirements. Lehigh County adopted the original *Little Lehigh Creek Watershed Act 167 Stormwater Management Plan* in March 1988. The first Plan Update incorporated significant hydrologic changes in the watershed and was adopted by Lehigh County in September 1999. This second Plan Update is an addendum to the 1999 Plan which adds water quality criteria to the model ordinance.

In this plan, the water quality criteria have been established using a "standard practice of care" developed by the Lehigh Valley Planning Commission. This standard practice of care provides a technical basis for calculating, designing, and implementing BMPs that can be used to meet State Water Quality Requirements, including but not limited to, infiltration.

The water quality criteria are developed from runoff models using watershed parameters such as existing land use, future land use (based on zoning), the existing physical characteristics of the study area and timing relationships. Computer models of the peak flows in the watershed have been calibrated to reflect actual gage data.

Approximately 70% of the Little Lehigh Creek Watershed is underlain by carbonate geology. The use of infiltration BMPs is a particular concern in this watershed because there may be an increased potential for groundwater contamination and sinkhole formation. To minimize these concerns, Cahill Associates has developed the *Technical Best Management Practice Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed*. LVPC incorporated this manual into the development of this watershed stormwater management plan update.

Our strategy of water quality control has also been shaped by two new programs/policies at the Department of Environmental Protection (DEP). The first is the Comprehensive Stormwater Management Policy dated September 28, 2002 developed by DEP. The Policy emphasizes the reduction of stormwater runoff generated by development and other activities by encouraging the minimization of impervious cover and the use of low impact development designs. Additionally, the Policy encourages the use of innovative stormwater BMPs that provide infiltration, water quality treatment and otherwise more effectively manage the volume and rate of stormwater discharges. The Policy supports the fulfillment of the State's obligation under 25 Pa. Code Section 93.4a to protect and maintain existing uses and the level of water quality necessary to protect those uses in all surface waters. The Policy recommends that, in order to meet the regulatory requirements of 25 Pa. Code Section 93.4a, developers and engineers first prepare a comparative pre- and post-construction stormwater management analysis.

Special Protection waters are defined by DEP as Pennsylvania's highest quality surface waters and include Exceptional Value (EV) and High Quality (HQ) waters. The Little Lehigh Creek is designated as HQ waters. In Special Protection watersheds, the Comprehensive Policy states that "planners and applicants can ensure that existing water quality will be protected and maintained by demonstrating that post-construction infiltration equals or exceeds pre-construction infiltration and that any post-construction discharge will not degrade the physical, chemical or biological characteristics of the Special Protection surface water." Further, the Policy states that "infiltration BMPs should be used to the maximum extent possible" in Special Protection watersheds. To the extent that infiltration cannot be used due to site constraints or limitations, water quality treatment BMPs must be used to ensure the protection and maintenance of water quality. Finally, the rate and volume of stormwater runoff must be managed to prevent the physical degradation of receiving waters from effects such as scour and streambank destabilization.

In view of DEP's Comprehensive Stormwater Policy, the Little Lehigh Creek Water Quality Plan Update provides a methodology to satisfy State Water Quality requirements, including ways to demonstrate that post-construction infiltration equals or exceeds pre-construction infiltration. Additionally, the planning process had to define site constraints associated with carbonate bedrock and where infiltration would be recommended or not recommended. Finally, the water quality control criteria had to be integrated with the existing Release Rate criteria.

The second new program at DEP has been the implementation of the National Pollutant Discharge Elimination System (NPDES) Phase II federal stormwater management regulations. These regulations, enacted in December 1999, require municipalities with separate storm sewer systems in urbanized areas to implement a stormwater management program through the adoption of an ordinance that has the following legal provisions: prohibition of non-stormwater discharges, requirements for erosion and sediment controls, requirements to address post-construction runoff from new development and redevelopment, requirements for the operation and maintenance of stormwater BMPs and sanctions to ensure compliance with the above provisions. Since under the Act 167 planning process counties and municipalities develop a stormwater management ordinance that deals with many of these issues, DEP has stated that municipalities will satisfy the NPDES ordinance adoption requirement if they adopt a stormwater management ordinance developed under Act 167 that contains the NPDES related provisions.

To be consistent with the NPDES Phase II regulations, each of the required ordinance provisions, as listed above, were added to the Little Lehigh Creek Model Stormwater Ordinance. The DEP model ordinance provisions were used as a guide for these additions. All 10 of the Lehigh County municipalities in the Little Lehigh Creek Watershed are subject to the NPDES Phase II regulations. The 10 municipalities are Alburtis, Allentown, Emmaus, Lower Macungie, Macungie, Salisbury, South Whitehall, Upper Macungie, Upper Milford and Weisenberg. Each of these municipalities can meet two of the NPDES Phase II permit requirements by participating on the Watershed Committees and by adopting and implementing the model ordinance included at the end of the Plan Update.

The *Little Lehigh Creek Watershed Act 167 Stormwater Management Plan Water Quality Update* has been prepared for Lehigh and Berks counties by the Lehigh Valley Planning Commission (LVPC). Lehigh County has designated the LVPC to prepare the watershed plans for all watersheds in the County on its behalf.

