

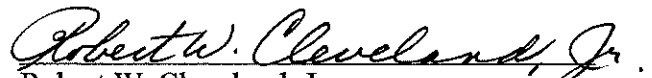
ORDINANCE NO. 216

BOROUGH OF AVONDALE  
CHESTER COUNTY, PENNSYLVANIA

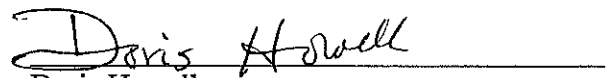
STORMWATER MANAGEMENT ORDINANCE.

The Council of the Borough of Avondale, Chester County, Pennsylvania, hereby ORDAINS that the appended Stormwater Management Ordinance is hereby adopted and shall be effective immediately:

Passed by Borough Council, this 20 day of February, 2007.


  
Robert W. Cleveland, Jr.  
President, Borough Council

Approved by the Mayor, this 20 day of February, 2007.

  
Doris Howell  
Mayor

Enacted, this 20 day of February, 2007.

BOROUGH OF AVONDALE

  
Rebecca Brownback  
Borough Secretary

# **Stormwater Management Ordinance**

**Avondale Borough  
P.O. Box 247  
Avondale, PA 19311**

**February 20, 2007**

## Table of Contents

### Post Construction Stormwater Management

	<u>Page Number</u>
<b>Section 1.0 Purpose.....</b>	<b>3</b>
<b>Section 2.0 General Provisions.....</b>	<b>4</b>
Section 2.1 Statutory Authority.....	4
Section 2.2 Applicability.....	4
Section 2.3 Exemptions .....	5
Section 2.4 General Requirements.....	7
Section 2.5 Repealer.....	9
Section 2.6 Severability.....	9
Section 2.7 Compatibility with Other Ordinance Requirements.....	9
Section 2.8 Enforcement and Penalties.....	9
<b>Section 3.0 Stormwater Management Plan.....</b>	<b>9</b>
<b>Section 4.0 Permanent Stormwater Management Design Standards.....</b>	<b>11</b>
Section 4.1 Design Goals, Principles and Standards.....	11
Section 4.1.1 Design Goals.....	11
Section 4.1.2 General Principles.....	11
Section 4.1.3 Minimum Performance Standards.....	13
Section 4.2 Stormwater Runoff Calculation Methods.....	17
Section 4.3 Design Standards for Stormwater Management Practices.....	20
Section 4.3.1 Runoff Volume and Water Quality Facility Sizing Criteria.....	20
Section 4.3.1.A Runoff Volume.....	20
Section 4.3.1.B Water Quality Volume.....	22
Section 4.3.2 Stormwater Infiltration Practices.....	23
Section 4.3.3 Open Vegetated Channels.....	25
Section 4.3.4 Retention Basins.....	25
Section 4.3.5 Detention Basins.....	29
Section 4.3.6 Conveyance Systems.....	31
Section 4.4 Landscaping of Stormwater Management Practices.....	32
<b>Section 5.0 Operation and Maintenance Responsibilities.....</b>	<b>34</b>
Section 5.1 General Responsibilities.....	34
Section 5.2 Ownership and Maintenance.....	36
Section 5.3 Operation and Maintenance Plan.....	38
Section 5.4 Operation and Maintenance Agreement.....	39
<b>Section 6.0 Definitions .....</b>	<b>39</b>
<b>Appendices</b>	
<b>A</b> Map of Watersheds of Chester County with Municipal Borders .....	A1
<b>B</b> Non-Structural Stormwater Management Practices.....	B1
<b>C</b> Operations and Maintenance Agreement.....	C1
<b>D</b> Soil Use Guide.....	D1
<b>E</b> List of References Cited .....	E1

## STORMWATER MANAGEMENT

### Section 1.0 PURPOSE

In order to protect the health, safety, and general welfare of the residents of Avondale Borough, as well as to protect, sustain, and enhance the surface and ground water resources of Avondale Borough, drainage and stormwater management practices shall be utilized as directed herein to achieve the following objectives:

- 1.1 Accommodate site development and redevelopment in a manner that protects public safety and that is consistent with (or re-establishes) the natural hydrologic characteristics of each watershed (refer to Appendix A for watershed delineations) and sustains ground water recharge, stream baseflows, stable stream channel (geomorphology) conditions, the carrying capacity of streams and their floodplains, ground water and surface water quality, and aquatic living resources and their habitats.
- 1.2 Reduce and minimize the volume of stormwater generated.
- 1.3 Protect natural infiltration and ground water recharge rates in order to sustain ground water supplies and stream baseflows.
- 1.4 Maintain runoff characteristics of the site after completion of development that are consistent with the carrying capacity and stable channel conditions of the receiving streams.
- 1.5 Protect water quality by removing and/or treating pollutants prior to discharge to ground and surface waters throughout Avondale Borough, and to protect, restore, and maintain the chemical, physical, and biological quality of ground and surface waters.
- 1.6 Protect instream channels and geomorphology conditions of the receiving streams; protect their flood carrying capacity and aquatic habitats and to reduce instream erosion and sedimentation.
- 1.7 Reduce flooding impacts and prevent a significant increase in surface runoff rates and volumes, predevelopment to post-development, which could worsen flooding downstream in the watershed, (refer to Appendix A for watershed delineations) enlarge floodplains, erode stream banks and create other flood-related health-welfare-property losses; in general, to preserve and restore the natural flood-carrying capacity of streams and their floodplains.
- 1.8 Protect adjacent lands from adverse impacts of direct stormwater discharges and concentrated runoff.
- 1.9 Ensure effective long-term operation and maintenance of all permanent stormwater management facilities.
- 1.10 Maintain natural drainage patterns and encourage the use of natural drainage systems.
- 1.11 Treat and release stormwater as close to the source of runoff as possible using a minimum of structures and maximizing reliance on natural processes.

- 1.12 Maintain the existing water balance in all watersheds, subwatersheds, and streams in Avondale Borough, and protect and/or restore natural hydrologic characteristics and habitats wherever possible throughout the watershed systems. (Refer to Appendix A for watershed delineations.)
- 1.13 Address certain requirements of the Municipal Separate Storm Sewer System (MS4) National Pollution Discharge Elimination System (NPDES) Phase II Stormwater Regulations.
- 1.14 Reduce the impacts of runoff from existing developed sites undergoing redevelopment while encouraging development and redevelopment in urban areas and areas designated for growth.
- 1.15 Meet legal water quality requirements under state law, including regulations at 25 Pa. Code Chapter 93.4a to protect and maintain "existing uses" and maintain the level of water quality to support those uses in all streams, and to protect and maintain water quality in "special protection" streams.

## **Section 2.0 GENERAL PROVISIONS**

### **2.1 Statutory Authority**

Avondale Borough is empowered to regulate land use activities that affect stormwater runoff by the authority of the Pennsylvania Municipalities Planning Code, Act 247, as amended, and Pennsylvania's Stormwater Management Act, Act 167, as amended. Avondale Borough as a Municipal Separate Storm Sewer System under Phase II of the National Pollution Discharge Elimination System (NPDES) Storm Water Program of the Environmental Protection Agency (EPA) is empowered to regulate stormwater by the authority of the Clean Streams Law, 35 P.S. §691.1, et seq. and The Clean Water Act, 33 U.S.C. §1251, et seq.

### **2.2 Applicability**

The standards contained herein shall apply to all areas within Avondale Borough. These standards shall only apply to permanent stormwater management facilities.

Local stormwater management design criteria (e.g., inlet spacing, inlet type, collection system design and details, outlet structure design, culvert design and capacity, material specifications etc.) shall continue to be regulated by the applicable Municipal Ordinances.

2.2.1 The following activities shall be regulated by this Ordinance for land disturbances of greater than two thousand (2,000) square feet except as otherwise provided per Section 2.3 of this ordinance:

- A. Land development and redevelopment.
- B. Subdivision.
- C. Construction of new or additional impervious or semi-pervious surfaces (driveways, parking lots, etc.).
- D. Construction of new buildings or additions to existing buildings.
- E. Diversion or piping of any natural or man-made stream channel.

- F. Installation of stormwater management facilities or appurtenances thereto.

## 2.3 Exemptions

2.3.1 With the approval of Avondale Borough Council, the following activities may be exempted from on-site stormwater runoff control. An exemption shall apply only to the requirement for on-site stormwater facilities and the preparation of a Stormwater Management Plan. All other stormwater management design elements, such as a storm sewer system, road culverts, erosion and sedimentation control, and runoff quality, shall be required. All exemption requests must be filed with the Borough zoning officer.

- A. Emergency Exemption. Emergency maintenance work performed for the protection of public health, safety and welfare. A written description of the scope and extent of any emergency work performed shall be submitted to the Avondale Borough within two (2) calendar days of the commencement of the activity. If the Borough of Avondale finds that the work is not an emergency, then the work shall cease immediately and the requirements of this ordinance shall be addressed as applicable.
- B. Maintenance Exemption. Any maintenance to an existing stormwater management system made in accordance with plans and specifications approved by the municipal engineer or Borough of Avondale.
- C. Gardening. Use of land for gardening for home consumption.
- D. Agricultural Activities. Agriculture when operated in accordance with a conservation plan, nutrient management plan or erosion and sedimentation control plan approved by the Chester County Conservation District, including activities such as growing crops, rotating crops, tilling of soil and grazing animals. Installation of new or expansion of existing farmsteads, animal housing, waste storage and production areas having impervious surfaces that result in a net increase in impervious surface of greater than one thousand (1,000) square feet shall be subject to the provisions of this ordinance.
- E. Forest Management. Forest management operations, which are consistent with a sound forest management plan as filed with the Avondale Borough zoning officer and which follow the Pennsylvania Department of Environmental Protection's management practices contained in its publication "Soil Erosion and Sedimentation Control Guidelines for Forestry." Such operations are required to have an erosion and sedimentation control plan.
- F. Improvement-related Exemption. Stormwater management facilities will not be required for any net increase of impervious surface of less than one thousand (1,000) square feet where the cumulative total square feet of all impervious surfaces does not exceed the impervious surface standards of the applicable zoning district. However, where the net increase in impervious surface exceeds one thousand (1,000) square feet but the total disturbed area is less than two thousand (2,000) square feet pursuant to a soil erosion and sediment pollution control plan and/or a grading plan, the Applicant shall demonstrate compliance

with Section 1.2, 1.8 and 1.10 of this ordinance to the municipal engineer for the increased impervious surface.

### 2.3.2 Waivers

- A. The Provisions of this Ordinance are the minimum standards for the protection of the public welfare.
- B. If an applicant demonstrates to the satisfaction of Borough Council that any mandatory provision of this Ordinance is unreasonable or causes unique or undue unreasonableness or hardship as it applies to the proposed Project, or that an alternate design may result in a superior result within the context of Section 1.0, 4.1.1 and 4.1.2 of this Ordinance, the Borough Council upon obtaining the comments and recommendations of the Borough Engineer may grant a waiver or relief so that substantial justice may be done and the public interest is secured; provided that such waiver will not have the effect of nullifying the intent and purpose of this Ordinance.
- C. The Applicant shall submit all requests for waivers in writing and shall include such requests as a part of the Application for Development, or during the plan review and approval process. The Applicant shall state in full the facts of unreasonableness or hardship on which the request is based, the provision or provisions of the Ordinance that are involved, and the minimum waiver or relief that is necessary. The Applicant shall state how the requested waiver and how the Applicant's proposal shall result in an equal or better means of complying with the intent of Section 1.0 "Purpose", 4.1.1 "Design Goals" and 4.1.2 "General Principles" of this Ordinance.
- D. The Borough Council may charge a fee for each waiver request, which shall be used to offset the administrative costs of reviewing the waiver request. The applicant shall also agree to reimburse the Borough for reasonable and necessary fees that may be incurred by the Borough Engineer in any review of a waiver request.
- E. In granting waivers, the Borough Council may impose reasonable conditions as will, in its judgment, secure substantially the objectives of the standards or requirements that are to be modified including a fee in lieu of to the Borough's MS-4 Stormwater Management Fund.
- F. The Borough Council may grant applications for waivers when the following findings are made, as relevant:
  - 1. That the waiver shall result in an equal or better means of complying with the intent of Section 1.0, 4.1.1 and 4.1.2 of this Ordinance.
  - 2. That the waiver is the minimum necessary to provide relief.
  - 3. That the applicant is not requesting a waiver based on cost considerations.
  - 4. That existing off-site stormwater problems will not be exacerbated.
  - 5. That runoff is not being diverted to a different drainage area.
  - 6. That increased flooding or ponding on off-site properties or roadways will not occur.
  - 7. That potential icing conditions will not occur.

8. That erosive conditions due to increased peak flows or volume will not occur.
9. That adverse impact to water quality will not result.
10. That increased 100-Year Floodplain levels will not result.
11. That increased or unusual municipal maintenance expenses will not result from the waiver.
12. That the amount of stormwater generated has been minimized to the greatest extent allowed.
13. That infiltration of runoff throughout the proposed site has been provided where practicable and pre-development ground water recharge protected at a minimum.
14. That peak flow attenuation of runoff has been provided.
15. That long term operation and maintenance activities are established.
16. That the receiving streams and/or water bodies will not be adversely impacted in flood carrying capacity, aquatic habitat, channel stability and erosion and sedimentation.

## 2.4 General Requirements

- 2.4.1 The management of stormwater on site, both during and upon completion of the disturbances associated with activities permitted under Section 2.2.1, shall be accomplished in accordance with the standards and criteria of this Ordinance. The design of any temporary or permanent facilities and structures and the utilization of any natural drainage systems shall be in full compliance with this article.

The intent of these design standards is to encourage environmentally sound stormwater management practices that provide necessary drainage facilities while protecting the hydrologic characteristics and water quality of the site and watershed. Developments shall be required to incorporate infiltration and stormwater management controls. Stormwater management design shall blend into the natural environment and be aesthetically integrated into the site design.

- 2.4.2 Applicants shall refer to the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD, 1998), (latest edition or the PA stormwater management design manual when published), the 2000 Maryland Stormwater Design Manual (MDE, 2000) or other appropriate references for guidance in the design of stormwater management facilities most appropriate to individual site conditions. Objectives for design are to reduce the volume of stormwater generated, infiltrate runoff at its source to the maximum extent possible, achieve water quality improvement at the source or during conveyance, and provide for peak flow attenuation. Applicants shall examine design alternatives by viewing them in a series. In addition, Applicants are strongly encouraged to use structural and nonstructural stormwater management practices that reduce or eliminate the need for detention basins.
- 2.4.3 All development activity within a Special Flood Hazard Area designated by the Federal Emergency Management Agency (FEMA) shall comply with the Borough Floodplain Regulations as contained within the Zoning Ordinance and this paragraph. All development shall be designed to maintain the flood carrying capacity of the floodway such that the base flood elevations are not increased, either upstream or downstream. The



natural conveyance characteristics of the site and the receiving floodplain shall be incorporated into the stormwater management practices proposed for the site.

- 2.4.4 The stormwater management system shall not create an adverse impact on stormwater quantity or quality in either upstream or downstream areas. Offsite areas which discharge to or across a site proposed for development shall be addressed in the stormwater management plan prepared for the development. No stormwater management plan shall be approved until it is demonstrated that the runoff from the project shall not adversely impact downstream areas.
- 2.4.5 Wetlands shall not be used to meet the minimum design requirements for stormwater management or stormwater runoff quality treatment, except when used as part of a treatment train that incorporates a portion of the outer zone (filter strip) of the wetland's riparian buffer as a stormwater outfall (Refer to Section 4.1.3.A.9).
- 2.4.6 All proposed stormwater management systems shall be designed to prevent the pollution of ground water resources by stormwater, promote safety, minimize health hazards, preserve natural features and provide infiltration and ground water recharge where appropriate. Neither submission of a plan under the provision herein nor compliance with the provisions of these Regulations shall relieve any person from responsibility for damage to any person or property otherwise imposed by law.
- 2.4.7 Where deemed necessary by the Borough engineer, or as addressed in an approved Act 167 stormwater management plan, the Applicant shall construct storm drains to handle on-site runoff; to the maximum extent permitted under the Municipalities Planning Code and Act 167, or any amendments thereto, provide on-site/off-site drainage easements; and provide for the conveyance of off-site runoff to an acceptable outlet in the same watershed.
- 2.4.8 Where watercourses traverse a development site, drainage easements shall be provided conforming to the line of such watercourses. The terms of the easements shall prohibit excavation, the placing of fill or structures, any alterations that may adversely affect the flow of stormwater within any portions of the easement, and require the establishment and protection of riparian buffers.
- 2.4.9 Any stormwater management facilities regulated by this Ordinance that would be located in or adjacent to Waters of the Commonwealth or wetlands shall be subject to approval by the PADEP through the Joint Permit Application process, or the General Permit Process, as required by PADEP regulations. When there is a question whether wetlands may be involved, it is the responsibility of the Applicant or his agent to demonstrate that the land in question is not classified as wetlands. Otherwise approval to work in the area shall be obtained from PADEP as determined through the jurisdictional determination process.
- 2.4.10 Any stormwater management facility or part thereof regulated by this Ordinance that will be located in State highway rights-of-way shall be subject to approval by the Pennsylvania Department of Transportation (Penn DOT).

