APPENDICES

CERTIFICATION OF PLAN ACCURACY

I hereby certify that, to the best of my knowledge, the plan shown and described hereon is true and correct to the accuracy required by the Rapho Township Storm Water Management Ordinance.

_____, 20___ *_____

* Signature and seal of a professional registered in the Commonwealth of Pennsylvania qualified to perform such duties and responsible for the preparation of the plan.

CERTIFICATION OF SURVEY ACCURACY

I hereby certify that, to the best of my knowledge, the survey shown and described hereon is true and correct to the accuracy required by the Rapho Township Storm Water Management Ordinance.

_____, 20___ *_____

* Signature and seal of a professional registered in the Commonwealth of Pennsylvania qualified to perform such duties and responsible for the preparation of the plan.

STORM DRAINAGE PLAN CERTIFICATION

I hereby certify that, to the best of my knowledge, the storm drainage facilities shown and described hereon are designed in conformance with the Rapho Township Storm Water Management Ordinance.

_____, 20___ *_____

* Signature and seal of a professional registered in the Commonwealth of Pennsylvania qualified to perform such duties and responsible for the preparation of the storm drainage plan.

CERTIFICATE OF OWNERSHIP, ACKNOWLEDGEMENT OF PLAN, AND OFFER OF DEDICATION (INDIVIDUAL)

COMMONWEALTH OF PENNSYLVANIA
COUNTY OF LANCASTER

On this, the _____day of _____, 20 ____, before me, the undersigned officer, personally appeared _____, who being duly sworn according to law, deposes and says that he is the *_____ of the property shown on this plan, that the plan thereof was made at his direction, that he acknowledges the same to be his act and plan, that he desires the same to be recorded, and that all streets and other property identified as proposed public property (excepting those areas labeled "NOT FOR DEDICATION") are hereby dedicated to the public use.

**_____

***_____

My Commission Expires _____, 20_____

* Identify Ownership or Equitable Ownership
** Signature of the Individual
*** Signature and Seal of Notary Public or Other Authorized to Acknowledge Deeds.

CERTIFICATE OF OWNERSHIP, ACKNOWLEDGEMENT OF PLAN, AND OFFER OF DEDICATION (COPARTNERSHIP)

COMMONWEALTH OF PENNSYLVANIA
COUNTY OF LANCASTER

On this, the _____day of _____, 20 ____, before me, the undersigned officer, personally appeared _____, being the members of the firm of _____ who being duly sworn according to law, deposes and says that the copartnership is the *_____ of the property shown on this plan, that the plan thereof was made at its direction, that it acknowledges the same to be its act and plan and desires the same to be recorded, and that all streets and other property identified as proposed public property (excepting those areas labeled "NOT FOR DEDICATION") are hereby dedicated to the public use.

**_____

***_____

My Commission Expires _____, 20_____

* Identify Ownership or Equitable Ownership
** Signature of the Individual
*** Signature and Seal of Notary Public or Other Officer Authorized to Acknowledge Deeds.

CERTIFICATE OF OWNERSHIP, ACKNOWLEDGEMENT OF PLAN, AND OFFER OF DEDICATION (CORPORATE)

COMMONWEALTH OF PENNSYLVANIA
COUNTY OF LANCASTER

On this, the _____day of _____, 20 ____, before me, the undersigned officer, personally appeared _____, being * _____ of ** _____ who being duly sworn according to law, deposes and says that the corporation is the *** _____ of the property shown on this plan, that he is authorized to execute said plan on behalf of the corporation, that the plan is the act and deed of the corporation, that the corporation desires the same to be recorded and on behalf of the corporation further acknowledges, that all streets and other property identified as proposed public property (excepting those areas labeled "NOT FOR DEDICATION") are hereby dedicated to the public use.

****
_____

*****
_____

******
_____

My Commission Expires _____, 20_____

*	Individual's Title
**	Name of Corporation
***	Identify Ownership or Equitable Ownership
****	Signature of Individual
*****	Corporate Seal
******	Signature and Seal of Notary Public or Other Officer Authorized to Acknowledge Deeds

RAPHO TOWNSHIP BOARD OF SUPERVISORS
STORM WATER MANAGEMENT SITE PLAN APPROVAL CERTIFICATE

At a meeting held on _____, 20___, the Rapho Township Board of Supervisors approved this project including the complete set of plans and information which are filed with the Supervisors in File No. _____, based upon its conformity with the standards of the Rapho Township Storm Water Management Ordinance.