To ensure the involvement of the municipalities and agencies that will be impacted by the Stormwater Management Plan, Act 167 requires that a Watershed Plan Advisory Committee be formed. The purposes of the Committee are to assist in the development of the Plan Update and familiarize the municipalities involved with the stormwater management concepts evolving from the planning process. Each municipality in the study area plus the County Conservation District is required to be represented on the Committee. Representation by additional agencies and interest groups is optional at the discretion of the County. Listed in Table 1 are the names and affiliations of the persons who participated on the Little Lehigh Creek Watershed Plan Advisory Committee.

TABLE 1
LITTLE LEHIGH CREEK WATERSHED PLAN ADVISORY COMMITTEE

Municipality/Organization	**Name**
Lehigh County	
Alburtis Borough	Melanie Hansen
Allentown City	Richard Rasch
Emmaus Borough	Jeff Clapper
Lower Macungie Township	William A. Erdman
Macungie Borough	Lucy Ackerman
Salisbury Township	Carl Best and Gabriel Khalife
South Whitehall Township	Rene Rodriguez
Upper Macungie Township	Thomas C. Gorr
Upper Milford Township	Daniel DeLong
Weisenberg Township	Thomas N. Wehr
Clean Water Action	Rick Loomis
Lehigh County Conservation District	John Bowman and Rebecca Hayden
Lehigh Valley Builders Association	Lou Tepes and Chuck Hamilton
Little Lehigh Watershed Coalition	Michael Siegel
Natural Resources Conservation Service	Marcia Farbotnik
Trout Unlimited	Lincoln Parmer
Wildlands Conservancy	Chris Kocher
Local Design Engineer	Andrew Bennett
Private Citizen	Scott Beiber
Berks County	
Hereford Township	Dan Solt
Longswamp Township	William G. Zollers and Harry D. Barrell
Maxatawny Township	Carl E. Zettlemoyer
Topton Borough	Kevin Tobias
Berks County Conservation District	John Ravert

There are two additional committees participating in the planning process. The Municipal Engineers Committee's purpose was to familiarize the municipal engineers with the technical background of the Plan Update and with the design standards to be implemented in their municipalities. The Legal Advisory Committee's purpose was to familiarize the municipal solicitors with the model ordinance that each municipality will be required to adopt. Each committee was given the opportunity to review and comment on the draft Plan Update and ordinance during the planning process. Tables 2 and 3 list each committee's participants and their affiliations.

TABLE 2
LITTLE LEHIGH CREEK MUNICIPAL ENGINEERS COMMITTEE

Municipality	**Name**	**Organization**
Lehigh County Alburtis Borough	Allison Bradbury	Martin, Bradbury & Griffith, Inc.
Allentown City	Neal Kern	City of Allentown
Emmaus Borough	Scott Muller	Barry Isett & Associates, Inc.
Lower Macungie Township	James Lancsek	Keystone Consulting Engineers, Inc.
Macungie Borough	William A. Erdman	Keystone Consulting Engineers, Inc.
Salisbury Township	J. Ralph Russek, Jr.	The Pidcock Company
South Whitehall Township	J. Ralph Russek, Jr.	The Pidcock Company
Upper Macungie Township	Dean Haas	Keystone Consulting Engineers, Inc.
Upper Milford Township	Russell Benner	Schoor DePalma
Weisenberg Township	Roy J. Stewart	Keystone Consulting Engineers, Inc.
Berks County Hereford Township	Jeffrey Kerlin	Technicon Enterprises II
Longswamp Township	Brian McElroy	Hanover Engineering Associates, Inc.
Maxatawny Township		Weiser Engineering Consultants
Topton Borough		Great Valley Consultants

TABLE 3
LITTLE LEHIGH CREEK LEGAL ADVISORY COMMITTEE

Municipality	**Name**	**Organization**
Lehigh County Alburtis Borough	David Knerr	
Allentown City	Robert Brown	
Emmaus Borough	Thomas Anewalt	McCarthy & Anewalt, LLP
Lower Macungie Township	Blake Marles	
Macungie Borough	Timothy Siegfried	
Salisbury Township	John W. Ashley	
South Whitehall Township	Blake Marles	
Upper Macungie Township	William E. Schantz	
Upper Milford Township	Marc Fisher	
Weisenberg Township	Donald H. Lipson	Tallman, Hudders & Sorrentino

TABLE 3, continued LITTLE LEHIGH CREEK LEGAL ADVISORY COMMITTEE		
Municipality	Name	Organization
Berks County Hereford Township	Paul Ober	
Longswamp Township	Richard Orwig	
Maxatawny Township	Richard Orwig	
Topton Borough	Francis M. Mulligan	

CHAPTER 2. WATER QUALITY

Most of the Little Lehigh Creek Watershed is underlain by carbonate bedrock. Two major concerns when proposing infiltration in carbonate geology are creation of sinkholes and groundwater contamination. There are only a small number of case studies of infiltration in carbonate bedrock areas. Given the limited data and experience with infiltration practices in carbonate bedrock, the plan does not mandate the use of infiltration BMPs in this watershed in areas of carbonate bedrock.

The stormwater management strategy does not contain a specific recharge standard. Since infiltration will not be mandated in areas of carbonate bedrock, there was no apparent way to manage recharge volume. However, conceptually, if a portion of the development sites in the watershed infiltrate the required water quality volume as defined below, then the recharge volume could be satisfied since recharge volumes are typically much smaller than water quality volumes. Additionally, for many sites that use infiltration, maintaining runoff volume will increase the recharge volume through conversion of pre-development evapotranspiration to recharge. This occurs when a non-vegetated infiltration system, like porous pavement, is used. The rainfall that was used by the pre-development vegetative cover and root systems then becomes recharge into the soil.