2.4.11 At the time of application for a building permit for any approved lot created by a subdivision and/or improved as a land development project, issuance of the permit shall be conditioned upon adherence to the terms of this Ordinance.

2.4.12 Stormwater discharges to critical areas with sensitive resources (e.g., special protection waters, cold water fisheries, recharge areas, water supply reservoirs, etc.) may be subject to additional performance criteria or may need to utilize or restrict certain stormwater management practices.

## 2.5 Repealer

Any Ordinance or Ordinance provision of the Borough of Avondale inconsistent with any of the provisions of this Ordinance is hereby repealed to the extent of the inconsistency only; provided, however, that this repeal shall in no manner be construed as a waiver, release or relinquishment of the right to initiate, pursue or prosecute, as the case may be, any proceeding at law or in equity pertaining to any act done which would have constituted a violation of such prior ordinance or ordinance provision. All of said ordinance or ordinance provisions shall remain in full force and effect and are not repealed hereby as they pertain to such acts and to the processing of such plans filed prior to the effective date of this ordinance, which are protected from the effect of intervening ordinances by Section 508(4) of the Pennsylvania Municipalities Planning Code.

## 2.6 Severability

Should any section or provision of this Ordinance be declared invalid by a court of competent jurisdiction, such determination of invalidity shall not affect the validity of the remaining provisions of this Ordinance.

## 2.7 Compatibility with Other Ordinance Requirements

Permits and approvals issued pursuant to this Ordinance shall not relieve the Applicant of the responsibility to comply with or to secure other required permits or approvals for activities regulated by any other applicable code, rule, act, statute or ordinance. This Ordinance shall not preclude the inclusion in such other permit of more stringent requirements concerning regulation of stormwater and erosion. Where a conflict exists between a provision within this ordinance and that of the PADEP Phase II NPDES regulations, as amended, the PADEP requirements shall govern.

## 2.8 Enforcement and Penalties

The standards contained herein shall be administered, enforced and penalties ascribed pursuant to the Avondale Borough Zoning Ordinance or Subdivision and Land Development Ordinance.

# Section 3.0 STORMWATER MANAGEMENT PLAN

For all activities regulated by this Ordinance in accordance with Section 2.2.1, the Applicant shall submit a stormwater management plan and report prepared by a Professional Engineer or Professional Land Surveyor licensed in the Commonwealth of Pennsylvania, which shall contain, but not be limited to, the following:

- 3.1 A suitable map of the watershed for any and all named streams within which the project is proposed (a United States Geological Survey quadrangle map is usually sufficient) with existing and proposed development areas presented on the map.
- 3.2 Suitable maps and drawings showing all existing natural and constructed drainage facilities affecting the subject property.
- 3.3 Hydrologic (watershed) and water feature boundaries, including all areas flowing to the proposed project, existing streams (including first order and intermittent streams), springs, lakes, ponds, or other bodies of water within the project area.
- 3.4 Sufficient topographical information with elevations to verify the location of all ridges, streams, etc. (two-foot contour intervals within the project's boundaries and for proposed offsite improvements; for slopes greater than fifteen percent (15%), five (5)-foot contours are acceptable).
- 3.5 Notes pertaining to and locations of existing standing water, areas of heavy seepage, springs, wetlands, streams, and hydrologically sensitive areas.
- 3.6 General type of soils with Hydrologic Soil Group noted, estimated permeabilities in inches per hour, and location and results of all soil tests and borings.
- 3.7 100-year flood elevations for any Special Flood Hazard Areas on or within one hundred (100) feet of the property. The source of these elevations shall also be shown on the plans.
- 3.8 Description of current and proposed ground cover and land use. The total area and percent impervious cover shall be noted.
- 3.9 A plan of the proposed stormwater drainage system attributable to the activity proposed, including runoff calculations, stormwater management practices to be applied both during and after development, and the expected project time schedule.
- 3.10 The design computations for all proposed stormwater drainage systems, including storm-drain pipes, inlets, runoff control measures and culverts, drainage channels, and other features, facilities, and stormwater management practices.
- 3.11 A grading plan, including all areas of disturbance, of the subject activity. The total area of disturbance shall be noted in square feet and acres.
- 3.12 A plan of the erosion and sedimentation procedures to be utilized as required under Section 4.9 of The Subdivision and Land Development Ordinance of the Borough of Avondale, Ordinance No. 171, as amended.
- 3.13 A delineation of the pathways of all concentrated flow (that is, flow other than overland sheet flow).
- 3.14 The effect of the project (in terms of runoff volumes and peak flows) on adjacent properties and on any other stormwater collection system that may receive runoff from the project site and specifics of how erosion and flooding impacts to adjacent properties will be avoided or otherwise mitigated.

- 3.15 An operation and maintenance plan consistent with the requirements of Section 5.0. Such a plan should clearly explain how the proposed facilities operate and the functions they serve.
- 3.16 The name of the development, the name and address of the property owner and Applicant, and the name and address of the individual or firm preparing the plan.
- 3.17 A north arrow, submission date, scale and revision dates as applicable shall be included on each page of all plans submitted.
- 3.18 Complete delineation of the flow paths used for calculating the time of concentration for the pre-developed and post-developed conditions.
- 3.19 Construction details sufficient to completely express the intended stormwater design components consistent with this ordinance.

## **Section 4.0 PERMANENT STORMWATER MANAGEMENT DESIGN STANDARDS**

### **4.1 Design Goals, Principles and Standards**

#### **4.1.1 Design Goals**

Applicants shall adhere to a holistic design process incorporating the goals listed below. The objective is to achieve post-development hydrologic conditions that are consistent with the predevelopment ground cover assumption for new development (refer to Section 4.2.2) and improve the runoff conditions for redevelopment (refer to Section 4.1.3.C). The design goals are:

- A. Minimize the volume of runoff that must be collected, conveyed, treated and released by stormwater management facilities;
- B. Maintain the natural infiltration process and rate, and infiltrate runoff at its source;
- C. Remove and/or treat pollutants at the source or during conveyance;
- D. Provide for peak flow attenuation, as needed; and
- E. Attenuate runoff to protect the instream channel of the receiving stream.

#### **4.1.2 General Principles**

The following general principles apply to all applicable activities pursuant to Section 2.2.1:

- A. Incorporate Conservation Design practices to minimize the amount of stormwater generated on a site, encourage the disconnection of impervious land cover, and maximize the use of pervious areas for stormwater treatment and on-site rainfall infiltration.

- B. Infiltration of surface water runoff at its source is to be the primary mechanism for stormwater management based on soil infiltration testing. Infiltration practices include, but are not limited to those referenced in Section 4.3.2.A and as outlined in the publications listed in Section 4.3. Infiltration practices shall adhere to the following criteria:
1. In choosing methods of infiltration, preference shall be given to a combination of surface and subsurface infiltration methods.
  2. Applicants shall first consider minimum disturbance/minimum maintenance techniques combined with site grading that distributes runoff to reduce concentration. Next, Applicants shall consider depression areas combined with subsurface infiltration practices, followed by other subsurface measures, including but not limited to porous paving and perforated pipe storage.
  3. The use of multiple infiltration features and facilities that provide for the following is encouraged:
    - a. Discourage concentration of flows,
    - b. Encourage disconnection of flows,
    - c. Infiltrate as close to the source of runoff as possible, and
    - d. Reduce visual impact.
  4. Where high water tables, subsurface contamination, or other site constraints preclude achieving the required infiltration volume, additional Conservation Design practices and alternative stormwater management practices should be implemented to reduce to the maximum extent practicable the total volume of stormwater released to streams. Applicant shall follow the stormwater runoff hierarchy of Section 4.3.1.A.
  5. Infiltration areas should be designed to maintain any broad and even infiltration pattern, which existed prior to development. Such facilities should use the natural topography and vegetation in order to blend in with the site. Infiltration designs, which do not provide this may be used if the Applicant demonstrates to the Borough's satisfaction that alternative approaches would be more effective, more harmonious with their existing environment and as easily maintained.
- C. Water quality improvement shall be achieved in conjunction with or as part of infiltration practices. Water quality improvements shall also be provided for drainage areas not otherwise addressed by infiltration practices either at the source of runoff and/or during conveyance away from the source of runoff.
- D. To reduce the need for large retention and/or detention basins designed to satisfy the peak flow attenuation requirements, other innovative stormwater management practices located close to the source of runoff generation shall be considered, including a combination of practices (e.g., rooftop storage, open vegetated channels, bioretention and infiltration trenches). Where basins are necessary, retention basins shall be considered first, then detention basins.

- E. When designing the stormwater management facility(ies) to satisfy the peak flow attenuation requirement (refer to Section 4.1.3.B.2), the effect of structural and non-structural stormwater management practices implemented as part of the overall site design may be taken into consideration when calculating total storage volume and release rates.
- F. Site hydrology and natural infiltration patterns shall guide site design, construction and vegetation decisions. All channels, drainage ways, swales, natural streams and other surface water concentrations shall be maintained and incorporated into design decisions unless changes can be justified to enhance natural runoff and/or infiltration patterns or reduce health/safety issues on the basis of other design objectives of this Ordinance.
- G. Stormwater management facilities that provide for reduction in volume of runoff are encouraged and may be taken into account in meeting the standards of this ordinance.

#### 4.1.3 Minimum Performance Standards

- A. The following minimum performance standards shall apply to all applicable activities, **whether they are new development or redevelopment**, pursuant to Section 2.2.1.
  - 1. Structural and non-structural stormwater management practices that provide, promote or otherwise make best possible use of infiltration on-site shall be considered first and foremost in all site designs.
  - 2. Infiltration into areas underlain by karst and/or carbonate geology is encouraged but only where the design, supporting calculations, and soils investigations are provided which determine that the potential or likelihood of subsidence or sinkholes is minimal (refer to Section 4.3.2.L). Concentrated flows and points of discharge are discouraged in limestone areas; measures should be taken to convert such flows to uniform, shallow sheet flow. Appropriate on-site testing and evaluation should support any design of infiltration practices in carbonate geology. Relevant guidance and practices are discussed in Technical Best Management Practice Manual & Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed (LVPC, 2002). Although this document specifically addresses carbonate rock conditions of the Lehigh Valley, site evaluation design guidance can be applied in Chester County.
  - 3. Water quality treatment of stormwater runoff shall be provided for all discharges prior to release to a receiving water body. If a stormwater management practice does not provide water quality treatment, then water quality best management practices shall be utilized prior to the runoff entering the stormwater management practice.
  - 4. Water quality management shall be provided through the use of structural and/or non-structural stormwater management practices. Water quality stormwater management practices shall be designed to reduce or eliminate

solids, sediment, nutrients, and other potential pollutants from the site. It is presumed that a stormwater management practice complies with this requirement if it is:

- a. Sized to capture the prescribed water quality volume (per section 4.3.1.B);
  - b. Designed according to the specific performance criteria outlined in the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD, 1998) (latest edition or the PA stormwater management design manual when published), or the 2000 Maryland Stormwater Design Manual (MDE, 2000), or other handbooks or manuals approved by the municipality;
  - c. Constructed in accordance with all permits and approved plans and specifications; and
  - d. Maintained per an approved operation and maintenance plan or agreement or, in lieu of that, in accordance with customary practices.
5. Stormwater discharges from land uses or activities with higher potential for pollutant loadings (hotspots) may require the use of specific structural stormwater management practices and pollution prevention practices. In addition, stormwater from a hotspot land use shall be provided with proper pretreatment prior to infiltration. For the purpose of this ordinance, the sites/facilities listed in Section 4.1.3.A.6 below, are considered hotspots.
6. Certain industrial sites may be required to prepare and implement a stormwater pollution prevention plan and file notice of intent as required under the provision of the EPA Industrial Stormwater NPDES Permit Requirements. Other industrial sites storing significant quantities of chemicals/wastes should also prepare a prevention plan. Sites that are required by EPA to prepare a plan include, but are not limited to:
  - a. Vehicle salvage yards and recycling facilities;
  - b. Vehicle and equipment cleaning facilities;
  - c. Fleet storage areas for buses, trucks etc.;
  - d. Marinas (service and maintenance);
  - e. Facilities that generate or store hazardous materials.
7. Conveyance structures/channels shall be designed and adequately sized so as to protect the properties receiving runoff from impacts of flooding and erosion. Where necessary, and to the maximum extent permitted under the Municipalities Planning Code and Act 167, or any amendments thereto drainage easement from adjoining properties shall be obtained to ensure the drainage way and the property and shall also establish the operation and maintenance requirements for the drainage way.

8. All stormwater management practices shall have an Operation and Maintenance Plan pursuant to Section 5.3 of this Ordinance and an enforceable Operation and Maintenance Agreement per Section 5.4 of this Ordinance to ensure the system functions as designed and to provide remedies for system failure.
9. Stormwater runoff generated from development and discharged directly into a jurisdictional wetland or waters of the United States and their adjacent wetlands shall be treated by an approved stormwater management practice prior to release into a wetland. Natural wetlands shall not be used to meet the minimum design requirements for stormwater management or stormwater runoff quality treatment, except when used as part of a treatment train that incorporates a portion of the outer zone (filter strip) of the wetland's riparian buffer as a stormwater outfall. In such instances, the discharge velocity from the terminal end of a pipe or associated energy dissipation practice shall not exceed two feet per second for the two-year frequency storm event. Where such a management strategy is used, all feasible methods shall be used to convert concentrated flow to uniform, shallow sheet flow before entering the outer zone of the wetland's riparian buffer. In addition, it shall be demonstrated that such an approach will not cause erosion.

B. The following minimum performance standards shall apply to all applicable new **development** activities, pursuant to Section 2.2.1.

1. Water quality improvement shall be achieved in conjunction with or as part of infiltration practices. Water quality improvements shall also be provided for drainage areas not otherwise addressed by infiltration practices either at the source of runoff and/or during conveyance away from the source of runoff. Stormwater quality management practices shall be designed to capture and treat stormwater runoff generated by the one-inch rainfall event. Refer to Section 4.3.1.B for Water Quality Volume design standards and assumptions. Stormwater quality management practice selection, design and implementation shall be based upon appropriate reference materials, including the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD, 1998), (latest edition or the PA stormwater management design manual when published), or the 2000 Maryland Stormwater Design Manual (MDE, 2000), and may include constructed wetlands, grass channels, dry swales, wet swales, filter strips, bioretention and other stormwater management practices.
2. The post development peak discharge rate shall not exceed the predevelopment peak discharge rate for the 2-year, 10-year, 25-year, 50-year and 100-year 24-hour storm events pursuant to the predevelopment cover assumption described in Section 4.2.2. Where the runoff volume design standards under Section 4.3.1.A.1.a and Section 4.3.1.A.1.b are **not** met, the post-development peak discharge rates for all storms up to and including the 10-year event shall not exceed the predevelopment discharge rate for the 2-year event given predevelopment cover assumptions per Section 4.2.2. For events greater than the 10-year event up to the 100-year event (i.e., the 25, 50 and 100 year events), the post-development peak discharge rates shall not



exceed ninety-percent (90%) of the peak discharge rate given predevelopment cover assumptions per Section 4.2.2.