*_____

* Signature of the Chairman or Vice Chairman or their designee.

RAPHO TOWNSHIP ENGINEER
REVIEW CERTIFICATE

Reviewed by the Rapho Township Engineer this _____ day of _____, 20___.

_____

* Signature of the Rapho Township Engineer.

RAPHO TOWNSHIP PLANNING COMMISSION
REVIEW CERTIFICATE

At a meeting held on _____, 20____, the Rapho Township Planning Commission reviewed this plan and a copy of the review comments is on file in the Township office.

*_____

* Signatures of the (Vice) Chairman or their designee.

RAPHO TOWNSHIP STORM WATER FACILITIES AND BEST MANAGEMENT PRACTICES (BMP) OPERATIONS AND MAINTENANCE (O&M) AGREEMENT AND DECLARATION OF EASEMENT

THIS AGREEMENT AND DECLARATION OF EASEMENT made this_____day of _____,20_____, by and between _____ (hereinafter referred to as the "Grantor") and **Rapho Township**, Lancaster County, Pennsylvania, a Township duly organized under the laws of the Commonwealth of Pennsylvania, with its municipal office located at 971 North Colebrook Road, Manheim, PA 17545 (hereinafter referred to as the "Township").

BACKGROUND

Grantor is the owner of premises located at_____ _____ , in Rapho Township, Lancaster County, Pennsylvania, as more specifically described in a deed recorded in Record Book _____, Page_____, in the Office of the Recorder of Deeds in and for Lancaster County, Pennsylvania, and as shown on the _____ , prepared by _____ , Drawing No. _____ , dated_____ , last revised_____(hereinafter referred to as the "Premises").

Prior to beginning construction on any subdivision or land development, Grantor is required, under the Rapho Township Subdivision and Land Development Ordinance and the Rapho Township Storm Water Management Ordinance (collectively referred to as the "Ordinances"), to file a final plan with Rapho Township. Pursuant to the Ordinances, Grantor must provide storm water management data in its application. The Ordinances require that Grantor's final plan reflect and/or be accompanied with supporting documentation which identifies the ownership of, and the method of administering and maintaining, all permanent storm water management facilities. Drainage courses, swales, grassed waterways, storm water inlets, pipes, conduits, detention basins, retention basins, infiltration structures, and other storm water management facilities, including Best Management Practices facilities ("BMPs"), shall be included under the term "storm water management facilities" in this Agreement and Declaration of Easement.

The purpose of this Agreement and Declaration of Easement is to describe the ownership and maintenance responsibilities for the storm water management facilities which will be installed on the Premises and to impose the ownership and maintenance responsibilities upon Grantor, his heirs, personal representatives and assigns and upon successor owners of the Premises, and set forth the rights of the Township.

NOW, THEREFORE, intending to be legally bound hereby and in consideration of receiving approval of its Subdivision and/or Land Development Plan or its Storm Water Management Site Plan (hereinafter referred to as the "Plan") from Rapho Township, and in consideration of receiving permits from the Township to develop the Premises, Grantor, for Grantor and the heirs, personal representatives and assigns of Grantor, covenant and declare as follows:

1. The storm water management facilities will be owned by Grantor, his heirs, personal representatives, successors and assigns.

2. All drainage courses, swales, storm water inlets, pipes, conduits, detention basins BMPs, and other storm water management facilities shall be installed, constructed and maintained by Grantor, his heirs, personal representatives, successors and assigns, in a first-class condition in conformance with the Plan, as approved by Rapho Township, including any accompanying storm

water management plans and information, and as recorded in the Office of the Recorder of Deeds in and for Lancaster County, and in a manner sufficient to meet or exceed the performance standards and specifications set forth on the Plan, as approved by Rapho Township, including any accompanying storm water management plans and information. These responsibilities shall include, but not be limited to, the following:

A. Liming, fertilizing, seeding and mulching of vegetated channels and all other unstablized soils or areas according to the specifications in the "Erosion and Sediment Pollution Control Manual" published by the Pennsylvania Department of Environmental Protection, the Penn State Agronomy Guide, or similar standard acceptable to Rapho Township.

B. Reestablishment of vegetation by seeding and mulching or sodding of scoured areas or areas where vegetation has not been successfully established.