A. Water Quality Volume (WQv)

The Water Quality Volume (WQv) to be captured and treated will be the larger of the following:

$$WQv = c \times P \times A / 12$$

Where WQv = water quality volume in acre-feet
c = Rational Method post-development runoff coefficient for the 2-year storm
P = 1.25 inches
A = Area in acres of proposed Regulated Activity

OR

$$WQv = \text{Post-development 2-yr. runoff volume} - \text{Pre-development 2-yr. runoff volume}$$

EXCEPT that in no case shall the WQv exceed

$$WQv = 1.25 \text{ inches} \times \text{site area in acres} / 12$$

To control water quality, the strategy first defines the WQv that must be captured and treated. The WQv must be calculated two ways. First, WQv is calculated as the Universal Rational Hydrograph volume for the site with Precipitation (P) equal to 1.25 inches. This calculation is, in part, based on the methodology in the Maryland Stormwater Design Manual, 2000. The Maryland WQv standard uses 1.0 inch of precipitation and is based on capturing 90% of the average annual rainfall. The recommended WQv for Maryland is between 0.2 inches and

0.95 inches of runoff across a site. This is consistent with traditional "first flush" water quality standards of capturing the initial 0.5 inches to 1.0 inch of runoff. The 90% average annual capture rainfall for the Little Lehigh Creek Watershed calculated from an analysis of daily rainfall data in Allentown for the period of 1947 to 2003 is 1.25 inches. The percent of the average annual rainfall captured increases as the assumed capture depth increases (e.g. a 1 inch capture depth represents 86% of the average annual rainfall and a 2 inch capture depth represents 97% of the average annual rainfall). The Maryland WQv is calculated using a formula that has impervious cover percentage as the only variable. Pervious cover and slope variations on a site are not considered. However, we can essentially replicate the Maryland WQv using the Universal Rational Hydrograph (URH) volume for a site. The URH produces a runoff volume in inches over a site that is equal to the Rational Method runoff coefficient multiplied by the total rainfall applied. This relationship holds true regardless of the site's time of concentration or the storm return period. Therefore, the URH volume for the 90% rainfall capture storm depth is (c)(1.25) in inches over the site area. Using this relationship allows the actual site characteristics of slope, hydrologic soil group and cover to be used. The Rational Method c value replaces the volumetric runoff coefficient (Rv) term in the Maryland equation. By inspection, Rational c values of 0.05 and 0.95 for pervious and impervious areas, respectively, would allow c and Rv to match for 0% and 100% impervious. The 0.05 value can be found in our Act 167 Ordinance for Meadow/Lawn for HSG A soils. The 0.95 impervious value is currently in several Act 167 Ordinances in the Lehigh Valley. The value in making this conversion is that we have extensive experience applying the URH for Act 167 designs. It currently represents the minimum acceptable volume for both detention designs and volume controls in the Act 167 Ordinance. Also, the curve number methodology is not recommended for small rainfall amounts like 1.25 inches and can not be used to define a comparable runoff volume for the 90% rainfall depth. As such, the best use for the URH volume is as a minimum WQv as proposed. Since this WQv closely approximates the Maryland WQv, it still allows us to rely on the established procedures in the Maryland Stormwater Design Manual.

Second, the WQv must be calculated as the difference in runoff volume from pre-development to post-development for the 2-year return period storm. The Little Lehigh Creek runoff quantity design standards specifically regulate the pre- to post-development impact. One concern with the Maryland procedures and the use of the URH method is that the pre-development condition is not considered in the calculation and therefore may not accurately reflect the "impact" created by the development. If the URH method does, in fact, under-predict runoff volume then sufficient water quality treatment may not be provided if this was the sole means for determining WQv. Further, the Pennsylvania Comprehensive Stormwater Management Policy states in part that water quality can be protected and maintained if post-construction infiltration equals or exceeds pre-construction infiltration. The Comprehensive Stormwater Management Policy is in part based on the understanding that water quantity and water quality are not separable. The Policy does not specify a return period for this relationship. For purposes of the Little Lehigh strategy, the following rationale was used to determine the design event to apply to this policy:

- The 100-year, 24-hour storm is approximately 7.44 inches for the Little Lehigh Creek. Using this as the basis for a WQv would conflict with any of the scientific evidence based on first flush and any attempt to apply cost-effective water quality controls.

- The lowest return period for which the runoff volumes calculated by the curve number methodology are valid is between the 1- and 2-year storms. This is based on making sure that the calculated runoff volumes, predevelopment, are about 0.5 inches or more as the documented minimum for use of TR-55 (see page 2-11 TR-55 June 1986). While TR-55 does not mention the 1- or 2-year storm specifically, the 1982 manual *Recommended Hydrologic Procedures for Urban Runoff from Small Developing Watersheds in PA*, written for DEP by Penn State University, indicates that, in general, the AMC II CNs tend to underestimate the smaller runoff events while providing reasonable estimates of the larger less-frequent floods (PSU, 1982). This underestimating tendency for smaller events is caused by the high initial abstractions that must be satisfied before any runoff can be produced under the NRCS/SCS rainfall-runoff equation. This reinforces not using the method for smaller events such as the 1-year storm.