3. Facilities capable of attenuating rainfall runoff shall be provided and designed to attenuate the runoff volume from the 1-year 24-hour storm event for at least 24 hours (i.e., the stormwater runoff will be released over a minimum of 24 hours). The rate of release to the receiving stream shall be based on the ability of the stream channel to contain the volume of discharge within the banks of the stream.
  4. Stormwater shall be infiltrated and/or discharged within the same drainage area of the stream receiving the runoff from the development site prior to development.
  5. Structural and non-structural stormwater management practices that provide, promote or otherwise make best possible use of infiltration on-site shall be considered first and foremost in all site designs. Stormwater infiltration practices shall be designed in accordance with the sizing criteria and hierarchy described in Section 4.3.1.A of this ordinance.
- C. The following minimum performance standards shall apply to all applicable redevelopment activities, pursuant to Section 2.2.1.
1. One of the following minimum performance standards shall be accomplished. Selection of the performance standard shall be whichever is most appropriate for the given site conditions as determined by Avondale Borough:
    - a. Reduce the total impervious cover on the site by at least twenty percent (20%), based on a comparison of existing impervious cover to proposed impervious cover, **or**
    - b. Achieve a ten percent (10%) reduction in the total volume of runoff generated and discharged from the site by a 2-year storm event. Runoff calculations shall be based on a comparison of existing site conditions to post development site conditions, **or**
    - c. Reduce the post development peak discharge rates to ninety percent (90%) of the predevelopment peak discharge rates for the 2-year, 10-year, 25-year, 50-year and 100-year 24-hour storm events based on a comparison of existing ground cover to post development site conditions.
  2. In addition to the minimum performance standards of Section 4.1.3.C above, water quality improvements shall be provided for drainage areas not otherwise addressed by infiltration practices either at the source of runoff and/or during conveyance away from the source of runoff. Stormwater quality management practices shall be designed to capture and treat stormwater runoff generated by the one-inch rainfall event. Refer to Section 4.3.1.B for Water Quality Volume design standards and assumptions.

Stormwater quality management practice selection, design and implementation shall be based upon appropriate reference materials, including the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD, 1998), (latest edition or the PA stormwater management design manual when published), or the 2000 Maryland Stormwater Design Manual (MDE, 2000), and may include constructed wetlands, grass channels, dry swales, wet swales, filter strips, bioretention and other stormwater management practices.

#### 4.2 Stormwater Runoff Calculation Methods

In addition to the infiltration and water quality requirements of this ordinance, peak flow from those activities resulting in increases in impervious surface and/or regrading and compaction shall be attenuated consistent with the following stormwater calculation methods:

- 4.2.1 The following design storms shall be analyzed for the peak discharge and volumes from the pre and post development conditions. These values are applicable to the Soil-Cover-Complex Method: (The Modified Rational Method may be utilized for drainage areas less than 20 acres when approved by the Borough Engineer.)
  - A. A one-year, twenty four hour storm of 2.6 inches of rainfall (PADEP, March 2000);
  - B. A two-year, twenty-four hour storm of 3.2 inches of rainfall;
  - C. A ten-year, twenty-four hour storm of 5.0 inches of rainfall;
  - D. A twenty-five-year, twenty-four hour storm of 5.7 inches of rainfall;
  - E. A fifty-year, twenty-four hour storm of 6.4 inches of rainfall;
  - F. A one-hundred-year, twenty-four-hour storm of 7.3 inches of rainfall.
  
- 4.2.2 The following assumptions shall be used for runoff calculations:
  - A. For new development sites, the ground cover used as the predevelopment assumption for runoff calculations shall be as follows:
    1. Wooded sites shall use a ground cover of woodland in good condition. Portions of a site having more than one viable tree of a DBH of six (6) inches or greater per fifteen-hundred (1,500) square feet shall be considered wooded where such trees existed within three (3) years of application.
    2. Agricultural sites shall use a ground cover of pasture in good condition.
    3. All other portions of a site shall use a ground cover of meadow in good condition even if the area is impervious.

4. The ground cover used for redevelopment sites is provided under Section 4.1.3.C.

- B. The runoff curve numbers listed in the table below shall be used in developing the runoff calculations for the ground covers noted in Section 4.2.2.A. These values are referenced from the Urban Hydrology for Small Watersheds Technical Release No. 55 (USDA, 1986). Coefficients for equivalent ground cover conditions shall be used if a runoff method other than the Soil Cover Complex Method is used.

Ground Cover	Hydrologic Soil Group Curve Numbers			
	A	B	C	D
Woodland	30	55	70	77
Meadow	30	58	71	78
Pasture	39	61	74	80

- C. Average antecedent moisture conditions (for the Soil Cover Complex Method only for example, TR-55, TR-20).
- D. A type II distribution storm (for the Soil Cover Complex Method only for example, TR-55, TR-20).

- 4.2.3 In all plans and designs for stormwater management systems and facilities submitted to the municipal engineer for approval, stormwater peak discharge and runoff shall be determined through the use of the NRCS Soil Cover Complex Method as set forth in Urban Hydrology for Small Watersheds, Technical Release No. 55 (USDA, 1986), with specific attention given to antecedent moisture conditions, flood routing, time of concentration, and peak discharge specifications included therein and in Hydrology National Engineering Handbook, Section 4, (USDA, 1985) both by the U.S. Department of Agriculture, Natural Resources Conservation Service. Note that when TR-55 is used for natural system-based approaches and practices encouraged herein, calculations must be performed on a detailed small sub-area basis. Use of Technical Release No. 20 and other methods listed in Table 1 are also acceptable. The design professional's selection of a specific method shall be based on the suitability of the method for the given project site conditions with due consideration to the limitations of the method chosen. Table 1 herein summarizes the computational methods available.

Table 1  
ACCEPTABLE COMPUTATION METHODOLOGIES FOR STORMWATER  
MANAGEMENT PLANS

METHOD	SOURCE	APPLICABILITY
TR-20 or commercial Package Based on TR-20	USDA – NRCS	When use of full model is desirable or necessary
TR-55 or Commercial Package Based on TR-55	USDA – NRCS	Applicable for plans within the model's limitations
HEC – HMS	U.S. Army Corps of Engineers	When full model is desirable or necessary
Modified Rational Method or Commercial package based On this Method	Emil Kuiching (1889)	For sites less than 20 acres
SWMM or commercial package based on SWMM	U.S. EPA	Most applicable in urban areas
Other Methods	Various	As approved by the municipal engineer

4.2.4 A Modified Rational Method analysis may be used for drainage areas smaller than twenty (20) acres when permitted by the municipal engineer. The term "Modified Rational Method" used herein refers to a procedure for manipulation of the basic rational method techniques to reflect the fact that storms with a duration greater than the normal time of concentration for a basin will result in a larger volume of runoff even though the peak discharge is reduced. The methodology and model chosen for use shall be well documented as being appropriate for use in this region, and all relevant assumptions, methodologies, calculations and data used shall be provided to the municipal engineer for review. Information on the Modified Rational Method is presented in the Recommended Hydrologic Procedures for Computing Urban Runoff from Small Watersheds in Pennsylvania (PADEP, 1982).

4.2.5 Rainfall intensities used for the Modified Rational Method shall be based on the current Penn DOT Storm Intensity-Duration-Frequency chart appropriate to the specific site.

4.2.6 The Rational Method (that is,  $Q = CIA$ ) shall be used for calculations of the peak rate of runoff for the design of storm sewers and drainage swales. The equation representing the Rational Method is comprised of the following (in English units):

Q = Peak flow rate, cubic feet per second (CFS)  
 C = Runoff coefficient, dependent on land use/cover  
 I = Design rainfall intensity, inches per hour  
 A = Drainage area, acres.

- 4.2.7 Runoff characteristics of off-site areas that drain through a proposed development shall be based on actual existing conditions.

#### 4.3 Design Standards for Stormwater Management Practices

The Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD, 1998), (latest edition or the PA stormwater management design manual when published), shall serve as a guide for the design of stormwater management practices. Additional design guidance may also be obtained from other related sources, including the 2000 Maryland Stormwater Design Manual, Volumes I and II (MDE, 2000), Design of Stormwater Filtering Systems (CWP, 1996), and the American Society of Civil Engineers Manual and Report on Engineering Practice, No. 87, Urban Runoff Quality Management (ASCE, 1998) for the design of stormwater runoff quality control features for site development. A list of references is provided with this ordinance. The Water Quality Volume design measures used herein are partially based on the methodology expressed in the Maryland manual referenced above. Water Quality Volume (WQv) represents the storage needed to capture and treat the runoff from ninety percent (90%) of the average annual rainfall. Applicants are encouraged to refer to the Maryland manual for additional guidance.

Pursuant to the design options recommended in the above documents, the following standards shall be adhered to:

##### 4.3.1 Runoff Volume and Water Quality Facility Sizing Criteria

The following sizing criteria shall be followed at all sites required to meet the standards of this Ordinance.

##### A. Runoff Volume

1. Stormwater runoff shall be managed according to a hierarchy in which the minimum design standards are examined in the following order:
  - a. To the extent that a site is located in and/or discharges to a stream or water body designated by the Commonwealth of Pennsylvania as High Quality and/or Exceptional Value Special Protection Watershed and is altered as a result of development, **there shall be no net increase in the total volume of stormwater discharged from the site over that which was calculated for the predevelopment condition** (as defined in Section 4.2.2.A) **as a result of the runoff generated by the two-year, twenty-four hour storm.** Compliance with this standard shall also satisfy the Water Quality Volume criteria described in Section 4.3.1.B. However, those drainage areas that do not satisfy this standard shall meet the water quality volume criteria described in Section 4.3.1.B. Achieving this standard will contribute significantly to maintaining constant total stormwater volumes.

- b. To the extent that a site is **not** located in and does not discharge to a stream or water body designated by the Commonwealth of Pennsylvania as High Quality and/or Exceptional Value Watershed or any site where the Applicant can demonstrate through on-site soils evaluations and supporting engineering calculations that site conditions preclude a design complying with Section 4.3.1.A.1.a, above, **then best management practices shall be provided that capture and infiltrate, or otherwise permanently retain on site the total volume of runoff generated from the one inch (1.0"), twenty-four hour storm such that this quantity of runoff is not discharged from the site.** The calculation of runoff generated shall be based on a summation of the runoff generated by each individual cover type. Impervious and pervious covers shall be calculated separately. The averaging or weighting of a composite curve number (CN) or runoff coefficient (c) is prohibited for volume calculations. Runoff calculations shall include all areas proposed to be disturbed and/or regraded.
- c. Where the Applicant can demonstrate through on-site soils evaluations and supporting engineering calculations that site conditions preclude a design complying with Section 4.3.1.A.1.b above, **then best management practices shall be provided that capture and infiltrate, or otherwise permanently retain on site the largest percentage of the total volume of runoff generated from the one inch (1.0"), twenty-four hour storm that site conditions allow such that this quantity of runoff is not discharged from the site.** The calculation of runoff generated shall be based on a summation of the runoff generated by each individual cover type. Impervious and pervious covers shall be calculated separately. The averaging or weighting of a composite curve number (CN) or runoff coefficient (c) is prohibited for volume calculations. Runoff calculations shall include all areas proposed to be disturbed and/or regraded.
- d. In complying with Section 4.3.1.A.1.a, Section 4.3.1.A.1.b and Section 4.3.1.A.1.c, above, **infiltration practices shall be provided that capture and infiltrate at least the first one-half-inch (0.5") of runoff generated by each rainfall event from all impervious areas to assure protection of ground water recharge.**

#### Infiltration Volume Required

$$= I * \text{Impervious Area (S.F.)} / 12 \text{ (inches)} = \text{Cubic Feet}$$

$$I = \text{Maximum Equivlent Infiltration Amount (Inches)}$$

- e. Water quality improvement shall be achieved in conjunction with the standards described in Section 4.3.1.A.1.a, b, c and d as well as in drainage areas not otherwise provided with stormwater runoff volume management practices. The Water Quality Volume (WQv) shall be calculated per Section 4.3.1.B and shall meet the following standard:

1. If the calculated WQv is less than the volume infiltrated and/or retained on site, then the WQv requirement is satisfied.
2. If the calculated WQv is greater than the volume required to be infiltrated and/or retained on site, then the difference between the two volumes shall be treated for water quality by an acceptable stormwater management practice(s).

#### B. Water Quality Volume

1. Treatment of the Water Quality Volume (WQv) of stormwater prior to its release to receiving waters or water bodies shall be provided at all developments where stormwater management is required. The WQv equals the storage volume needed to capture and treat the runoff from storms of one (1) inch or less. Runoff from the first one (1) inch of rainfall transports most of the total pollutant load. The one (1) inch storm event represents 80% of the total volume of rainfall and 95% of all rainfall events that occur in a typical year in Chester County. Thus, capture of a one (1) inch storm is established as the criteria for calculating the WQv.

The WQv is based on the following equation:

$$WQv = [(P)(Rv)(A)]/12 \text{ (acre-feet)}$$

Where:

P = rainfall depth in inches (set to 1 inch)

Rv = volumetric runoff coefficient,  $0.05 + 0.009(I)$  where I is percent impervious cover

A = area (acres).

2. The formula assumes approximately five percent (5%) runoff from pervious surfaces, and ninety percent (90%) runoff from impervious surfaces. A minimum of 0.2 inches per acre of runoff volume shall be met at sites or in drainage areas that have less than fifteen percent (15%) impervious cover.
3. Drainage areas having no impervious cover and no proposed disturbance during development may be excluded from the WQv calculations. However, designers are encouraged to incorporate water quality treatment practices for these areas.
4. Stormwater Quality Treatment: The final WQv shall be treated by an acceptable stormwater management practice(s) from those described in this Section or as approved by the Borough of Avondale.
  - a. For new developments and redevelopments, infiltration is considered an acceptable method of satisfying part or all of the Water Quality Volume.

- b. For new developments, the WQv requirements of this section shall be sized and designed in conjunction with the standards under Section 4.3.1.A.

5. As a basis for design, the following assumptions may be made:

- a. Multiple Drainage Areas: When a project contains or is divided by multiple drainage areas, the WQv volume shall be addressed for each drainage area.
- b. Offsite Drainage Areas: The WQv shall be based on the impervious cover of the proposed site. Offsite existing impervious areas may be excluded from the calculation of the water quality volume requirements.

#### 4.3.2 Stormwater Infiltration Practices

- A. Infiltration practices shall be selected based on suitability of soils and site conditions. Initial site evaluation shall include the information provided in Appendix D Soil Use Guide. Acceptable infiltration practices include, but are not limited to: filter strips or stormwater filtering systems (for example bioretention facilities, sand filters), open vegetated channels (that is, dry swales and wet swales), infiltration trenches, dry wells, subsurface infiltration basins, retention basins, wet extended detention ponds, riparian corridor management, riparian forested buffers, rooftop runoff management systems, and sand filters (closed or open), or as otherwise described in the manuals referenced in Section 4.3 and Appendix E.

Where sediment transport in the stormwater runoff is anticipated to reach the infiltration system, appropriate permanent measures to prevent or collect sediment shall be installed prior to discharge to the infiltration system.

- B. Pursuant to Section 4.1.2.B soil infiltration tests shall be performed. The soil infiltration rate of discharge from the infiltration area being used in the proposed design shall be based on these measurements.

Soil evaluations shall be performed to determine the feasibility and extent to which infiltration systems can be used. The evaluation shall be performed by a qualified, licensed geologist, geotechnical/civil engineer or soil scientist and, at a minimum, address soil types, soil permeability, depth to bedrock, limitations of soils, presence/absence of carbonate geology susceptibility to subsidence and/or sinkhole formation and subgrade stability. The testing and evaluation should be completed at the preliminary design stage. See Section 4.3.2.L for discussion of infiltration in areas of karst and/or carbonate geology.

Infiltration requirements shall be based on the portions of the site that are permeable prior to disturbance and the degree to which development will reduce the permeability of the site. Permeability of the site shall be determined based on the detailed evaluations described herein. Use of stormwater management practices to retain stormwater for infiltration should be applied to all areas where the soils evaluation indicates favorable conditions. Areas generally not favorable



for infiltration shall still be provided with an appropriate water quality practice (refer to Section 4.1.3.A.4).