C. Mowing as necessary to maintain adequate stands of grass and to control weeds. Chemical weed control may be used if federal, state and local laws and regulations are met. Selection of seed mixtures shall be subject to approval by the Township.

D. Removal of silt from all permanent structures which trap silt or sediment in order to keep the material from building up in grass waterways, pipes, detention or retention basins, infiltration structures, BMPs, and/or other facilities and thus reducing their capacity.

E. Removal of silt from all permanent drainage structures, in particular BMPs, in order to maintain the design storage volumes. Regular programs shall be established and maintained.

F. Regular inspection of the areas in question to assure proper maintenance and care, including, but not limited to, proper implementation of BMPs. **ADD ANY SPECIFIC INSPECTION REQUIREMENTS IN THE PCSM PLAN.**

G. Regular maintenance to insure that all pipes, swales and detention facilities shall be kept free of any debris or other obstruction. **ADD ANY SPECIFIC MAINTENANCE REQUIREMENTS IN THE PCSM PLAN.**

H. Regular maintenance of all storm water management facilities designed to improve water quality to ensure that the storm water management facilities function in accordance with their design. **ADD ANY SPECIFIC MAINTENANCE REQUIREMENTS IN THE PCSM PLAN SUCH AS:** Maintenance of the infiltration system by mowing grass regularly over the infiltration system; keeping the yard drains and roof drains free of debris in good repair at all times; flushing the infiltration system using a water hose at the cleanouts once every ninety (90) days to insure the infiltration system is clear of debris; keeping the sumps in the yard inlets and downspout sumps free of debris; and inspecting the infiltration system four (4) times per year or after each rain event exceeding one (1) inch.

I. Repair of any subsidence, including subsidence caused by sinkholes.

J. **IF APPLICABLE:** Replacement of displaced riprap within the outlet energy dissipater immediately after it is displaced, particularly after major storm discharge events.

K. **IF APPLICABLE:** Vacuum sweeping of areas of porous paving to keep surface free of sediment, typically three to four times per year and maintaining all areas of porous paving free from sealing, surfacing or re-paving with non-porous materials.

L. Removal of trash and debris on a regular basis.

Include a statement that the approved Operations and Maintenance (O&M) Plan is attached as an exhibit if there are any requirements in addition to those in Paragraph 2.

Grantor, his heirs, personal representatives, successors and assigns, shall be responsible for performing the foregoing maintenance.

3. Grantor, for himself, his heirs, personal representatives, successors and assigns, agrees that the failure to maintain all drainage courses, swales, storm water inlets, pipes, conduits, detention basins, BMPs, and other storm water management facilities in a first-class condition in conformance with this Agreement and Plan, as approved by Rapho Township, including any accompanying storm water management plans and information, shall constitute a nuisance and shall be abatable by the Township as such.

4. The Grantor agrees to provide the Township with an annual written report documenting the following items:

   A. Listing of all Post-Construction Storm Water Management (PCSM) Best Management Practices (BMPs) that were installed to meet requirements in NPDES Permits for Stormwater Discharges Associated with Construction Activities approved since March 10, 2003;

   B. The exact location of the PCSM BMP (e.g., street address);

   C. Information (e.g., name, address, phone number(s)) for BMP owner and entity responsible for BMP Operation and Maintenance (O&M), if different from BMP owner;

   D. The type of BMP and the year it was installed;

   E. Maintenance required for the BMP type according to the Pennsylvania Storm Water BMP Manual or other manuals and resources;

   F. The actual inspection/maintenance activities performed for each BMP during the year;

   G. An assessment by the permittee if proper operation and maintenance occurred during the year and if not, what actions the permittee has taken, or shall take, to address compliance with O&M requirements.

5. Grantor, for himself, his heirs, personal representatives, successors and assigns, authorizes the Township, at any time and from time to time, by its authorized representatives, to enter upon the Premises to inspect the storm water management facilities. Grantor acknowledges that the Township has the right to establish a schedule of regular inspections including, but not limited to, annual inspections. If the Township determines to establish a schedule of inspections of storm water management facilities, Grantor, its successors and assigns, shall reimburse the Township for the costs of such inspection and/or pay any annual fee for the administration of a Township storm water management program.