- The 2-year 24-hour rainfall depth for the Little Lehigh Creek Watershed is 3.0 inches. Based on our analysis of local rainfall data, this amount represents more than 97% of the annual precipitation for the watershed. Therefore, its direct use as the WQv estimate would mean that only 3% of the annual rainfall would go untreated – clearly expensive and only marginally beneficial to both water quality treatment and groundwater recharge. Therefore, in no case would it seem reasonable to use a return period higher than the 2-year event as a basis for the WQv.

- The first flush concept has been questioned in the literature. Stormwater Magazine for September/October 2001 cites studies for Austin, Texas and Portland, Oregon that indicate that traditional first flush volumes may not achieve the desired water quality control. Rather than controlling the predominant pollutant loading these techniques may only control less than 50% of annual pollutant loads. In Austin they found that the first 0.5 inches of runoff may only contain 20% of the annual pollutant load rather than the presumed 90%. In Portland they found that 0.83 inches of runoff only treated 20% of the annual pollutant load.

- Data and graphs developed by Environmental Engineers for the City of Austin, Texas show that 90% control of total annual pollutant loadings will require the following watershed storage amounts, based upon observed water quality loading data: 0.42 inches for a 30% impervious site, 0.75 inches for a 50% impervious site, and 2.0 inches for a 90% impervious site (City of Austin, 1990). These volumes follow closely the incremental 2-year volumes based on an analysis by return period prepared by the LVPC. Stated otherwise, the incremental 2-year runoff volume can provide a WQv that achieves pollutant control effectiveness traditionally thought to be provided by the first flush concept.

- The 2-year event is the initial storm to control for water quantity purposes in the existing Little Lehigh Creek Ordinance. Applicants will need to manage this storm for peak rate control, typically in a BMP that also is sized for the 100-year event.

Therefore, using the incremental 2-year runoff volume as the WQv should not introduce significant, if any, additional costs to the developer. This is similar to using a 30% release rate for the 2-year storm. Since basins are designed to handle the 100-year event, this requirement is unlikely to add any significant costs.

- The incremental 2-year runoff volume provides a means to define the WQv for this watershed that provides a reasonable safety factor in design relative to the URH volume for development proposals with higher percent impervious cover, especially given its close fit to the Austin, Texas data.

For these reasons, the alternative WQv standard is the difference in runoff volume pre- to post-development for the 2-year storm. This volume may exceed the URH WQv or may be less. In fact, for the example of converting agricultural lands to low impervious cover development, the incremental 2-year runoff volume could be negative.

Therefore, the greater of these two calculated values will be used as the WQv except in situations where it would exceed 1.25 inches of runoff. The 90% annual rainfall capture volume of 1.25 inches provides a reasonable upper limit to the WQv given that only 10% of the annual rainfall volume from larger events is not treated. Therefore, the recommended WQv standard is limited to no more than 1.25 inches of runoff. This retains applicability of the Maryland Stormwater Design Manual while assuring that the pre- and post-development conditions are considered.

B. Preliminary Site Investigation

Each developer must conduct a preliminary site investigation on the proposed development site. The goal of the preliminary site investigation is to evaluate the feasibility of infiltrating on the site. This requires the determination of site characteristics such as the infiltration capacity of the soil mantle, the depth to bedrock and the absence or presence of any special geologic features. The preliminary site investigation may be an iterative process, testing different locations on the site to find suitable locations for infiltration. Data to be gathered as part of a preliminary site investigation includes the following:

- Bedrock composition – Any apparent boundaries between carbonate and non-carbonate bedrock must be verified through more detailed site evaluations by a qualified geotechnical professional.
- Bedrock structural geology – This includes the possible presence of faults and mapping of conspicuous fracture traces or lineaments.
- Overburden and soil mantle composition and thickness
- Permeability of the soil
- Depth to the seasonal high water table
- Presence of special geologic features – This includes sinkholes, closed depressions, fracture traces, lineaments and geologic contacts between carbonate and non-carbonate bedrock

Some of the required information, as listed above, can be found in existing published data. Suggested resources are listed below.

- Geologic maps and references for the development area
- The Little Lehigh Creek Basin Carbonate Prototype Area Closed Depression Map – available at the LVPC
- USGS topographic maps
- Lehigh and Berks County soil survey maps
- Aerial photographs from the LVPC or other sources
- Relevant Pennsylvania Geologic Survey Open File Reports (Kochanov 1987a, 1987b) that provide maps of sinkholes and Karst features for Lehigh and Berks counties

In addition to gathering data from published sources, a field inspection of the proposed site is required and the soil mantle at the development site must be examined directly with a backhoe during the preliminary site investigation. A minimum of one soil test pit and two percolation tests are required on each site proposed for development. The engineer or other qualified professional exposes the surface horizon to a depth of up to eight feet and identifies the type and condition of the soil mantle by distinct horizons or layers. If infiltration is proposed, additional testing is required. The Preliminary Site Investigation and additional testing must be conducted in accordance with the procedures outlined in Appendix G of the model ordinance included at the back of this Plan Update. If at any point in the Preliminary Site Investigation, the data (e.g. location of Karst features on the site or the published soils data for the site) indicates that the entire site will not be recommended for infiltration based on the Ordinance standards, then no further investigation is required.

Based on the results of the preliminary site investigation, it can be determined if infiltration is recommended or not recommended.