Soil infiltration tests shall be performed to an equivalent depth or elevation of the bottom of the proposed infiltration areas. These tests shall follow the procedures of percolation test holes as established by the Chester County Health Department (CCHD) for on-lot septic systems. The testing shall include a test pit and percolation test holes. The test hole shall be excavated to a depth so that the presence or absence of bedrock and/or seasonal high water table can be determined. A soil log describing the soils present in each test pit shall be performed. All test holes used for evaluating the percolation rate shall be pre-soaked in accordance with the procedures established by the CCHD. The location and number of test pits and percolation holes shall be determined based on the type(s) of stormwater management practices being designed in consultation with and guidance from the municipal engineer. Acceptability of infiltration rates shall be based on sound engineering judgment and recommended design considerations described in the design manuals listed in the references or other source material acceptable to the municipal engineer.

- C. All infiltration practices shall be set back at least fifteen (15) feet from all structures with sub-grade elements (e.g., basements, foundation walls).
- D. The lowest elevation of the infiltration area shall be at least two (2) feet above the Seasonal High Water Table and bedrock, except in the case of areas underlain by karst and/or carbonate geology, in which case the distance shall be determined on a site specific basis (refer to Section 4.3.2.L).
- E. Where roof drains are designed to discharge to infiltration practices, they shall have appropriate measures to prevent clogging by unwanted debris (for example, silt, leaves and vegetation). Such measures shall include but are not limited to leaf traps, gutter guards and cleanouts.
- F. All infiltration practices shall have appropriate positive overflow controls.
- G. All infiltration practices shall be designed to infiltrate the stored volume within seventy-two (72) hours.
- H. All surface inflows shall be treated to prevent the direct discharge of sediment into the infiltration practice; accumulated sediment reduces stormwater storage capacity and ultimately clogs the infiltration mechanism. No sand, salt or other particulate matter may be applied to a porous (pervious) surface for winter ice conditions.
- I. During site construction, all infiltration practice components shall be protected from compaction due to heavy equipment operation or storage of fill or construction material. Infiltration areas shall also be protected from sedimentation. Areas that are accidentally compacted or graded shall be remediated to restore soil composition and porosity. Adequate documentation to this effect shall be submitted for review by the municipal engineer. All areas

designated for infiltration shall not receive runoff until the contributory drainage area has achieved final stabilization.

- J. The following procedures and materials shall be required during the construction of all subsurface facilities:
  1. Excavation for the infiltration facility shall be performed with equipment that will not compact the bottom of the seepage bed/trench or like facility.
  2. The bottom of the bed and/or trench shall be scarified prior to the placement of aggregate.
  3. Only clean aggregate with documented porosity, free of fines, shall be allowed.
  4. The tops and sides of all seepage beds, trenches, or like facilities shall be covered with drainage fabric. Fabric shall meet the specifications of Penn DOT Publication 408, Section 735, Construction Class 1.
  5. Perforated distribution pipes connected to centralized catch basins and/or manholes with the provision for the collection of debris shall be provided in all facilities unless the municipal engineer agrees that site soils provide superior infiltration (A soils or highly porous B soils). Where perforated pipes are used to distribute stormwater to the infiltration practice, stormwater shall be distributed throughout the entire seepage bed/trench or like facility.
- K. All infiltration practices that serve more than one (1) lot and are considered a common facility shall have a drainage easement. The easement shall provide to the Borough of Avondale the right of access.

#### 4.3.3 Open Vegetated Channels

- A. Open Vegetated Channels are conveyance systems that can be engineered to also perform as water quality and infiltration practices. Such systems may be used for the conveyance, retention, infiltration and filtration of stormwater runoff, subject to approval of the Borough Engineer.
- B. Open Vegetated Channels primarily serve a water quality function (WQv), they also have the potential to augment infiltration. Examples of such systems include, but are not limited to: dry swales, wet swales, grass channels, and biofilters. Open vegetated Channels are primarily applicable for land uses such as roads, highways, residential developments (dry swales only) and pervious areas.
- C. Open Vegetated Channels shall be designed to meet the following minimum standards:
  1. The channel shall be designed to safely convey the twenty-five-year frequency storm event with a freeboard of at least six (6) inches. Freeboard is the difference between the elevation of the design flow in the channel and the top elevation of the channel.

2. The peak velocity of the runoff from the twenty-five-year storm shall be non-erosive for the soil and ground cover provided in the channel.
3. The longitudinal slope shall be no greater than four percent (4%).
4. Channels shall be trapezoidal in cross section. The minimum bottom width shall be two (2) feet. The maximum bottom width shall be eight (8) feet.
5. Channels shall be designed with moderate side slopes of four (4) horizontal to one (1) vertical. Flatter side slopes may be necessary under certain circumstances.
6. The maximum allowable ponding time in the channel shall be less than 48 hours.
7. Channels (for example, dry swales) may require an underdrain in order to function and dewater.
8. Channels shall be designed to temporarily store the WQv within the system for a maximum period of 48 hours and a minimum period of one (1) hour.
9. Landscape specifications shall address the grass species, wetland plantings (if applicable), soil amendment and hydric conditions present along the channel.
10. Accumulated sediment within the channel bottom shall be removed when twenty-five (25%) of the original WQv volume has been exceeded.
11. Check dams along the channel length may be warranted.
12. The bottom of dry swales shall be situated at least two (2) feet above the seasonal high water table.

D. Additional design information for Open Vegetated Channels is available in Design of Stormwater Filtering Systems (CWP, 1996).

#### 4.3.4 Retention Basins

- A. Retention basins shall be designed to create a healthy ecological community with sufficient circulation of water to prevent the growth of unwanted vegetation and mosquitoes. Care should be taken to landscape retention basins in accordance with Section 4.4.
- B. The retention basin shall be of sufficient size to allow the appropriate aquatic community needed to maintain healthy pond ecology and avoid mosquitoes capable of carrying West Nile Virus and other diseases. The Chester County Health Department, Pennsylvania Fish and Boat Commission, the Natural Resource Conservation Service, the Pennsylvania Extension Service, or other qualified professional consultant shall be consulted during the design of these

facilities in order to ensure the health of aquatic communities and minimize the risk of creating mosquito breeding areas.

- C. An outlet structure shall be designed to allow complete drainage of the pond for maintenance.
- D. The design of a retention basin shall include the determination of the proposed site's ability to support a viable permanent pool. The design shall take into account such factors as the available and required rate and quality of dry weather inflow, the stormwater inflow, seasonal and longer-term variations in ground water table, and impacts of potential pollutant loadings.
- E. Sediment storage volume equal to at least twenty percent (20%) of the volume of the permanent pool shall be provided.
- F. A sediment forebay with a hardened bottom shall be provided at each inlet into the retention basin. The forebay storage capacity shall at minimum be ten percent (10%) of the permanent pool storage. The forebay shall be designed to allow for access by maintenance equipment for periodic cleaning and must not permanently pond water.
- G. Emergency spillways shall be sized and located to permit the safe passage of stormwater flows from a 100-year storm. The maximum velocities in vegetated spillways excavated in otherwise undisturbed soil shall be analyzed based upon the velocity of peak flow in the emergency spillway during an assumed clogged primary outlet condition. Where maximum velocities exceed design standards contained in the Engineering Field Manual for Conservation Practices (USDA, SCS, July 1984) suitable lining shall be provided. All emergency spillways placed on fill materials shall be lined. Lining for emergency spillways shall incorporate native colors and materials where possible including mono slab revetments, grass pavers and native stone.
- H. Existing ponds or permanent pool basins can be used for stormwater management provided that it can be demonstrated that the ponds are structurally sound and meet the design requirements herein.
- I. Inlet structures and outlet structures shall be separated to the greatest extent possible in order to maximize the flow path through the retention basin.
- J. Retention basins shall be designed to provide a length-to-width ratio of at least 3L:1W as measured in plan view (for example, a ratio of 4L:1W is too narrow).
- K. The retention basin depth shall average three (3) to six (6) feet with no area shallower than three (3) feet. In residential areas, ponds shall be equipped with management practices that reduce the potential for unauthorized entry and use of the pond by the general public. Preference shall be given to split rail fences equipped with mesh wire or other such practices that are both functional and attractive. A securable gate shall be provided to allow for periodic maintenance equipment/vehicle access. Any fence or barrier around a retention basin shall be

no less than 42 inches in height or as otherwise required by local building codes or ordinances.

- L. An aquatic bench/shelf at least ten (10) feet wide and with a gentle slope not exceeding 10H:1V shall be provided along the entire perimeter of the retention basin.
- M. Any side slopes below the permanent water surface level shall not exceed 5H:1V. Side slopes above the permanent water surface level shall not exceed 3H:1V.
- N. Stabilization. Proper stabilization structures, including stilling basins, energy dissipaters, and channel lining shall be constructed at the outlets of all retention basins and emergency spillways. The stabilization structures shall control water to: avoid erosion; reduce velocities of released water and direct water so that it does not interfere with downstream activities.
- O. Energy Dissipaters and Level Spreaders. Energy dissipaters and/or level spreaders shall be installed to prevent erosion and/or initiate sheet flow at points where pipes or drainage ways discharge to or from basins. Energy dissipaters shall comply with criteria in Hydraulic Engineering Circular No. 15- Design for Stable Channels with Flexible Linings (USDOT, FHWA, 1986) or the Engineering Field Manual for Conservation Practices (USDA, SCS, July 1984). Such facilities shall be both functional and harmonious with the surrounding environment; for example, native rock shall be used in constructing dissipaters where practical.
- P. Discharge Points. The minimum distance between a proposed basin discharge point (including the energy dissipater, etc.) and a downstream property boundary shall in no case be less than twenty-five (25) feet. Where there is discharge onto or through adjacent properties prior to release to a stream, designers shall demonstrate how downstream properties are to be protected. The municipal engineer may require that the setback distance be increased based upon factors such as topography, soil conditions, the size of structures, the location of structures, and discharge rates. A drainage easement may also be required.
- Q. Outlet Structures. Outlet structures shall meet the following specifications:
  1. To minimize clogging and to facilitate cleaning and inspecting, outlet pipes shall have an internal diameter of at least fifteen (15) inches and a minimum grade of one half percent (0.50%).
  2. Anti-seep collars shall be provided on all outlet pipes within a constructed berm.
  3. All principal outlet structures shall be built using reinforced concrete with watertight construction joints.
  4. The use of architecturally treated concrete, stucco, painted surface or stone facade treatment shall be considered for enhancing the outlet structure. Such

facilities shall be both functional and harmonious in design with the surrounding environment. .

5. Outlet pipes shall be constructed of reinforced concrete with rubber gaskets in conformance with AASHTO M170, M198 and M207.
6. Basin outlet structures shall have childproof non-clogging trash racks over all design openings exceeding twelve (12) inches in diameter except those openings designed to carry perennial stream flows. Periodic cleaning of debris from trash racks shall be included in the operation and maintenance plan.
7. Anti-vortex devices, consisting of a thin vertical plate normal to the basin berm, shall be provided at the top of all circular risers or stand pipes.

#### 4.3.5 Detention Basins

- A. Detention basins are generally discouraged as a stormwater management practice and should only be used as a last resort where no other management facility is practical. Detention basins typically collect and quickly release runoff from a site in a manner that is contrary to the principles, goals and standards presented within this ordinance. The landscape standards of Section 4.4 shall apply.
- B. The maximum inside side slopes shall not exceed three (3) horizontal to one (1) vertical (3H:1V). The minimum required slope for the basin bottom is two percent (2%). A level bottom is acceptable, provided the designer demonstrates to the Borough of Avondale's satisfaction that the basin bottom will be landscaped with appropriate wetland vegetation pursuant to Section 4.4. In addition, Detention Basins of sufficient size and slope may serve other functions as well, including recreational uses which do not hinder or conflict with the function of the detention basin.
- C. Inlet Structures. The inlet pipe invert into a basin shall be at least six (6) inches above the basin floor or lining so that the pipe can adequately drain after rainstorms. Inlets shall discharge into areas of the basin that slope toward the outlet structure.
- D. Inlet structures and outlet structures shall be separated to the greatest extent possible in order to maximize the flow path through the retention basin.
- E. Low Flow Channels. Low flow channels constructed of concrete or asphalt are not permitted. Where low flow channels are necessary, they shall be composed of a natural or bioengineered material. Low flow channels shall be designed to promote water quality and slow the rate of flow through the basin. Low flow channels may also be designed to infiltrate where practical.
- F. Outlet Structures. Outlet structures shall meet the following specifications:

1. To minimize clogging and to facilitate cleaning and inspection, outlet pipes shall have an internal diameter of at least fifteen (15) inches and a minimum grade of one half percent (0.50%).
  2. Anti-seep collars shall be provided on all outlet pipes within a constructed berm.
  3. All principal outlet structures shall be built using reinforced concrete with watertight construction joints.
  4. The use of architecturally treated concrete, stucco, painted surface or stone facade treatment shall be considered for enhancing the outlet structure. Such facilities shall be both functional and harmonious in design with the surrounding environment.
  5. Outlet pipes shall be constructed of reinforced concrete with rubber gaskets in conformance with AASHTO M170, M198 and M207.
  6. Energy dissipation practices that convert concentrated flow to uniform shallow sheet flow shall be used where appropriate.
  7. Basin outlet structures shall have childproof non-clogging trash racks over all design opening exceeding twelve (12) inches in diameter except those openings designed to carry perennial stream flows.
  8. Anti-vortex devices, consisting of a thin vertical plate normal to the basin berm, shall be provided at the top of all circular risers or stand pipes.
- G. Emergency spillways shall be sized and located to permit the safe passage of stormwater flows from a 100-year storm. The maximum velocities in vegetated spillways excavated in otherwise undisturbed soil shall be analyzed based upon the velocity of peak flow in the emergency spillway during an assumed clogged primary outlet condition. Where maximum velocities exceed design standards contained in the Engineering Field Manual for Conservation Practices (USDA, SCS, July 1984) suitable lining shall be provided. In general, emergency spillways should not be located in fill areas; all such practices placed on fill materials shall be lined. Lining for emergency spillways shall incorporate native colors and materials where possible, including mono slab revetments, grass pavers and native stone.
- H. Freeboard. Freeboard is the difference between the elevation of the design flow in the emergency spillway (usually the 100 year peak elevation) and the top elevation of the settled basin embankment (that is, top of berm). The minimum freeboard shall be one (1) foot.
- I. Energy Dissipaters and Level Spreaders. Energy dissipaters and/or level spreaders shall be installed to prevent erosion and/or initiate sheet flow at points where pipes or drainage ways discharge to or from basins. Energy dissipaters shall comply with criteria in Hydraulic Engineering Circular No. 15- Design for Stable Channels with Flexible Linings (USDOT, FHWA, 1986) or the

Engineering Field Manual for Conservation Practices (USDA, SCS, July 1984). Such facilities shall be both functional and attractive; for example, native rock shall be used in constructing dissipaters where practical.

- J. Stabilization. Proper stabilization structures, including stilling basins, energy dissipaters, and channel lining, shall be constructed at the outlets of all basins and emergency spillways. The stabilization structures shall control water to: avoid erosion, reduce velocities of released water and direct water so that it does not interfere with downstream activities.
- K. Discharge Points. The minimum distance between a proposed basin discharge point (including the energy dissipater, etc.) and a downstream property boundary shall in no case be less than twenty-five (25) feet. Where there is discharge onto or through adjacent properties prior to release to a stream, designers shall demonstrate how downstream properties are to be protected. The municipal engineer may require that the setback distance be increased based upon factors such as topography, soil conditions, the size of structures, the location of structures, and discharge rates. A drainage easement may also be required.
- L. A sediment forebay with a hardened bottom shall be provided at each inlet into the detention basin. The forebay storage capacity shall at minimum be ten (10) percent of the permanent pool storage. The forebay shall be designed to allow for access by maintenance equipment for periodic cleaning. Forebays shall not permanently pond water.