6. The Township may require that Grantor, and assigns or any future owner or occupier of the Premises or any part thereof, take such corrective measures as the Township may deem reasonably necessary to bring the Premises into compliance with this Agreement and with the Plan, as approved by Rapho Township, including any accompanying storm water management plans and information.

7. Upon the failure of the owner or occupier of the Premises or any part thereof to comply with the terms of this Storm Water Management Agreement or to take corrective measures following reasonable notice from the Township, the Township, through its authorized representatives, may take such corrective measures as it deems reasonably necessary to bring the Premises into compliance with this Agreement and with the Plan, as approved by Rapho Township, including any accompanying storm water management plans and information, including, but not limited to, the removal of any blockage or obstruction from drainage pipes, swales, detention basins, and BMPs, and may charge the cost thereof to Grantor, his heirs, personal representatives, successors and assigns, or any owner of the Premises or any part thereof and, in default of such payment, may cause a municipal lien to be imposed upon the Premises or any part thereof. Any municipal lien filed pursuant to this Agreement shall be in the amount of all costs incurred by the Township, plus a penalty of ten percent (10%) of costs, including the Township's reasonable engineering and attorneys' fees.

8. If ownership or maintenance responsibility of the storm water management facilities is assigned to a home owners' association, condominium unit owners' association, or similar entity, the Township shall be notified. If the association fails to properly maintain the storm water management facilities, the Township shall have the same rights granted to municipalities under Section 705 of the Pennsylvania Municipalities Planning Code, Act of July 31, 1968, P.L. 805, No. 247, with reference to maintenance of common open space, to maintain the storm water management facilities. Any association so formed shall enter into an agreement with the Township recognizing its duties and the Township's rights under this Agreement.

9. Grantor hereby imposes upon the Premises for the benefit of all present and future owners of the Premises or part of the Premises, the Township, and all other property owners affected by the storm water management facilities, the perpetual right, privilege and easement for the draining of storm water in and through the drainage courses, swales, storm water inlets, pipes, conduits, detention basins, BMPs, and other storm water management facilities depicted on the plan or plans submitted to the Township or hereafter made of record and now or hereafter installed on or constructed upon the Premises and, in addition, easements of access to the storm water facilities.

10. Grantor agrees to indemnify and defend Rapho Township and all of its elected and appointed officials, agents and employees (hereafter collectively referred to as the "Indemnitees") against and hold Indemnitees harmless from any and all liability, loss or damage, including attorneys' fees and costs of investigation and defense, as a result of claims, demands, costs or judgments against Indemnitees which arise as a result of the design, installation, construction or maintenance of the storm water facilities.

11. Grantor's personal liability under this Agreement shall cease at such time as:

    A. all storm water management facilities have been constructed in accordance with the specifications of the Township Subdivision and Land Development Ordinance, the Township Storm Water Management Ordinance and the approved plans;

    B. the storm water management facilities have been inspected and approved by the Township Engineer;

    C. all financial security, including any maintenance security, posted by Grantor has been released by the Township; and

    D. Grantor has transferred the Premises and/or all lots to be created from the Premises to third parties.

Notwithstanding the foregoing, Grantor's personal liability shall continue for any violations of this Agreement and Declaration of Easement which occurred during the time that Grantor owned the Premises or any lot created from the Premises or in the event the storm water management facilities were not completed, inspected or approved as set forth in (a) through (c) herein.

12. It is the intent of the parties to this Agreement that personal liability and maintenance obligations shall pass to subsequent title owners upon change in ownership of the Premises or any lot created from the Premises, and such subsequent owners shall assume all personal liability and maintenance obligations for the time period during which they hold title. Personal liability shall remain for any violations of this Agreement and Declaration of Easement which occurred during the period in which an owner held title.

13. The Township may, in addition to the remedies prescribed herein, proceed with any action at law or in equity to bring about compliance with the Rapho Township Storm Water Management Ordinance, the Rapho Township Subdivision and Land Development Ordinance and this Agreement.

14. This Agreement and Declaration of Easement shall be binding upon the Grantor, the successors and assigns of Grantor, and all present and future owners of the Premises or any part thereof and is intended to be recorded in order to give notice to future owners of the Premises of their duties and responsibilities with respect to the storm water management facilities. Grantor shall include a specific reference to this Agreement in any deed of conveyance for the Premises or any part thereof.

15. This Agreement and Declaration of Easement may be amended only by written instrument signed on behalf of all owners of the Premises and Rapho Township.