C. Non-Carbonate Area Standards

Since infiltration is the best BMP for runoff volume control, groundwater recharge and water quality control in non-carbonate areas, the WQv must be infiltrated unless the applicant demonstrates that it is infeasible to infiltrate the WQv for reasons of seasonal high water table, permeability rate, soil depth or isolation distances. Additionally, the municipality may, after consultation with DEP, approve an alternate method(s) for meeting the State Water Quality Requirements other than those described in the Ordinance. A site investigation must be performed to quantify the parameters listed below. The site investigation, including soil test pits and percolation tests, must be conducted in accordance with Appendix G of the model ordinance included at the back of this Plan Update. The Preliminary Site Investigation described above shall continue on different areas of the site until a suitable infiltration location is found or the entire site is determined to be infeasible for infiltration. The recommended site conditions, as listed below, are designed to have infiltration on sites with well drained soils and adequate soil depth for removal of pollutants:

- Depth to bedrock greater than or equal to 2 feet
- Depth to seasonal high water table greater than or equal to 3 feet (If the depth to bedrock is between 2 and 3 feet and the evidence of the seasonal high water table is not found in the soil, no further testing to locate the depth to seasonal high water table is required.)

- Soil permeability greater than or equal to 0.5 inches/hour and less than or equal to 12 inches per hour
- Setback distances or buffers as follows:
  - 100 feet from water supply wells
  - 10 feet downgradient or 100 feet upgradient from building foundations
  - 50 feet from septic system drainfields
  - 50 feet from a geologic contact with carbonate bedrock unless a preliminary site investigation is done in the carbonate bedrock to show the absence of special geologic features within 50 feet of the proposed infiltration area.
  - 100 feet from the property line unless documentation is provided to show that all setbacks from wells, foundations and drainfields on neighboring properties will be met.

If it is not feasible to infiltrate the full water quality volume, the applicant must infiltrate that portion of the WQv that is feasible based on site characteristics. The model ordinance allows a municipality to determine infiltration to be infeasible on a site if there are known existing conditions or problems that may be worsened by the use of infiltration.

D. Carbonate Area Standards

Each site located entirely in limestone must conduct a preliminary site investigation prepared by a qualified geotechnical professional to define the special geologic features present on the site. As previously discussed, the preliminary investigation must include a minimum of one test pit and *two* percolation tests on the portion of the site that is judged to be the best candidate for possible infiltration as detailed in Appendix G of the model ordinance included at the back of this plan. The preliminary investigation must include an assessment of the remainder of the site for possible infiltration based on required isolation distances from special geologic features and the likely soil depth and permeability based on published data or other site data available. The data gathered during the preliminary site investigation will then be used as input in the *Recommendation Chart for Infiltration Stormwater BMPs in Carbonate Bedrock* chart contained in Appendix D of the model ordinance.

There are five basic management principles that should be followed to minimize the risk associated with designing infiltration in carbonate areas. Each of the principles is discussed below.

1. Maintain the Natural Water Balance

   When the natural or pre-development water balance is maintained, infiltration to groundwater is maintained along with stream baseflow. This will also maintain the existing water table elevation. Carbonate rock located below the water table has an increased buoyant strength which is sacrificed when the water table drops and water is removed. De-watering of carbonate rock that results when infiltration is reduced and the water table is lowered results in an effective weakening of the carbonate rock formations and increases the likelihood of sinkhole formation. Additional benefits of maintaining the water table elevation by maintaining pre-development infiltration include maintaining stream baseflow, maintaining spring and well yields, maintaining the temperature of the receiving stream and less of an increase in runoff from new development.

With the goal of maintaining the natural water balance in mind, the Ordinance requires that, for the site as a whole, the post-development 2-year runoff volume leaving the site must be 80% or more of the pre-development runoff volume. This 80% provision is to prevent infiltration of volumes far in excess of the pre-development infiltration volume. This is especially important since while holding infiltration constant there still may be an increase in recharge due to the conversion of evapotranspiration to recharge. The restriction on the amount of runoff volume that can be infiltrated in limestone bedrock only deals with the 2-year storm because the 2-year storm captures well over 97% of the annual rainfall volume. Note that this 80% provision should not be confused with the 30% Release Rate criteria that may apply to the 2-year storm.

2. Avoid Concentrating Stormwater Flows and Attempt to Replicate Natural Loading Rates

The overall objective when working in carbonate bedrock areas should be to maintain the pre-development water balance through the use of broad and evenly distributed stormwater. The typical practice of excavating a depression as a detention basin and concentrating many acres of runoff into a relatively small surface area may result in new hydraulic stresses on the overburden soils and accelerate sinkhole development. The added weight of the water in a rapidly filled detention basin may cause a collapse. Ideally, infiltration BMPs should simply mimic the pre-development loading rate. A loading rate is defined as the ratio of additional infiltration to natural infiltration and for ease of implementation can be calculated as the ratio of the land area draining to the system to the base area of the infiltration system. However, in reality, both the change of surface vegetation and the creation of impervious surfaces increase the amount of precipitation that the remaining land surface must infiltrate, assuming the use of BMPs. A range of loading rates has been defined along with a level of risk. A low risk loading rate is where there is up to a 100% more tributary area to the BMP versus base area of the BMP. A medium risk loading rate is where there is between 100% and 300% more tributary area to the BMP versus base area of the BMP. A high risk loading rate is where there is between 300% and 500% more tributary area to the BMP versus base area of the BMP. Loading rates exceeding a 500% increase are not recommended.