#### 4.3.6 Conveyance Systems (Open Channels, Drainageways, and Storm Sewers)

- A. Applicants are encouraged to design conveyance systems that encourage infiltration and improve water quality wherever practicable. Open Channels proposed for the sole purpose to avoid installation of pipe culvert as a cost savings shall not be permitted.
- B. Wherever conveyance channels are necessary, subject to Borough Engineer approval, drainage shall be maintained by an open channel with landscaped banks designed to carry the 100-year, 24-hour stormwater runoff from upstream contributory areas. All open channels shall be designed with one (1) foot of freeboard above the design water surface elevation of the design runoff condition.
- C. Flood relief channels shall be provided and designed to convey the runoff from the 100-year, 24-hour storm, such that a positive discharge of this runoff to an adequate receiving stream or conveyance system occurs without allowing this runoff to encroach upon other properties.
- D. Open channels along existing roadways may be required to be enclosed by the Borough if Penn DOT standards for safety and maintenance cannot be satisfied. All drainage structures shall conform to the latest edition of Form 408, Penn DOT specifications.



- E. Manholes and/or inlets shall not be spaced more than three hundred (300) feet apart for pipe sizes up to twenty-four (24) inches in diameter and not more than four hundred fifty (450) feet apart for larger pipe sizes.
- F. Where drainage swales are used in lieu of or in addition to storm sewers, they shall be designed to carry the required runoff without erosion and in a manner not detrimental to the properties they cross. Drainage swales shall provide a minimum grade of two percent (2%) but shall not exceed a grade of nine percent (9%). Drainage swales used strictly for conveyance are not the same as Open Vegetated Channels. Design standards for Open Vegetated Channels are provided under Section 4.3.3 of this ordinance.
- G. On streets that must contain curbing, storm sewers shall be placed in front of the curbing. To the greatest extent possible, storm sewers shall not be placed directly under curbing. At curbed street intersections, storm inlets shall be placed in the tangent section of the road.
- H. Use of grassed swales or open vegetated swales in lieu of curbing to convey, infiltrate and/or treat stormwater runoff from roadways is subject to Borough approval. When permitted, Inlets shall be placed at the center of the shoulder swale draining the street and shall be located no closer than four (4) feet from the edge of the cartway.
- I. Avondale Borough shall be granted a minimum twenty (20)-foot-wide drainage easement over all storm sewers, drainage swales, channels, etc., that are a component of the stormwater management system when located within undedicated land. All permanent detention basins and/or other stormwater management facilities providing stormwater control for other than a single residential lot shall be located within a defined drainage easement that allows proper legal access and maintenance vehicle access by Avondale Borough personnel if the need arises for such access.
- J. No property owner shall obstruct or alter the flow, location or carrying capacity of a stream, channel or drainage swale to the detriment of any other property owner, whether upstream or downstream. All subdivision and/or land development plans containing streams, channels, drainage swales, storm sewers or other conveyance systems that cross property boundaries, existing or proposed, or whose discharge crosses such boundaries shall contain a note stating the above.
- K. Water Quality Inlets. Storm drainage systems that collect runoff from parking areas and/or loading areas exceeding 10,000 square feet of impervious coverage and discharge to stormwater management systems, including surface or subsurface infiltration systems, shall have a minimum of one (1) water quality inlet per each acre of drainage area. The purpose of water quality inlets is to remove oil, grease, and heavy particulates or total suspended solids, hydrocarbons and other floating substances from stormwater runoff. Methods other than water quality inlets may be permitted if the Applicant demonstrates to the Borough's satisfaction that any such alternative will be as effective and as

easily maintained. Periodic cleaning of these systems shall be addressed in the Operation and Maintenance Plan submitted to the Borough of Avondale.

#### 4.4 Landscaping of Stormwater Management Practices

Stormwater management practices shall be landscaped in accordance with the following standards. Landscape plans shall be prepared by a professional Landscape Architect licensed in the Commonwealth of Pennsylvania.

- 4.4.1 Landscaping shall be required in and around all constructed stormwater management practices with a minimum surface area of one thousand (1,000) square feet for the purposes of:
  - A. Assisting in the management of stormwater;
  - B. Stabilizing the soil within such facilities to minimize and control erosion;
  - C. Enhancing the visual appearance of such facilities; and
  - D. Mitigating maintenance problems commonly associated with the creation of such facilities.
- 4.4.2 A planting plan and planting schedule shall be submitted in accordance with the following:
  - A. Wet meadows including floors of stormwater management practices.
    1. Wet meadows and floors of stormwater management practices shall be planted with wildflowers and nonaggressive grasses, the intent being to create a mixed meadow of such plantings, where appropriate. Selection of plantings shall be based on whether the area in question is usually well drained or permanently wet and whether the area will be used for recreation purposes. No woody plants shall be planted within the saturated zone (phreatic line) of a stormwater management practice or on a berm constructed for impounded water.
    2. Seeding by drills, corrugated rollers, cyclone or drop seeders or hand seeding of such areas is preferred; however, hydroseeding followed by hydromulching can be used on wet ground and steep slopes.
    3. Fertilizers, as a nutrient supplement, shall not be used unless it is documented that soil conditions warrant such use and nutrient applied does not exceed plant uptake. Soil for planting of wildflowers shall contain not less than three percent (3%) or more than ten percent (10%) organic matter, as determined by an agricultural chemist, with certification of the test before planting.
    4. Seeding shall take place either between April 1 and May 15 or between September 1 and October 15. Planting areas shall be soaked to maintain a

consistent level of moisture for at least four (4) to six (6) weeks after planting.

5. Once established, a single annual mowing when plants are dormant should be sufficient to maintain a wet meadow and/or floor of a stormwater management practice.

B. Wet edges that remain wet all or most of the year shall be planted with wildflowers, grasses and shrubs. Plants to be located on rims or banks, which remain dry most of the year, shall be planted with species tolerant of dry soil conditions.

C. Wooded areas

1. Where stormwater management practices adjoin wooded areas, trees and shrubs shall be selected and planted outside the practice so as to blend with existing surroundings.
2. Plantings in such areas shall be of sufficient density to eliminate the need for mowing.
3. It is recommended that clusters of trees and shrubs be planted around stormwater management facilities but well away from outfalls and any constructed berms, where applicable, to provide for wildlife habitat, wind control and buffering and screening.
4. Vegetation shall be planted during appropriate times of the year, predominantly between late March and mid May or from early October until evidence of ground freezing, depending upon the species selected. Most deciduous trees and shrubs can be planted in either spring or fall. Evergreens are best planted in late summer or early fall.

D. Slopes

1. Where slopes are gentle, a mixture of meadow grasses and wildflowers (for wet meadows) shall be planted.
2. On steep slopes as defined by the Avondale Borough code of ordinances, dense spreading shrubs (shrubs tolerant of dry soils) shall be planted. Heavy mat mulch shall be used during the period of establishment.
3. No woody plant materials or trees shall be located on a constructed or natural berm acting as the impoundment structure of a stormwater management practice. Trees shall be located downstream of an impoundment berm a sufficient distance from the toe of the constructed slope to assure that the toe of the slope is outside the dripline of the species planted at maturity but in no case less than fifteen (15) feet.

E. In cases where stormwater management practices are to be located in proximity to wetlands or waterways, the Applicant's planting plan and schedule shall

consider the sensitive conditions existing therein and be modified accordingly to reflect existing flora.

- F. Stormwater management practices shall be screened in a manner which complements the existing landscape and provides sufficient access for maintenance.

## **Section 5.0 OPERATION AND MAINTENANCE RESPONSIBILITIES**

### **5.1 General Responsibilities**

- 5.1.1 The owner of stormwater management facilities shall be responsible for the proper operation and maintenance of those facilities during and after construction. An Operation and Maintenance Plan consistent with the requirements of Section 5.3 shall be prepared for review and approval by the Borough engineer and shall be executed by Applicant.
- 5.1.2 The Owner of the stormwater management facilities for a tract shall be responsible for the proper installation and function of those facilities in accordance with the approved Stormwater Management Plan. All temporary soil erosion and sedimentation control measures shall be removed or converted to their permanent configuration in accordance with an approved erosion control plan. This requirement in no way precludes the authority of the Chester County Conservation District to determine when sufficient stabilization has occurred on a site in order to convert to the permanent stormwater management facilities.
- 5.1.3 Dedication and Acceptance of Stormwater Management Practices.
  - A. Upon completion of construction of stormwater management facilities shown on an approved subdivision or land development plan and within ninety (90) days after approval of such construction, the Applicant shall submit written offer of such stormwater management facilities for dedication to the Borough. Said offer shall include a deed of dedication covering said facilities together with satisfactory proof establishing an Applicant's clear title to said property. Such documents are to be filed with the Borough Secretary for review by the Borough Solicitor. Deeds of dedication for stormwater management facilities may be accepted by resolution of the Avondale Borough at a regular meeting thereof. The Borough of Avondale reserves the right but not the obligation to accept dedication of stormwater management facilities.
  - B. Avondale Borough may require that stormwater management facilities remain undedicated, with operation and maintenance the responsibility of individual lot owners or a homeowners association or similar entity, or an organization capable of carrying out maintenance responsibilities.
  - C. Regardless of ownership, the Applicant shall submit a written offer deeding an access and/or drainage easement to Avondale Borough pursuant to Section 5.2. Such easement shall cover the stormwater management facilities, any drainage to and from such facilities, and shall clearly permit entry for inspection and/or maintenance purposes.

- D. Regardless of ownership, the Applicant shall submit to Avondale Borough an actual "as built" plan for the stormwater management facilities required per the approved Stormwater Management Plan. The "as built" plan shall show all final design specifications for all permanent stormwater management facilities and shall be prepared and certified by a licensed professional engineer. The "as built" plan shall be based on an actual field survey performed by a licensed professional land surveyor. The surveyor shall certify as to the accuracy of the plan. The "as built" plan shall be submitted to Avondale Borough for review and final inspection by the municipal engineer. Any performance and/or financial securities established for the project shall include requirements for submittal of "as built" plans.

## 5.2 Ownership and Maintenance

All stormwater management facilities identified within an approved Stormwater Management Plan shall be owned and maintained by one, or a combination of, the following entities:

### 5.2.1 Individual On-Lot Stormwater Management Facilities

- A. Where individual on-lot stormwater management facilities are proposed, the subdivision and/or land development plan shall contain a note in a form satisfactory to the Avondale Borough Solicitor designating the entity responsible for operation and maintenance of the on-lot facilities consistent with an approved Operation and Maintenance Plan and, in the event that the responsible person or entity fails to do so, granting to the Avondale Borough the right but not the duty to enter upon the premises to repair or restore said facilities, to charge and assess the costs thereof to the owner and to enforce said charges and assessments by lien upon the property. In addition, the deed for each lot shall contain a covenant binding on the grantee and all successors in interest designating the responsibility for operation and maintenance of the on-lot facilities. The following is an example of such a clause:

"UNDER AND SUBJECT, nevertheless, to the following conditions and restrictions: Prior to the construction of a dwelling or any other earthmoving activities, Grantee shall construct the permanent stormwater management facilities as shown on the stormwater management plan prepared by \_\_\_\_\_, P.E., dated and last revised and approved by Avondale Borough; thereafter, the Grantee, his heirs, executors, administrators, successors and assigns ("owner"), at his or their sole cost and expense, shall operate, maintain and repair said stormwater management facilities on the lot in accordance with said plan, so that the facilities shall at all times continue to operate and function in the same manner and capacity as they were designed. In the event of the failure of the owner to comply with these conditions and restrictions, Avondale Borough shall have the right but the obligation to have said stormwater management facilities repaired or restored as required, and the costs thereof shall be assessed to the owner; said assessment shall be a charge and a continuing lien upon the property herein. The Borough of Avondale, before it may exercise this right, shall notify the owner by certified mail of its intention to take the aforementioned

action. The notice shall set forth in what manner the owner has neglected the operation and maintenance of or repair to the stormwater management facilities, and if the owner fails to correct or repair the items listed in the notice from the Avondale Borough, then and only then may the Avondale Borough exercise this right."

- B. In addition to the above, the Developer shall record in the Office of Recorder of Deeds for Chester County a declaration of covenants and restrictions in a form satisfactory to the Borough Solicitor describing the responsibility for operation and maintenance of the on-lot facilities, consistent with an approved Operation and Maintenance Plan, prior to the sale of any individual lots. The terms of this covenant and restriction shall run with the land and be binding upon the initial grantees of each lot within the subdivision, his, her or their heirs, administrators, successors or assigns.

#### 5.2.2 Homeowners or Condominium Association Ownership

Where a homeowners' association is created to own and manage common facilities, the subdivision and/or land development plan shall contain a note in a form satisfactory to the Borough Solicitor designating the entity responsible for construction and/or maintenance of the stormwater management facilities consistent with an approved Operation and Maintenance Plan and, in the event that the responsible entity fails to do so, granting to the Borough of Avondale the right but not the duty to enter upon the premises to repair or restore said facilities, to charge and assess the costs thereof to each owner of property within the development and to enforce said charges and assessments by lien upon each property within the development. In addition, the developer shall record in the office of Recorder of Deeds for Chester County a declaration of covenants in a form satisfactory to the Borough Solicitor setting forth the rights and responsibilities of the homeowners' association for operation and maintenance of the stormwater management facilities, prior to the sale of individual lots. The terms of this covenant and restriction shall run with the land and be binding upon the initial grantees of each lot within the subdivision, his, her or their heirs, administrators, successors and assigns.

#### 5.2.3 Municipal Ownership

Where the Borough of Avondale has accepted an offer of dedication of the permanent stormwater management facilities, the Borough shall be responsible for operation and maintenance. Municipal ownership notwithstanding, the Applicant is required to prepare a Stormwater Management Plan and an Operation and Maintenance Plan, as defined herein. Upon approval of the stormwater management facilities by the Borough, the Applicant shall provide a lump sum long-term maintenance payment to the Borough, to be reserved and used at all times by Avondale Borough only for costs of operation and maintenance of the dedicated facilities, as follows:

- A. Long-term Maintenance Payment – the long-term maintenance payment shall be in an amount equal to the present value of operation and maintenance costs for the facilities for a ten-year period. The long-term maintenance payment shall be based on a ten-year cost estimate prepared by the Applicant's engineer and reviewed and approved by the municipal engineer. The amount of the payment shall include all costs of operation and maintenance which shall include but not

be limited to, typical operation and maintenance costs as well as costs such as landscaping and planting, tax payments required and construction of any kind associated with the use, benefit and enjoyment of the facilities by the owners. In particular, a description of routine facility operation and day-to-day management requirements and a description of projected maintenance actions and schedules necessary to ensure proper operation of stormwater management facilities shall be submitted for review and approval to the municipal engineer.

- B. Documentation. The terms of the long-term maintenance payment shall be documented as part of the Stormwater Management Plan and the Operation and Maintenance Plan.

### 5.3 Operation and Maintenance Plan

An Operation and Maintenance Plan shall be prepared to identify the ownership, operation and maintenance responsibilities and as-built conditions for all stormwater management facilities. At a minimum, the operation and maintenance plan shall include the following:

- 5.3.1. Any obligations concerning perpetuation and/or maintenance of natural drainage or infiltration facilities, and other facilities identified within the Stormwater Management Plan. Ownership of and responsibility for operation and maintenance of stormwater management facilities, including names and contact information, shall be required.
- 5.3.2. A description of the permanent stormwater management practices on the site, explaining how each practice is intended to function and operate over time. All drainage and access easements shall be depicted and any site restrictions to be recorded against the property shall be identified on the plan. All such easements and restrictions shall be perfected to run with the land and be binding upon the landowner and any successors in interest.
- 5.3.3. A description of the actions, budget and schedule for operating and maintaining the stormwater management facilities. This description should be written in a clear manner, consistent with the knowledge and understanding of the intended user.
- 5.3.4. A general description of operation and maintenance activities and responsibilities for facilities held in common or on-lot, including but not limited to: lawn care, vegetation maintenance, clean out of accumulated debris and sediment (including from grates, trash racks, inlets, etc.), liability insurance, maintenance and repair of stormwater management facilities, landscaping and planting, payment of taxes and construction of any kind associated with the use, benefit and enjoyment of the facilities by the owners. In particular, a description of routine facility operation and day-to-day management requirements (as needed) and a description of routine maintenance actions and schedules necessary to ensure proper operation of stormwater management facilities shall be submitted.
- 5.3.5. Assurances that no action will be taken by any lot owner to disrupt or in any way impair the effectiveness of any stormwater management system, setting forth in deed restrictions the ability of the Borough to take corrective measures if it is determined at any time that stipulated permanent stormwater management facilities have been eliminated, altered, or improperly maintained, including the ability of the Borough to cause the work to be done and lien all costs against the property should the required corrective measures not be

taken by the lot owner, following written notification, within a period of time set by municipal engineer.