16. When the sense so requires, words of any gender used in this Agreement and Declaration of Easement shall be held to include any other gender, and the words in the singular number shall be held to include the plural, and vice versa.

IN WITNESS WHEREOF, the undersigned have caused this Agreement and Declaration to be executed on the day and year first above written.

Rapho Township
Lancaster County, Pennsylvania

Attest: _____ By:_____

(Assistant) Secretary

(Vice) Chairman
Township Board of Supervisors

[Rapho Township SEAL]

(Individual or Husband and Wife Developer)

Witness:

_____ _____(SEAL)
(Signature of Individual)

_____ _____(SEAL)
(Signature of Spouse if Husband and Wife are Co-Developers)

IF APPLICABLE
Trading and Doing Business as
_____

(Partnership Developer*)

_____
(Name of Partnership)

Witness:

_____ By_____(Seal)
Partner

_____ By_____(Seal)
Partner

_____ By_____(Seal)
Partner

*All Partners must execute the Agreement.

(Corporation Developer)

_____
(Name of Corporation)

ATTEST:

By:_____ By:_____
(Assistant) Secretary (Vice) President

(CORPORATE SEAL)

(Limited Liability Company Landowner***)

_____
(Name of Limited Liability Company)

Witness:

_____ By_____(Seal)
Member

_____ By_____(Seal)
Member

_____ By_____(Seal)
Member

***All Members must sign.

ACKNOWLEDGMENT FOR RAPHO TOWNSHIP

COMMONWEALTH OF PENNSYLVANIA)
) SS:
COUNTY OF _____)

On this, the _____ day of _____, A.D., 20___, before me, the undersigned officer, a Notary Public in and for the aforesaid Commonwealth and County, personally appeared _____, who acknowledged ___self to be (Vice) Chairman of the Board of Supervisors of Rapho Township, Lancaster County, Pennsylvania, and that he/she, as such officer, being authorized to do so, executed the foregoing Storm Water Management Agreement and Declaration of Easement, for the purposes therein contained, by signing the name of such Township by ___self as such officer.

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

Notary Public: _____
My Commission expires:_____

ACKNOWLEDGMENT FOR INDIVIDUAL OR HUSBAND AND WIFE DEVELOPER

COMMONWEALTH OF PENNSYLVANIA)
) SS:
COUNTY OF _____)

On this, the _____day of_____, 20___, before me, the undersigned officer, a Notary Public, in and for the aforesaid Commonwealth and County, personally appeared _____, known to me (or satisfactory proven) to be the person(s) whose name(s) is/are subscribed on the within instrument and acknowledged the foregoing Storm Water Management Agreement and Declaration of Easement to be _____ act and deed and desired the same to be recorded as such.

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

Notary Public: _____
My Commission expires:_____

ACKNOWLEDGMENT FOR CORPORATE DEVELOPER

COMMONWEALTH OF PENNSYLVANIA)
) SS:
COUNTY OF _____)

On this, the _____day of_____, 20____, before me, a Notary Public, personally appeared, the undersigned officer,_____who acknowledged ___self to be the _____ of _____, a corporation, and that such officer being authorized to do so, acknowledged the foregoing instrument for the purpose therein contained, by signing the name of the corporation by ___self as _____.

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

Notary Public: _____
My Commission expires:_____

ACKNOWLEDGMENT FOR PARTNERSHIP DEVELOPER

COMMONWEALTH OF PENNSYLVANIA)
) SS:
COUNTY OF _____)

On this, the _____day of_____, 20_____, before me, a Notary Public, the undersigned officer, personally appeared _____ who acknowledged themselves to be all of the partners of _____, a _____ partnership, and that they, as such partners, being authorized to do so, executed the foregoing instrument for the purposes therein contained, by signing the name of the partnership by themselves as such partners.

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

Notary Public: _____
My Commission expires:_____

ACKNOWLEDGMENT FOR LIMITED LIABILITY COMPANY LANDOWNER

COMMONWEALTH OF PENNSYLVANIA)
) SS:
COUNTY OF _____)

On this, the _____day of_____, 20____, before me, the undersigned officer, personally appeared _____ who acknowledged themselves to be all of the members of _____, a _____ limited liability company, and that they, as such members, being authorized to do so, executed the foregoing instrument for the purposes therein contained, by signing the name of said limited liability company by themselves as such members.