The calculation of loading rate should take into account the fact that different land uses will produce different amounts of runoff for the remaining land surface to infiltrate. Therefore, the ratio of areas used to calculate loading rate should be modified as follows:

All disturbed areas to be made impervious:	100% of measured area
All disturbed areas to be made pervious:	50% of measured area

All undisturbed pervious areas:	0% of measured area
All existing impervious areas:	100% of measured area

3. Maximize Soil Mantle Thickness and Permeability

When using infiltration BMPs, the soil mantle acts as a pollutant filter and hydraulic "buffer" that intercepts, distributes, slows, absorbs and retains infiltrating stormwater runoff before the runoff reaches the underlying carbonate formations. The risk of sinkholes decreases as the thickness of the soil increases along with the buffering and lateral dispersion potential. In the areas proposed for infiltration, the removal of top soil should be minimized.

Soil permeability in areas proposed for infiltration must be evaluated. Soil permeabilities of less than 0.5 inches/hour are not recommended for infiltration because they are not considered to be well drained. On the other hand, rapid permeabilities may increase the risk of sinkhole formation or groundwater contamination as water flows through the soil mantle with minimal lateral dispersion and slowing. Therefore, the maximum allowable permeability in areas proposed for infiltration is 12 inches/hour.

Soil thickness and permeability are accounted for through the calculation of effective soil thickness. In areas where the soil thickness is marginal but where soil permeability is relatively slow, the effective soil thickness is weighted to take into account the beneficial effect of the "heavier" soil. Conversely, because of the loss of water quality benefit occurring when permeability becomes quite rapid together with increased subsidence potential, a reverse weighting has been included in the effective soil thickness calculation, as shown below.

The effective thickness in the *Recommendation Chart for Infiltration Stormwater Management BMPs in Carbonate Bedrock* in Appendix D is the measured soil thickness below a proposed infiltration area multiplied by the thickness factor based on soil permeability, as follows:

TABLE 4

PERMEABILITY RANGE*	THICKNESS FACTOR
6.0 to 12.0 inches/hour	0.8
2.0 to 6.0 inches/hour	1.0
1.0 to 2.0 inches/hour	1.4
0.75 to 1.0 inches/hour	1.2
0.5 to 0.75 inches/hour	1.0

**If the permeability rate falls on a break between two thickness factors, the smaller thickness factor shall be used.

4. Maximize Buffering of Special High Risk Geological Features

To minimize the risk associated with designing infiltration BMPs in carbonate areas, the presence of and proximity to existing sinkholes, fracture traces, lineaments, joints, faults, geologic contacts or other special geologic features must be considered. The greater the separation distance or buffer maintained from these features, the lower the potential for sinkholes to develop in the future. Stormwater management systems should not be located on or in any special geologic feature. Therefore, a low buffer is defined as 10 to 50 feet of separation distance. It should be noted that in the *Recommendation Chart for Infiltration Stormwater Management BMPs in Carbonate Bedrock* in Appendix D of the model ordinance that low buffer conditions on a site are generally not recommended for infiltration. A medium buffer is defined as 50 to 100 feet of separation distance. A high buffer is defined as over 100 feet of separation distance.

5. Interaction of Site Risk and Design Factors

   In most cases, the likelihood of sinkhole formation depends on a combination of the site risk factors discussed above. For example, proposing a 500% increase in stormwater loading rate to an infiltration basin on carbonate rock that is buffered with 3 feet of soil depth within 40 feet of faults and fracture traces, increases the risk of sinkhole formation tremendously and would not be recommended for infiltration. On the other hand, a 100% increase in stormwater loading rate with 9 feet of soil depth over carbonate rock in the absence of faults and fractures translates into a significant reduction in risk and would be recommended for infiltration.

Additional design constraints that must be met on carbonate sites include the following:

- Maintain a minimum depth to bedrock of 2 feet
- Depth to seasonal high water table greater than or equal to 3 feet (If the depth to bedrock is between 2 and 3 feet and the evidence of the seasonal high water table is not found in the soil, no further testing to locate the depth to seasonal high water table is required.)
- Soil permeability greater than or equal to 0.5 inches/hour and less than or equal to 12 inches per hour
- Setback distances or buffers as follows:
  – 100 feet from water supply wells
  – 10 feet downgradient or 100 feet upgradient from building foundations
  – 50 feet from septic system drainfields
  – 100 feet from the property line unless documentation is provided to show that all setbacks from wells, foundations and drainfields on neighboring properties will be met.

E. Sites with Both Carbonate and Non-carbonate Areas

If a site has both carbonate and non-carbonate areas, the applicant shall investigate the ability of the non-carbonate portion of the site to fully meet the Ordinance provisions to control runoff for the whole site through infiltration. If that proves infeasible, the applicant shall perform the preliminary site investigation for the carbonate area to determine the appropriate design strategy. No infiltration structure in the non-carbonate area shall be located within 50 feet of a boundary with carbonate bedrock, except when a preliminary site investigation has been done showing the absence of special geologic features within 50 feet of the proposed infiltration area.