- 5.3.6 Parties responsible for the long term operation and maintenance of stormwater management facilities shall make records of the installation and of all maintenance and repairs, and shall retain the records for at least ten (10) years. These records shall be submitted to the Borough as established by the Operation and Maintenance Plan or if otherwise required by Avondale Borough.

#### 5.4 Operations and Maintenance Agreement

- 5.4.1 The owner of any land upon which permanent stormwater management facilities and/or BMPs will be placed, constructed or implemented, as described in an approved Stormwater Management Plan and the Operations and Maintenance Plan, shall record the following documents in the Office of the Recorder of Deeds for Chester County, within 15 days of approval of the Operations and Maintenance Plan by the Municipality:

- A. The Operations and Maintenance Plan, or a summary thereof,
- B. Operations and Maintenance Agreement, and
- C. Access and/or drainage Easements.

- 5.4.2 The Operation and Maintenance Agreement shall be substantially the same as the sample agreement in Appendix C of this Ordinance.

- 5.4.3 Other items or conditions may be included in the Operation and Maintenance Agreement where determined necessary to guarantee the satisfactory operation and maintenance of all permanent stormwater facilities and BMPs. The agreement shall be subject to the review and approval of the Municipality.

- 5.4.4 The Municipality may suspend or revoke any approvals granted for the project site upon discovery of the failure of the owner to comply with Section 5 of this Ordinance.

#### Section 6.0 DEFINITIONS

**AASHTO** - American Association of State Highway & Transportation Officials. The current web site home page for ASHTO is <http://transportation1.org/aashtoneu/>

**Attenuate** – To reduce the magnitude of the flow rate by increasing the time it takes to release a specified volume of runoff (for example the 1 year, 24 hour storm event). Attenuation is a method of reducing the peak flow rates for post development compared to the peak flow rates in predevelopment.

**Aquifer** - A geologic formation, group of formations, or part of a formation that contains sufficient saturated, permeable material to yield useful quantities of ground water to wells and springs.

**Baseflow** – Portion of stream discharge derived from ground water; the sustained discharge that does not result from direct runoff or from water diversions, reservoir releases, piped discharges, or other human activities.



**Best Management Practice (BMP)** – Methods, measures or practices to prevent or reduce surface runoff and/or water pollution, including but not limited to, structural and non-structural stormwater management practices and operation and maintenance procedures.

**CCHD** - Chester County Health Department.

**CFS** – Cubic Feet per Second.

**Channel** - A natural or artificial watercourse that conveys, continuously or periodically, flowing water.

**Conservation Design** - A series of holistic land development design practices that maximize protection of key land and environmental resources, preserve significant concentrations of open space and greenways, evaluate and maintain site hydrology, and ensure flexibility in development design to meet community needs for complementary and aesthetically pleasing development. Conservation Design encompasses the following objectives: conservation/enhancement of natural resources, wildlife habitat, biodiversity corridors and greenways (interconnected open space); minimization of environmental impact resulting from a change in land use (minimum disturbance, minimum maintenance); maintenance of a balanced water budget by making use of site characteristics and infiltration; incorporation of unique natural, scenic and historic site features into the configuration of the development; preservation of the integral characteristics of the site as viewed from adjoining roads; and reduction in maintenance required for stormwater management practices. Such objectives can be met on a site through an integrated development process that respects natural site conditions and attempts, to the maximum extent possible, to replicate or improve the natural hydrology of a site.

**Concentrated Storm Runoff** - Surface runoff from rainfall events, which converges and flows primarily through water conveyance features such as swales, gullies, waterways, channels or storm sewers and which exceeds the maximum specified flow rates of filters or perimeter controls intended to control sheet flow.

**Design Storm** - The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., a 5-year storm) and duration (e.g., 24-hours), used in the design and evaluation of stormwater management systems.

**Detention or To Detain** - The prevention of, or to prevent, the discharge, directly or indirectly, of a given volume of stormwater runoff into surface waters by temporary storage.

**Detention Basin** - An impoundment designed to collect and retard stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate. Detention basins are designed to drain completely shortly after any given rainfall event and are dry until the next rainfall event.

**Discharge** – To release of water from a project, site, aquifer, drainage basin or other point of interest (verb); The rate and volume of flow of water such as in a stream, generally expressed in cubic feet per second (volume per unit of time) (noun).

**Ditch** - An artificial waterway for irrigation or stormwater conveyance.

**Drainage Area** - That land area contributing runoff to a single point and that is enclosed by a ridge line.

**Drainage System** - All facilities and natural features used for the movement of stormwater through and from a drainage area, including, but not limited to, any and all of the following; conduits, pipes and

appurtenant features: channels, ditches, flumes, culverts, streets, swales, gutters as well as all watercourses, water bodies and wetlands.

**EPA** - Environmental Protection Agency.

**Easement** – A right of use of a specified portion of land of another for a specified purpose.

**Erosion** – The wearing away of land surface by water or wind which occurs naturally from weather or runoff, but is often intensified by human activity.

**FEMA** – Federal Emergency Management Agency.

**First Order Stream** – Upper-most perennial tributary in a watershed that has not yet confluenced with another perennial stream. The confluence of two first order streams forms a “second” order stream.

**Ground Water** – Water that occurs in the subsurface and fills or saturates the porous openings, fractures and fissures of under-ground soils and rock units.

**Hotspots** – An area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

**Hydrology** – The study of the properties, distribution, circulation and effects of water on the Earth’s surface, soil and atmosphere.

**Hydrograph** - A graph of discharge versus time for a selected point in the drainage system.

**Impervious Cover** – See “Impervious Surface”.

**Impervious Surface** - A surface, which has been compacted or covered with a layer of material so that it is resistant to infiltration by water. It includes semi-pervious surfaces such as compacted clayey soils, as well as most conventionally surfaced streets, roofs, sidewalks, parking lots, and other similar surfaces. Net Increase of Impervious Surface refers to the difference between the existing impervious coverage and the total impervious surface proposed.

**Infiltration** – Movement of surface water into the soil, where it is absorbed by plant roots, evaporated into the atmosphere, or percolates downward to recharge ground water.

**Intensity** - The depth of accumulated rainfall per unit of time.

**Intermittent Stream** – A defined channel in which surface water is absent during a portion of the year, as ground water levels drop below the channel bottom.

**Karst** – A type of topography that is formed over limestone or other carbonate rock formations by dissolving or solution of the rock by water, and that is characterized by closed depressions, sinkholes, caves, a subsurface network of solution conduits and fissures through which ground water moves, and no perennial surface drainage features.

**LVPC** – Lehigh Valley Planning Commission.

**Level Spreader** – A low earthen berm constructed perpendicular to the direction of slope and extending across the width of the slope for the purpose of intercepting surface runoff and spreading it behind the berm to enhance infiltration and reduce erosion and runoff from the slope. The purpose of a level spreader is to prevent concentrated, erosive flows from occurring and to spread out stormwater runoff uniformly over the ground as sheet flow.

**Loading** – The total amount (generally measured in pounds or kilograms per acre per year) of material (sediment, nutrients, oxygen-demanding material, or other chemicals or compounds) brought into a lake, stream or water body by inflowing streams, runoff, direct discharge through pipes, ground water, the air (aerial or atmospheric deposition) and other sources over a specific period of time (often annually).

**Maintenance** -The action taken to restore or preserve the as-built functional design of any facility or system.

**Meadow Condition** - A natural groundcover with less than one viable tree of a DBH of six (6) inches or greater per fifteen-hundred (1,500) square feet within three (3) years of application; a cover condition for which SCS curve numbers have been assigned or to which equivalent rational method runoff coefficients have been assigned.

**MS4** - Municipal Separate Storm Sewer System.

**NOAA** - National Oceanic and Atmospheric Administration.

**NRCS** – Natural Resources Conservation Service.

**National Pollution Discharge Elimination System (NPDES)** – Created in 1972 under the Clean Water Act to authorize discharges to local receiving waters only pursuant to governmental permits, in an effort to reduce point source and non-point source pollutants.

**New Development** – Any activity regulated by this ordinance that is not considered a redevelopment as defined in this ordinance.

**Non-structural Stormwater Management Practices** - Passive, site design approaches or regulatory approaches that positively impact water quality and reduce or minimize the generation of stormwater runoff without requiring the construction of specific or discrete stormwater management control structures.

**Open Channel** – Any natural or man-made watercourse or conduit in which water flows with a free surface.

**Open Vegetated Channel** – also known as swales, grass channels, and biofilters. These systems are used for the conveyance, retention, infiltration and filtration of stormwater runoff.

**PACD** - Pennsylvania Association of Conservation Districts.

**PADEP** – Pennsylvania Department of Environmental Protection.

**Pasture Condition** – A ground cover of grassland or range with continuous forage for grazing and greater than 75% ground cover and lightly or only occasionally grazed; a cover condition for which the

Soil Conservation Service curve numbers have been assigned or to which equivalent rational method runoff coefficients have been assigned.

**Penn DOT** – Pennsylvania Department of Transportation.

**Percolation Rate** – The rate of movement of water under hydrostatic pressure through interstices of rock or soil. For stormwater analysis, it is typically measured as a distance per unit of time (e.g., inches per hour).

**Predevelopment Assumption** - The ground cover assumption used when analyzing the stormwater runoff characteristics of a drainage area prior to the proposed development.

**Rainfall Intensity** -The depth of accumulated rainfall per unit of time.

**Rate** - Volume per unit of time.

**Receiving Waters** – Any water bodies, watercourses or wetlands into which surface waters flow.

**Recharge** – The replenishment of ground water through the infiltration of rainfall, other surface waters, or land application of water or treated wastewater.

**Redevelopment** - An existing, developed property and/or a graded, altered and compacted site (as of or after the date of adoption of this Ordinance) that is proposed for reconstruction.

**Retention or To Retain** - The prevention of direct discharge of stormwater runoff into receiving waters or water bodies by temporary or permanent containment in a pond or depression; examples include systems which discharge by percolation to ground water, exfiltration, and/or evaporation processes and which generally have residence times of less than three days.

**Retention Basin** - An impoundment designed to collect and retard stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate. Retention basins may also be designed to permanently retain additional stormwater runoff. Retention basins are designed to retain a permanent pool of water during dry weather.

**Riparian** – Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

**Riparian Buffer** – An area of land adjacent to a body of water and managed to maintain the integrity of stream channels and shorelines to 1) reduce the impact of upland sources of pollution by trapping, filtering and converting sediments, nutrients and other chemicals, and 2) supply food, cover and thermal protection to fish and other wildlife.

**Runoff** – see **Stormwater**.

**SLAMM – Source Loading and Management Model**. This model is based on small storm hydrology and pollutant runoff from urban land uses. Pollutant sources are identified and both structural and nonstructural stormwater practices can be accounted for in the model.

**SCS** – Soil Conservation Service.

**SWMM – Stormwater Management Model.** EPA developed this model for analyzing stormwater quantity and quality associated with runoff from urban areas. Both single event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. Information on SWMM is currently available at <http://www.epa.gov/ceampubl/swater/swmm/index.htm>.

**Sediment** – Fragmented material that originated from weathering rocks and decomposing organic material that is transported by, suspended in, and eventually deposited in the streambed.

**Sedimentation** – Occurs when sediment particles that have been suspended within flowing water are deposited on the stream bottom or floodplain.

**Sheet Flow** – A flow process associated with broad, shallow water movement on sloping ground surfaces that is not channelized or concentrated.

**Special Flood Hazard Area** - Those areas identified by the Federal Emergency Management Agency (FEMA), Federal Insurance Administration (FIA) as floodway area (FW), flood fringe area (FF), and general floodplain area (FA); where determined by the Avondale Borough identified alluvial soils may be included as well.

**Storm Event** - The storm of a specific duration, intensity, and frequency.

**Stormwater or Runoff** - The flow of water overland and/or in water bodies that results from and occurs during and immediately following a rainfall event.

**Stormwater Management Plan** - The approved detailed analysis, design, and drawings of the stormwater management system required for all construction.

**Stormwater Management Practices** - The designed and/or constructed features which infiltrate, treat, collect, convey, channel, store, inhibit, or divert the movement of stormwater; such practices include structural and non-structural practices.

**Structure** - Anything constructed or installed with a fixed location on the ground, or attached to something having a fixed location on the ground.

**Structural Stormwater Management Practices** - Any measures that require the design and construction of a facility to help reduce or eliminate a non-point source of pollution and control stormwater.

**Subgrade** - The top elevation of graded and compacted earth underlying roadway pavement.

**Swale** - An artificial or natural waterway which may contain contiguous areas of standing or flowing water only following a rainfall event, or is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake, or is designed to take into account the soil erodibility, soil percolation, slope, slope length, and contributing drainage area so as to prevent erosion and reduce the pollutant concentration of any discharge.

**USDA** – United States Department of Agriculture.

**USDOT FHWA** – United States Department of Transportation Federal Highway Administration.

**Water Body** - Any natural or artificial pond, lake, reservoir, or other area which ordinarily or intermittently contains water and which has a discernible shoreline and receives surface water flow.

**Watercourse** - A permanent or intermittent stream or other body of water, whether natural or man-made, which gathers or carries surface water.

**Water Table** - The upper most level of saturation of pore space or fractures by subsurface water in an aquifer. Seasonal High Water Table refers to a water table that rises and falls with the seasons due either to natural or man-made causes.

**Waters of the Commonwealth** - Any and all rivers, streams, creeks, rivulets, impoundments, ditches, watercourses, storm sewers, lakes, dammed water, wetlands, ponds, springs, and all other bodies or channels of conveyance of surface and underground water, or parts thereof, whether natural or artificial, within or on the boundaries of this Commonwealth.

**Watershed** - Land area that drains to a common water body. As used within this ordinance, refers to the land areas draining to the twenty-one (21) regionally recognized named streams illustrated in Appendix A of this ordinance.

**Wetlands** - Land areas that are inundated or saturated by surface or groundwater with a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (wetlands generally include swamps, marshes, bogs, and similar areas); or areas that are defined and delineated in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands, dated January 10, 1989, and as may be amended from time to time; or as further defined and delineated by the United States Army Corps of Engineers, the United States Environmental Protection Agency, or the Pennsylvania Department of Environmental Protection.

**Woodland Condition** - A natural groundcover with more than one viable tree of a DBH (diameter at breast height) of six (6) inches or greater per fifteen-hundred (1,500) square feet which existed within three (3) years of application; a cover condition for which SCS curve numbers have been assigned or to which equivalent rational method runoff coefficients have been assigned.

# **APPENDIX A**

## **Map of Watersheds Of Chester County With Municipal Borders**

#### DELAWARE RIVER BASIN

##### Schuylkill River Tributaries

Crow Creek  
French Creek  
Gulph Creek  
Pickering Creek  
Pigeon Creek  
Schuylkill River Drainages  
Stony Run  
Trout Creek  
Valley Creek

##### Delaware River Tributaries

Chester Creek  
Crum Creek  
Darby Creek  
Ridley Creek

##### Christina River Tributaries

Christina River  
East Branch Brandywine  
Main Stem Brandywine  
Red Clay Creek  
West Branch Brandywine  
White Clay Creek

#### CHESAPEAKE BAY BASIN

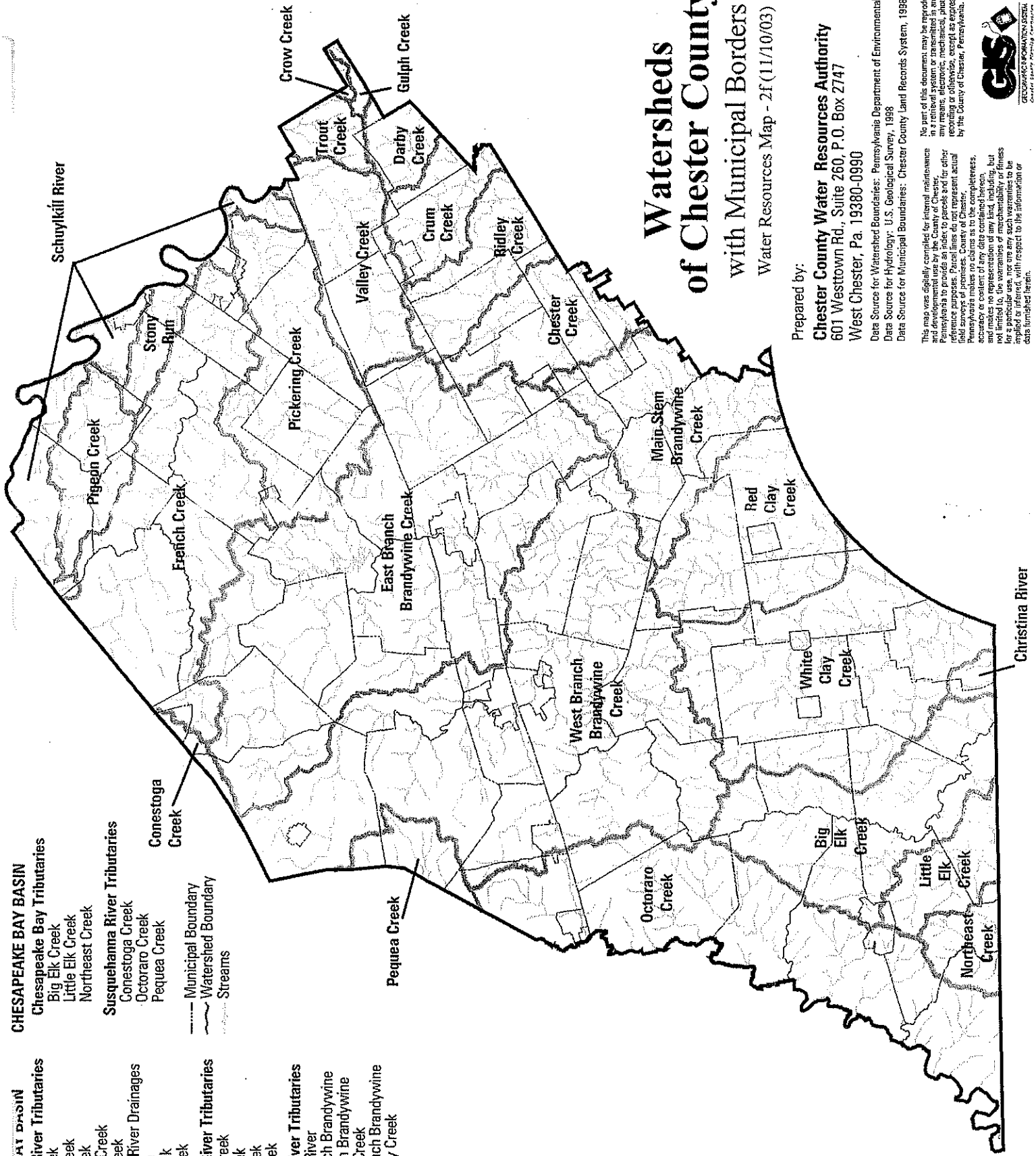
##### Chesapeake Bay Tributaries

Big Elk Creek  
Little Elk Creek  
Northeast Creek

##### Susquehanna River Tributaries

Conestoga Creek  
Octoraro Creek  
Pequea Creek

----- Municipal Boundary  
~~~~~ Watershed Boundary  
~~~~~ Streams



# Watersheds of Chester County with Municipal Borders

Water Resources Map - 2f(11/10/03)

Prepared by:

**Chester County Water Resources Authority**  
601 Westtown Rd., Suite 260, P.O. Box 2747  
West Chester, Pa. 19380-0990

Data Source for Watershed Boundaries: Pennsylvania Department of Environmental Protection, 1998  
Data Source for Hydrology: U.S. Geological Survey, 1998  
Data Source for Municipal Boundaries: Chester County Land Records System, 1998.

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This map was digitally compiled for internal maintenance and development use by the County of Chester, Pennsylvania to provide an index to parcels and for other field use purposes. Parcel lines do not represent actual field boundaries. Chester County does not warrant the accuracy or content of any data contained herein, and makes no representation of any kind, including, but not limited to, the warranties of merchantability or fitness for a particular use, nor are any such warranties to be applied to parcels, with respect to the information or data furnished herein.



## **APPENDIX B**

### **NON-STRUCTURAL STORMWATER MANAGEMENT PRACTICES ALTERNATIVE APPROACH FOR MANAGING STORMWATER RUNOFF**

Natural hydrologic conditions may be altered radically by poorly planned development practices, such as introducing unneeded impervious surfaces, destroying existing drainage swales, constructing unnecessary storm sewers, and changing local topography. A traditional drainage approach of development has been to remove runoff from a site as quickly as possible and capture it in a detention basin. This approach leads ultimately to the degradation of water quality as well as expenditure of additional resources for detaining and managing concentrated runoff at some downstream location.

The recommended alternative approach is to promote practices that will minimize post-development runoff rates and volumes, which will minimize needs for artificial conveyance and storage facilities. To simulate pre-development hydrologic conditions, forced infiltration is often necessary to offset the loss of infiltration by creation of impervious surfaces. The ability of the ground to infiltrate depends upon the soil types and its conditions.

Preserving natural hydrologic conditions requires careful alternative site design considerations. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, and protecting natural depression storage. A well-designed site will contain a mix of all those features. The following describes various techniques to achieve the alternative approach:

**Preserving Natural Drainage Features.** Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in land development. In fact, commonly held drainage philosophy encourages just the opposite pattern -- streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. As a result, runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration. Developments designed to fit site topography also minimizes the amount of grading on site.

**Protecting Natural Depression Storage Areas.** Depressional storage areas have no surface outlet, or drain very slowly following a storm event. They can be commonly seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining, thereby obliterating their ability to reduce surface runoff volumes and trap pollutants. The volume and release-rate characteristics of depressions should be protected in the design of the development site. The depressions can be protected by simply avoiding the depression or by incorporating its storage as additional capacity in required detention facilities.

**Avoiding introduction of impervious areas.** Careful site planning should consider reducing impervious coverage to the maximum extent possible. Building footprints, sidewalks, driveways and other features producing impervious surfaces should be evaluated to minimize impacts on runoff.

**Reducing the Hydraulic Connectivity of Impervious Surfaces.** Impervious surfaces are significantly less of a problem if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are routing of roof runoff over lawns and reducing the use of storm sewers. Site grading should promote increasing travel time of stormwater runoff, and should help reduce concentration of runoff to a single point in the development.

**Routing Roof Runoff Over Lawns.** Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. By routing roof drains and crowning the driveway to run off to the lawn, the lawn is essentially used as a filter strip.

**Reducing the Use of Storm Sewers.** By reducing use of storm sewers for draining streets, parking lots, and back yards, the potential for accelerating runoff from the development can be greatly reduced. The practice requires greater use of swales and may not be practical for some development sites, especially if there are concerns for areas that do not drain in a "reasonable" time. The practice requires educating local citizens and public works officials, who expect runoff to disappear shortly after a rainfall event.

**Reducing Street Widths.** Street widths can be reduced by either eliminating on-street parking or by reducing roadway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets which ultimately could lower maintenance.

**Limiting Sidewalks to One Side of the Street.** A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk could be replaced with bicycle/recreational trails that follow back-of-lot lines. Where appropriate, backyard trails should be constructed using pervious materials.

**Using Permeable Paving Materials.** These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low use surfaces such as driveways, overflow parking lots, and emergency access roads.

**Reducing Building Setbacks.** Reducing building setbacks reduces driveway and entry walks and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

**Constructing Cluster Developments.** Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development. Cluster development clusters the construction activity onto less-sensitive areas without substantially affecting the gross density of development.

In summary, a careful consideration of the existing topography and implementation of a combination of the above mentioned techniques may avoid construction of costly stormwater control measures. Other benefits include reduced potential of downstream flooding, water quality degradation of receiving streams/water bodies and enhancement of aesthetics and reduction of development costs. Beneficial results include more stable baseflows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

(Source: This appendix is taken from, Guidance on MS4 Ordinance Provisions, Document Number 392-0300-003, by the Pennsylvania Department of Environmental Protection, dated August 2, 2003.)

## APPENDIX C

### STORMWATER BEST MANAGEMENT PRACTICES OPERATIONS AND MAINTENANCE AGREEMENT

**THIS AGREEMENT**, made and entered into this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, by and between \_\_\_\_\_, (hereinafter the "Landowner") and the Borough of Avondale ("Borough"), Chester County ("County"), Pennsylvania, (collectively the "Parties");

#### WITNESSETH

**WHEREAS**, the Landowner is the owner of certain real property (the "Property"), identified by the County as uniform parcel identifier ("UPI") # \_\_\_\_\_, pursuant to the deed, recorded with the County Recorder of Deeds, at Deed Book \_\_\_\_\_ at Page \_\_\_\_\_; and

**WHEREAS**, the Landowner is proceeding to build on and/or develop the Property; and

**WHEREAS**, the stormwater management BMP Operations and Maintenance Plan (the "Plan") approved by the Borough for the Property, which Plan is attached hereto as Appendix A and made part hereof, provides for management of stormwater within the confines of the Property through the use of Best Management Practices (BMP's); and

**WHEREAS**, the Borough and the Landowner, the Landowner's successors and assigns, agree that the health, safety, and welfare of the residents of the Borough and the protection and maintenance of water quality require that on-site stormwater Best Management Practices be constructed and maintained on the Property; and

**WHEREAS**, the Borough requires that stormwater management BMP's, as required by the Plan and the Borough Stormwater Management Ordinance, be constructed and adequately operated and maintained by the Landowner and the Landowner's successors and assigns.

**NOW, THEREFORE**, in consideration of the mutual covenants contained herein, and the following terms and conditions, the Parties agree as follows:

1. For the purposes of this agreement, the following definitions shall apply:

- BMP – “Best Management Practice”; activities, facilities, designs, measures and/or procedures used to manage stormwater impacts from land development, to protect and maintain water quality and groundwater recharge and to otherwise meet the purposes of the Borough Stormwater Management Ordinance, including but not limited to infiltration trenches, seepage pits, filter strips, bioretention, wet ponds, permeable paving, rain gardens, grassed swales, forested buffers, sand filters and detention basins;
  - Infiltration Trench – A BMP surface structure designed, constructed, and maintained for the purpose of providing infiltration and/or recharge of stormwater into the soil and/or groundwater aquifer;
  - Seepage Pit – An underground BMP structure designed, constructed, and maintained for the purpose of providing infiltration and/or recharge of stormwater into the soil and/or groundwater aquifer; and
  - Rain Garden – A BMP overlain with appropriate mulch and suitable vegetation and designed, constructed, and maintained for the purpose of providing infiltration or recharge of stormwater into the soil and/or underground aquifer.
2. The BMP’s shall be constructed by the Landowner at such time and in accordance with the designs and specifications established by the Plan.
  3. The Landowner shall operate and maintain, at all times, the BMP(s) as shown on the Plan in good working order acceptable to the Borough and in accordance with the specific maintenance requirements noted on the Plan.
  4. The Landowner hereby grants permission to the Borough, its authorized agents and employees, to enter upon the Property, at reasonable times and upon presentation of proper identification, to inspect the BMP(s) whenever the Borough deems necessary. The Borough shall make reasonable efforts to notify the Landowner prior to entering the Property for such inspection.
  5. In the event the Landowner fails to operate and maintain the BMP(s) as shown on and/or required by the Plan in good working order acceptable to the Borough and in compliance with the Plan, the Borough or its representatives may enter upon the Property and take whatever action the Borough deems necessary to maintain the BMP(s) in such condition. Toward this end, the Borough may construct any permanent structure on the Property and/or reconstruct BMP(s) to achieve

compliance with the Plan. It is understood and agreed that the Borough is under no obligation to maintain and/or repair the facilities required by the Plan, and in no event shall this Agreement be construed to impose any such obligation on the Borough.

6. In the event the Borough, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of such work (*e.g.*, for labor, use of equipment, supplies, materials, and the like), the Landowner shall reimburse the Borough for all its expenses (direct and indirect) so incurred within 10 days of receipt of invoice from the Borough. Such obligation shall be a municipal claim and lien on the Property and may be collected as such.
7. The intent and purpose of this Agreement is to ensure the proper construction and maintenance of the required onsite BMP(s) by the Landowner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability for any Party for damage alleged to result from or to have been caused by stormwater runoff.
8. The Landowner, and the Landowner's executors, administrators, heirs, assigns, and other successors in interest, shall release the Borough and the Borough's employees and designated representatives from all damages, accidents, casualties, occurrences and/or claims which might arise or be asserted against the Borough and/or its employees and representatives from the construction, presence, existence, and/or maintenance of the BMP(s) by the Landowner and/or Borough. In the event that a claim is asserted against the Borough, its designated representatives and/or employees, the Borough shall promptly notify the Landowner and the Landowner shall defend, at the Landowner's own expense, any suit based on the claim. If any claim(s) against the Borough and/or the Borough's employees and/or designated representatives shall be allowed and/or awarded, the Landowner shall hold the Borough and its employees and designated representatives harmless therefrom and indemnify them.
9. The Borough intends to inspect the BMP(s) at a minimum of once every three years to ensure their continued functioning.
10. All duties and obligations of the Landowner, pursuant to this Agreement, shall be the duties and obligations of the Landowner's administrators, executors, heirs, assigns and of any other successors in interest of the Property.

This Agreement shall be recorded at the Office of the Recorder of Deeds of the County, and shall constitute a covenant running with the Property and/or equitable servitude, and shall be binding on the Landowner, and the Landowner's administrators, executors, heirs, assigns and any other successors in interest of the Property, in perpetuity.

IN WITNESS WHEREOF, intending to be bound legally hereby, the Parties have executed this Agreement.