F. Non-infiltration BMPs

If, after preliminary testing is completed, a site is not recommended for infiltration or if an applicant chooses not to use infiltration in carbonate bedrock areas, then the WQv must be treated by two acceptable BMPs in each drainage direction. Two BMPs are being required because no other single BMP approaches the pollutant removal efficiency of infiltration. Therefore, if infiltration is not being used, the use of two other BMPs in series will achieve comparable water quality control. Sheet flow draining across a pervious area can be considered as one BMP. This will encourage disconnection of impervious cover and will not create an undue management burden for disturbed areas proposed to be pervious cover. Sheet flow across impervious areas and concentrated flow must flow through two BMPs in series. If sheet flow from an impervious area is to be drained across a pervious area as one BMP, the flow length of the pervious area must be at least equal to the flow length of impervious area.

In no case, may the same BMP be employed consecutively to meet the two BMP requirement.

A list of acceptable BMPs is provided below. A definition for each BMP, along with a reference for design details, is provided in the model ordinance in the back of this Plan Update.

- Bioretention
- Capture/Reuse (cisterns, etc.)*
- Constructed Wetlands
- Minimum Disturbance/Minimum Maintenance Practices
- Oil/Water Separators
- Sediment Traps/Catch Basin Sumps
- Significant Reduction of Existing Impervious Cover
- Stormwater Filters (Sand, Peat, Compost, etc.)
- Trash/Debris Collectors in Catch Basins
- Vegetated Buffers/Filter Strips
- Vegetated Roofs
- Vegetated Swales/Filter Strips
- Water Quality Inserts for Inlets
- Wet Detention Ponds

*If this BMP is used to treat the entire WQv then only one BMP is required because of this BMPs superior water quality performance.

G. Temperature Sensitive BMPs

Because the Little Lehigh Creek is designated a High Quality water, BMPs shall be chosen to prevent thermal impacts on the stream and the aquatic community. Therefore, if an applicant is proposing to use a wet pond, constructed wetland or other BMP that ponds water on the land surface and may receive direct sunlight, the discharge from that BMP must be treated by infiltration, a vegetated buffer, filter strip, bioretention, vegetated swale or other BMP that provides a thermal benefit to protect the High Quality waters of the Little Lehigh Creek from thermal impacts.

H. Hot Spot Land Uses

Hot Spot land uses are land uses or activities that generate higher concentrations of hydrocarbons, trace metals or other toxic substances than typically found in stormwater runoff. Stormwater runoff from Hot Spot land uses, because of the higher pollutant loads, needs to be pre-treated with suitable BMPs before being discharged to surface waters of the Commonwealth. The model ordinance at the back of this Plan Update prohibits infiltration of runoff from Hot Spot land uses. Acceptable methods of pre-treatment for each Hot Spot land use are listed below. In no case, may the same BMP be employed consecutively to meet the Hot Spot pretreatment requirement and the WQv treatment requirement. References for design details for the pre-treatment methods are provided in the model ordinance in the back of this Plan Update.

TABLE 5

HOT SPOT LAND USE	PRE-TREATMENT METHOD(S)
Vehicle Maintenance and Repair Facilities including Auto Parts Stores	-Oil/Water Separators -Use of Drip Pans and/or Dry Sweep Material Under Vehicles/Equipment -Use of Absorbent Devices to Reduce Liquid Releases -Spill Prevention and Response Program
Vehicle Fueling Stations	-Oil/Water Separators -Water Quality Inserts for Inlets -Spill Prevention and Response Program

TABLE 5, continued	
HOT SPOT LAND USE	**PRE-TREATMENT METHOD(S)**
Storage Areas for Public Works	-Oil/Water Separators -Sediment Traps/Catch Basin Sumps -Water Quality Inserts for Inlets -Use of Drip Pans and/or Dry Sweep Material Under Vehicles/Equipment -Use of Absorbent Devices to Reduce Liquid Releases -Spill Prevention and Response Program -Diversion of Stormwater away from Potential Contamination Areas
Outdoor Storage of Liquids	-Spill Prevention and Response Program
Commercial Nursery Operations	-Vegetated Swales/Filter Strips -Constructed Wetlands -Stormwater Collection and Reuse
Salvage Yards and Recycling Facilities*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Fleet Storage Yards and Vehicle Cleaning Facilities*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Facilities that Store or Generate Regulated Substances*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Marinas*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit
Certain Industrial Uses (listed under NPDES)*	-BMPs that are a part of a Stormwater Pollution Prevention Plan under an NPDES Permit

*Regulated under the NPDES Stormwater Program

I. Alternative Approach to Meeting State Water Quality Requirements

The municipality may approve, in consultation with DEP, alternative methods for meeting the State Water Quality Requirements other than those specified in the model ordinance, provided that they meet the minimum requirements of and do not conflict with state law including but not limited to the Clean Streams Law.

J. Exemptions for "Small Projects"

An exemption from certain requirements of the Ordinance is provided in the Plan and Ordinance for new developments which are expected to have an insignificant impact on the watershed. The exemption provides that any development which would create 10,000 square feet or less of additional impervious cover will not be required to meet the Drainage Plan preparation provision of the Ordinance. The date of Municipal Ordinance adoption of the original Little Lehigh Act 167 Stormwater Management Ordinance (1988) shall be the starting point from which to compute cumulative increases in impervious cover. Examples of projects that would be exempted would include building residential sheds or patios, small building or home expansions and development of a single residential home on a small lot.