ATTEST:

Borough of Avondale

\_\_\_\_\_

By: \_\_\_\_\_

Borough Secretary

Borough Council President

(SEAL)

ATTEST:

For the Landowner:

\_\_\_\_\_

By: \_\_\_\_\_ (SEAL)

Commonwealth of Pennsylvania:

County of \_\_\_\_\_:

On this, the \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, before me, the undersigned officer, a Notary Public in and for the Commonwealth of Pennsylvania, personally appeared

\_\_\_\_\_, known to me (or satisfactorily proven) to be the person(s) whose name(s) is/are subscribed above, acknowledged that he executed the above Agreement dated \_\_\_\_\_ for the purposes therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

\_\_\_\_\_  
Notary Public

## APPENDIX D

### SOIL USE GUIDE

Prepared: January 2005

Prepared By: Chester County Water Resources Authority

Footnotes to the Soil Use Guide table:

1. Potential for infiltration is divided into three broad categories; Low, Medium and High. Actual infiltration will vary. A soils investigation should be performed to determine if infiltration practices are appropriate for a given site. SHWT stands for Seasonal High Water Table.
  2. Hydrologic Soil Group designation is per U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) (formerly USDA-SCS). A complete listing is available in Technical Release No. 55, Urban Hydrology For Small watersheds, June 1986.
  3. The term "soil erodibility" is distinctly different from that of the term "soil erosion". Soil erosion on a given area generally depends more on the length and steepness of slope, rainstorm characteristics, surface cover and management than on soil properties. Some soils, however, erode more rapidly than others even when slope, rainstorm characteristics, surface cover and management are the same. This is due to soil properties alone and is the basis for predicting soil erodibility. Information on soil erodibility is available in the U.S. Department of Agriculture Natural Resources Conservation Service (USDA-SCS) publication titled, Pennsylvania Soil Interpretations Chester and Delaware Counties, 1975. Erodibility is divided into five classes and an associated erodibility value as follows:  
Low (0.10 - 0.20); Medium (0.24 - 0.32)  
High (0.37 - 0.49); Very High (0.49 - 0.64)
  4. Hydric Soil classification is per United States Department of Agriculture, Hydric Soils List For Pennsylvania, 1995.
  5. Alluvial soils classification is per Natural Resources Conservation Service.
  6. These soil series may contain hydric soil inclusions within individual map units. It is recommended that an on-site investigation by a professional soil scientist take place to determine the suitability of the site for infiltration practices or stormwater management facilities.
  7. If soils otherwise recommended for Retention/Detention basins are available on site, these soils are not recommended where the runoff to those facilities are from areas identified as having the potential for high levels of pollutants (commonly referred to as "hotspots").
  8. This soil is an alluvial or colluvial soil frequently found in floodplains and high water areas. Since the municipality's floodplain regulations restrict structures in many of these soil areas, reference must be made to the floodplain map and the ordinance to determine whether a basin may be built at a particular location. High water tables in soils may require basins above ground level, since an excavated area would frequently fill with water.
  9. The Unified Soil Classification System (USCS) is a widely used system for identifying soils according to their textural and plasticity qualities and on their grouping with respect to behavior. Additional information on the USCS is available in the United States Department of the Army, Field Manual 5-472, October 1999.
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## APPENDIX D - SOIL USE GUIDE

Prepared By: Chester County Water Resources Authority

Prepared: January 2005

| Soil Type    | Infiltration Potential<br>(see note 1) | Depth to Seasonally High Water Table | Depth to Bedrock | Hydrologic Soil Group<br>(see note 2) | Retention / Detention Basin Location                      | Soil Erodibility Class (see note 3)          | Unified Soil Classification<br>(see note 9) | Hydric Soil Yes/No?<br>(see note 4) | Alluvial Soil Yes/No?<br>(see note 5) |
|--------------|--|--------------------------------------|------------------|---------------------------------------|---|--|---|-------------------------------------|---------------------------------------|
| Aldino       | Low (SHWT)                             | 0.5 - 1 ft.                          | 1.5 - 2.5 ft.    | C                                     | Not Recommended   | High   | CL, SM                                      | No<br>(see note 6)                  | No                                    |
| Bedford      | High                                   | 2 - 3 ft.                            | 4 - 6 ft.        | C                                     | Recommended   | High, Medium when stripped of Topsoil        | ML-CL, MH                                   | No                                  | No                                    |
| Beltsville   | Low (SHWT)                             | 1 - 2 ft.                            | 6+ ft.           | C                                     | Not Recommended   | High, Medium when stripped of Topsoil        | CL, ML-CL, SC                               | No<br>(see note 6)                  | Alluvial                              |
| Bownansville | Low (potential for flooding)           | 0 - 1.5 ft.                          | 3 - 6 ft.        | B/D                                   | Not Recommended   | High, Medium to low when stripped of Topsoil | CL  | Yes                                 | Alluvial                              |
| Brandywine   | High                                   | 10+ ft.                              | 3 - 4 ft.        | C                                     | Recommended When High Pollution Risk Exists. (See note 7) | Medium to Low                                | SC, SM                                      | No                                  | No                                    |
| Brecknock    | High                                   | 5+ ft.                               | 3 - 4 ft.        | B                                     | Recommended   | Medium                                       | ML, CL                                      | No                                  | No                                    |
| Bucks        | High                                   | 5+ ft.                               | 3-5 ft.          | B                                     | Recommended   | Medium to Low                                | ML, ML - CL                                 | No                                  | No                                    |



## APPENDIX D - SOIL USE GUIDE

Prepared By: Chester County Water Resources Authority

Prepared: January 2005

| Soil Type | Infiltration Potential (see note 1)          | Depth to Seasonally High Water Table | Depth to Bedrock | Hydrologic Soil Group (see note 2) | Retention / Detention Basin Location | Soil Erodibility Class (see note 3)                   | Unified Soil Classification (see note 9) | Hydric Soil Yes/No? (see note 4) | Alluvial Soil Yes/No? (see note 5) |
|-----------|--|--------------------------------------|------------------|------------------------------------|--------------------------------------|---|--|----------------------------------|------------------------------------|
| Calvert   | Low (SHWT limits in Spring)                  | 0 - 1 ft.                            | 3+ ft.           | ****                               | Not Recommended                      | High  | SM, MH                                   | Yes                              | Alluvial                           |
| Chester   | High   | 5+ ft.                               | 5 - 6 ft/        | B                                  | Recommended                          | Medium at grade. High when stripped of topsoil        | SM, SC, ML-CL                            | No                               | No                                 |
| Chewacla  | Low (Subject to Flooding)                    | 0 - 1 ft.                            | 3 - 6 ft.        | C                                  | Recommended Except as noted in 8     | High  | CL                                       | No (see note 6)                  | Alluvial                           |
| Chrome    | Medium                                       | 5+ ft.                               | 1 - 2.5 ft.      | C                                  | Shallow Bedrock restricts Excavation | Medium. Low when stripped of topsoil                  | GM, ML, MH, SM, GM                       | No                               | No                                 |
| Conestoga | Medium (Subject to Limestone Considerations) | 5+ ft.                               | 4 - 6 ft.        | B                                  | Recommended                          | High. Medium when stripped of topsoil                 | ML-CL, MH, ML                            | No                               | No                                 |
| Conowingo | Medium (SHWT)                                | 1 - 2 ft.                            | 3 - 4 ft.        | C                                  | Recommended                          | High at grade. Medium to low when stripped of topsoil | GM, SM, MH                               | No                               | No                                 |

## APPENDIX D - SOIL USE GUIDE

Prepared By: Chester County Water Resources Authority

Prepared: January 2005

| Soil Type  | Infiltration Potential<br>(see note 1)    | Depth to Seasonally High Water Table | Depth to Bedrock | Hydrologic Soil Group<br>(see note 2) | Retention / Detention Basin Location                          | Soil Erodibility Class (see note 3)            | Unified Soil Classification<br>(see note 9) | Hydric Soil Yes/No?<br>(see note 4) | Alluvial Soil Yes/No?<br>(see note 5) |
|------------|---|--------------------------------------|------------------|---------------------------------------|---|--|---|-------------------------------------|---------------------------------------|
| Croton     | Low                                       | 0 - 0.5 ft.                          | 3 - 5 ft.        | D                                     | Not Recommended   | High at grade. Medium when stripped of topsoil | CH, CL, SM, SC                              | Yes                                 | No                                    |
| Edgemont   | High                                      | 5+ ft.                               | 2 - 6 ft.        | B                                     | Not Recommended When High Pollution Risk Exists. (See note 7) | Medium at grade. Low when stripped of topsoil  | SM  | No                                  | No                                    |
| Glenelg    | High                                      | 5+ ft.                               | 3 - 5 ft.        | B                                     | Not Recommended When High Pollution Risk Exists. (See note 7) | Medium   | SM, GM, ML                                  | No                                  | No                                    |
| Glenville  | Low (SHWT)                                | 1 - 1.5 ft.                          | 3 - 6 ft.        | C                                     | Recommended   | High at grade. Medium at 4 feet depth          | ML, ML-CL, MH                               | No<br>(see note 6)                  | No                                    |
| Guthrie    | Low (SHWT)                                | 0 - .5 ft.                           | 3 - 5 ft.        | D                                     | Not Recommended   | High at grade. Medium when stripped of topsoil | CL  | Yes                                 | Alluvial                              |
| Hagerstown | High (Subject to Limestone Consideration) | 5+ ft.                               | 4 - 6 ft.        | C                                     | Recommended   | Medium   | CL, ML                                      | No                                  | No                                    |

## APPENDIX D - SOIL USE GUIDE

Prepared By: Chester County Water Resources Authority

Prepared: January 2005

| Soil Type | Infiltration Potential<br>(see note 1)                                      | Depth to Seasonally High Water Table | Depth to Bedrock | Hydrologic Soil Group<br>(see note 2) | Retention / Detention Basin Location | Soil Erodibility Class (see note 3)               | Unified Soil Classification<br>(see note 9) | Hydric Soil Yes/No?<br>(see note 4) | Alluvial Soil Yes/No?<br>(see note 5) |
|-----------|---|--------------------------------------|------------------|---------------------------------------|--------------------------------------|---|---|-------------------------------------|---------------------------------------|
| Hollinger | Medium<br>(Subject to Limestone Consideration and potential bedrock Issues) | 5+ ft.                               | 2 - 6 ft.        | B                                     | Recommended                          | High at grade.<br>Medium when stripped of topsoil | GM, SM, GP, GM                              | No                                  | No                                    |
| Lawrence  | Low   | 1 - 2 ft.                            | 4 - 6 ft.        | C                                     | Not Recommended                      | High at grade.<br>Medium when stripped of topsoil | ML, CL                                      | No<br>(see note 6)                  | Colluvial                             |
| Lehigh    | Low   | 1 - 2 ft.                            | 2-4 ft.          | C                                     | Not Recommended                      | High at grade.<br>Medium when stripped of topsoil | CL-ML, GM-GC, ML, CL                        | No<br>(see note 6)                  | No                                    |
| Lindside  | Low   | 0 - 1 ft.                            | 3 - 6 ft.        | C                                     | Not Recommended                      | High  | ML, CL                                      | No<br>(see note 6)                  | Alluvial                              |
| Manor     | High  | 5+ ft.                               | 2 - 7 ft.        | B                                     | Recommended                          | High  | GM, SM, GP, GM                              | No                                  | No                                    |
| Melvin    | Low   | 0 - 0.5 ft.                          | 4 - 7 ft.        | D                                     | Not Recommended                      | High  | CL, ML-CL                                   | Yes                                 | Colluvial                             |
| Montalto  | High  | 5+ ft.                               | 3 - 5 ft.        | C                                     | Recommended                          | Medium  | MH  | No                                  | No                                    |

## APPENDIX D - SOIL USE GUIDE

Prepared By: Chester County Water Resources Authority

Prepared: January 2005

| Soil Type  | Infiltration Potential<br>(see note 1) | Depth to Seasonally High Water Table | Depth to Bedrock | Hydrologic Soil Group<br>(see note 2) | Retention / Detention Basin Location         | Soil Erodibility Class (see note 3)              | Unified Soil Classification<br>(see note 9) | Hydric Soil Yes/No?<br>(see note 4) | Alluvial Soil Yes/No?<br>(see note 5) |
|------------|--|--------------------------------------|------------------|---------------------------------------|--|--|---|-------------------------------------|---------------------------------------|
| Neshaminy  | High                                   | 5+ ft.                               | 4 - 6 ft.        | B                                     | Recommended                                  | Medium at grade.<br>Low when stripped of topsoil | ML, ML-CL, MH, SM                           | No                                  | No                                    |
| Penn       | High (subject to Depth of Bedrock)     | 5+ ft.                               | 2 - 4 ft.        | C                                     | Recommended; subject to Depth to Bedrock     | Medium   | ML, CL-ML                                   | No                                  | No                                    |
| Readington | Low                                    | 1+ ft.                               | 2 - 5 ft.        | C                                     | Not Recommended                              | High at grade.<br>Medium at 4 feet depth         | CL, SM, ML-CL                               | No (see note 6)                     | No                                    |
| Rowland    | Low                                    | 0 - 2 ft.                            | 4 - 5 ft.        | C                                     | Not Recommended                              | Hig at grade.<br>Medium to low at 3 feet depth   | CL  | No (see note 6)                     | Alluvial                              |
| Watchung   | Low                                    | 0 - 1 ft.                            | 3 - 4.5 ft.      | D                                     | Recommended<br>Except as noted in 8<br>Below | High. Medium when stripped of topsoil            | MH  | Yes                                 | No                                    |
| Wehadkee   | Low                                    | 0 - 1 ft.                            | 5 - 8 ft.        | D                                     | Recommended<br>Except as noted in 8<br>Below | High. Medium when stripped of topsoil            | ML  | Yes                                 | Alluvial                              |
| Worsham    | Low                                    | 0 - 1 ft.                            | 3 - 5 ft.        | D                                     | Recommended<br>Except as noted in 8<br>Below | High. Medium when stripped of topsoil            | ML, MH                                      | Yes                                 | Alluvial                              |

## APPENDIX E

### List of References Cited and Additional Sources of Information

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#### List of References Cited

1. American Society of Civil Engineers and Water Environment Federation, Urban Runoff Quality Management, AM. Soc. Civ. Eng. Manuals and Reports of Engineering Practice No. 87, New York, NY; Water Environ. Fed. Manual of Practice No.23, Alexandria, VA, 1998.
2. Center for Watershed Protection, Design of Stormwater Filtering Systems, December 1996.
3. Chester County Board of Commissioners, *Watersheds: An Integrated Resources Plan for Chester County, Pennsylvania and Its watersheds*, Adopted September 17, 2002.
4. Chester County Water Resources Authority, Chester County, Pennsylvania Water Resources Compendium, Parts 1 and 2, December 2001.
5. Hershfield, D.M., Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, Technical Paper No. 40 (Washington DC: Weather bureau, U.S. Department of Commerce), 1961.
6. Lehigh Valley Planning Commission, Technical Best Management Practice Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed, Lehigh Valley Planning Commission, November 2002.
7. Maryland Department of the Environment, Water Management Administration, 2000 Maryland Stormwater Design Manual Volume I & II, Baltimore, MD, 2000.  
[http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater\\_design/index.asp](http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp)
8. National Oceanic and Atmospheric Administration, NOAA Atlas 14, Volume 2, June 2004.  
<http://hdsc.nws.noaa.gov/hdsc/pfds/>
9. Pennsylvania Association of Conservation Districts, Pennsylvania Handbook of Best Management Practices for Developing Areas, Harrisburg, PA, 1998.
10. Pennsylvania Department of Environmental Protection, Erosion and Sediment Pollution Control Program Manual, Harrisburg, PA, March 2000.
11. Pennsylvania Department of Environmental Protection, Guidance On MS4 Ordinance Provisions, Document Number 392-0300-003, Harrisburg, PA., August 2, 2003.
12. Pennsylvania Department of Environmental Resources, Recommended Hydrologic Procedures for Computing Urban Runoff From Small Watersheds In Pennsylvania, Harrisburg, Pa., January 1982.
13. Pennsylvania Department of Transportation, Field Manual of Pennsylvania Department of Transportation Storm Intensity-Duration-Frequency Charts PDT-IDF, May 1986.

14. U.S. Department of Agriculture, Soil Conservation Service, Pennsylvania Soil Interpretations Chester and Delaware Counties, 1975.
15. U.S. Department of Agriculture and Natural Resources Conservation Service, Urban Hydrology for Small Watersheds, Technical Release 55, 2<sup>nd</sup> Edition, Washington, D.C., June 1986.
16. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4 – Hydrology, March 1985.
17. U.S. Department of Agriculture, Soil Conservation Service, Engineering Field Manual for Conservation Practices, Washington, D.C., July 1984.
18. U.S. Department of the Army, Field Manual 5-472 NAVFAC MO 330 AFJMAN 32-1221(I), Materials Testing, July 2001.
19. U.S. Department of Transportation, Federal Highway Administration, Design of Stable Channels with Flexible Linings, Hydraulic Engineering Circular No. 15, Washington DC, 1986.

#### **Additional Sources of Information**

1. Byle, Michael J., Stormwater Infiltration Practices in Karst, 2001 Southeastern Pennsylvania Stormwater Management Symposium, October 2001, Villanova University.
2. Chester County Planning Commission, Community Planning Handbook Volume 1, A Toolbox for Managing Change In Chester County, May 1997.
3. Chester County Planning Commission, Community Planning Handbook Volume 2, A Toolbox for Managing Change In Chester County, March 1999.
4. Chester County Planning Commission, Planning Bulletin No. 9, Stormwater Management Practices (revised), Chester County Planning Commission, Westtown, PA. 2003.
5. Center for Watershed Protection, Ellicott City, MD. <http://www.cwp.org/>
6. Mays, Larry W., Stormwater Collection Systems Design Handbook, McGraw-Hill, 2001.
7. Metropolitan Washington Council of Governments, A Current Assessment of Urban best Management Practices; Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone, March 1992.
8. New Jersey Department of Environmental Protection, Division of Watershed Management, The New Jersey Stormwater Best Management Practices Manual, April 2004.  
[http://www.njstormwater.org/bmp\\_manual2.htm](http://www.njstormwater.org/bmp_manual2.htm)
9. New York State Department of Environmental Conservation and Center for Watershed Protection, New York State Stormwater Design Manual, October 2001.  
<http://www.dec.state.ny.us/website/dow/toolbox/swmanual/index.html>