Attempting to regulate these types of projects could be burdensome to the homeowner or developer and impractical for the municipality. It should be noted that although persons responsible for these “small projects” will not be required to prepare a Drainage Plan to be reviewed against this Ordinance, they are still obligated under Section 110 of the Ordinance to implements such measures as are reasonably necessary to meet State Water Quality Requirements and to prevent injury to health, safety and property. Such measures shall include such actions as are required to manage the rate, volume, direction and quality of resulting stormwater runoff in a manner which otherwise adequately protects health and property from possible injury.

CHAPTER 3. WATER QUANTITY

A. Release Rates

The release rate concept applied in earlier versions of the Little Lehigh Creek Watershed Plan still applies in this Plan Update. The basic goal is no increase in the peak rate of runoff at any point in the watershed. However, simply controlling peak rates of runoff at-site does not guarantee an effective watershed-level control because the increase in total runoff volume could accumulate throughout the watershed and increase peak flows. As part of the *Little Lehigh Creek Watershed Act 167 Stormwater Management Plan Update, 1999*, modeling was done to study how runoff from the various parts of the watershed interact, in time, with one another. A complete discussion of the release rate concept and the modeling are contained in the 1999 Update, which is available at the LVPC offices. The release rates that were determined from that modeling effort have not changed and designs consistent with the release rates are still required as part of the model ordinance. The release rates for each location in the watershed are shown on Plate I in the back of the Plan Update.

It should be noted that the release rate concept assumes that peak rate and volume of runoff will increase with development. If, through the use of infiltration or other BMPs, an applicant can demonstrate that neither the peak rate nor the volume of runoff are increasing with development, additional controls to meet the release rates are not required. This is because if the peak rate and volume of runoff are not increasing with development, then the goal of the release rates, to maintain existing peak flows in the watershed, has been met.

B. Release Rate Implementation Provisions

In addition to the release rates discussed above, the stormwater management district implementation provisions also still apply in this Plan Update. The implementation provisions are detailed in Section 306 of the model ordinance and regulate issues like closed depressions, multiple drainage directions leaving a site, off-site areas, etc.

CHAPTER 4. MUNICIPAL ORDINANCE TO IMPLEMENT THE LITTLE LEHIGH CREEK WATERSHED ACT 167 STORMWATER MANAGEMENT PLAN WATER QUALITY UPDATE

The implementation of the runoff quality and quantity control strategy for new development will be through municipal adoption of the appropriate ordinance provisions. As part of the preparation of the water quality update to the Little Lehigh Creek Watershed Stormwater Management Plan Update, a model Ordinance has been prepared which would implement the Plan Update provisions. The Ordinance is a single purpose ordinance which could be adopted essentially as is by the municipalities. Cross-references to the provisions of this Update would also be required in the municipal Subdivision and Land Development Ordinance and the municipal Building Code to ensure that activities regulated by the Ordinance were appropriately referenced.

Additionally, the model ordinance contains all of the required NPDES Phase II criteria for post-construction stormwater management. These provisions are marked with an asterisk (*) and are not required for municipalities that are not subject to the NPDES Phase II requirements. This Ordinance will satisfy the post-construction stormwater management minimum measure for those municipalities required to apply for NPDES Phase II permit coverage. As needed, the ordinance provisions were copied from DEP's model Ordinance with some minor revisions.

The updated *Little Lehigh Creek Watershed Act 167 Stormwater Management Ordinance* will not completely replace the existing storm drainage ordinance provisions currently in effect in the Little Lehigh Creek Watershed municipalities. The reasons for this are as follows:

- Not all of the municipalities in the Little Lehigh Creek Watershed are completely within the watershed. Since the water quantity provisions (i.e. Release Rates) have been developed specifically for this watershed, for those portions of a municipality outside of the Little Lehigh Creek Watershed, the existing water quantity ordinance provisions still apply. Lehigh County municipalities with areas outside of the watershed may need to apply the water quality provisions to the entire municipality or to the entire urbanized area in the municipality to satisfy the NPDES Phase II requirements.

- The Act 167 Ordinance contains only those stormwater runoff control criteria and standards which are necessary or desirable from a total watershed perspective. Additional stormwater management design criteria (i.e. inlet spacing, inlet type, collection system details, etc.) which should be based on sound engineering practice should be regulated under the current Ordinance provisions.

- The Act 167 Ordinance contains criteria and standards for runoff control from new development that are the *minimum* criteria from a watershed perspective. Individual municipalities may adopt more stringent ordinance provisions so long as consistency with the Plan Update is maintained.

The Act 167 Ordinance is composed of the basic ordinance body and a set of appendices. The Ordinance Appendices, to be made part of a municipal ordinance, should provide maps of the Little Lehigh Creek Watershed, stormwater management districts and storm drainage problem areas as well as technical data to be used in the calculation methodology. The Ordinance is intended to be separable from the Plan Update document itself. The maps in the Ordinance Appendices would be duplicative of those already included in this Plan Update or the 1999 version of the Plan and are not included in the model Ordinance.

Although the actual stormwater control provisions may vary significantly from an existing municipal ordinance, the structure of the Ordinance itself is very similar to many ordinances. The actual ordinance adopted by a municipality to implement the Little Lehigh Creek Watershed Act 167 Plan Update may differ in form from the Ordinance provided herein so long as it includes, at minimum, all of the provisions of the suggested Ordinance. A municipality may tailor the Ordinance provisions to best fit into their current ordinance structure.