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

Notary Public: _____
My Commission expires:_____

JOINDER BY MORTGAGEE

_____("Mortgagee"), as holder of a certain mortgage on the premises of within Rapho Township, Lancaster County, Pennsylvania, described in the Deed in recorded in/at_____ in the Office of the Recorder of Deeds in and for Lancaster County, Pennsylvania, which mortgage, in the amount of _____ dollars ($_____) and dated_____ and is recorded or is about to be recorded in the Recorder of Deeds Office in and for Lancaster County, Pennsylvania, as well as any other mortgages which Mortgagee may now or hereafter hold on the Premises (all such mortgages hereinafter collectively referred to as the "Mortgages"), joins in, consents to, and expressly approves the grant of easements and other rights and privileges described in the attached Storm Water Management Agreement and Declaration of Easement (the "Agreement").

The Mortgagee, for itself, its successors and assigns (which shall include any assignee of the Mortgages and any purchaser of the Premises at a sale in foreclosure of the Mortgages or otherwise), hereby covenants and agrees that the rights and privileges herein granted with respect to the Premises shall not be terminated or disturbed by reason of any foreclosure or other action which may be instituted by the Mortgagee, its successors and assigns, as a result of any default under the Mortgages or the debt instruments that such Mortgages secure. Mortgagee by consenting to the Agreement shall not by virtue of its interest as Mortgagee be deemed to have undertaken any of the obligations of the Grantor under the Agreement, including, but not limited to, construction, maintenance, inspection or indemnification.

IN WITNESS WHEREOF, Mortgagee hereby joins in the execution of the Agreement as of this _____ day of _____, 20___

_____

(Name of Mortgagee)

ATTEST: _____ By:

[SEAL]

ACKNOWLEDGMENT FOR MORTGAGEE

COMMONWEALTH OF PENNSYLVANIA)

) SS:

COUNTY OF _____)

On this, the _____day of_____, 20____, before me, a Notary Public, the undersigned officer, personally appeared, _____ who acknowledged ___self to be the _____ of _____, a corporation, and that such officer being authorized to do so, acknowledged the foregoing instrument for the purpose therein contained, by signing the name of the Bank by ___self as _____.

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

Notary Public: _____

My Commission expires:_____

LOW IMPACT DEVELOPMENT PRACTICES

LOW IMPACT DEVELOPMENT PRACTICES
ALTERNATIVE APPROACHES FOR MANAGING STORM WATER 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 runoff 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 approaches:

- **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 minimize 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 (2) 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 storm water 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. The routing of roof drains and crowning the driveway to allow runoff to discharge to pervious areas is desirable as the pervious area essentially acts as a filter strip.
- **Reducing the Use of Storm Sewers.** By reducing the use of storm sewers for draining streets, parking lots, and backyards, 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 cartway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets, which ultimately could lower maintenance and maintenance-related costs.
- **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, careful consideration of the existing topography and implementation of a combination of the above mentioned techniques may avoid construction of costly storm water control measures. Other benefits include: reduced potential of downstream flooding, reduced water quality degradation of receiving streams and water bodies, enhancement of aesthetics, and reduction of development costs. Beneficial results include: more stable base flows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

STORM WATER MANAGEMENT DESIGN CRITERIA

RATIONAL METHOD RUNOFF COEFFICIENTS

Hydrologic Soil Group and Slope Range

	A			B			C			D		
Land Use	**0 to 2%**	**2 to 6%**	**6+%**	**0 to 2%**	**2 to 6%**	**6+%**	**0 to 2%**	**2 to 6%**	**6+%**	**0 to 2%**	**2 to 6%**	**6+%**
Cultivated Land	0.08[a] 0.14[b]	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Pasture	0.12 0.15	0.20 0.25	0.30 0.37	0.18 0.23	0.28 0.34	0.37 0.45	0.24 0.30	0.34 0.42	0.44 0.52	0.30 0.37	0.40 0.50	0.50 0.62
Meadow	0.10 0.14	0.16 0.22	0.25 0.30	0.14 0.20	0.22 0.28	0.30 0.37	0.20 0.26	0.28 0.35	0.36 0.44	0.24 0.30	0.30 0.40	0.40 0.50
Forest	0.05 0.08	0.08 0.11	0.11 0.14	0.08 0.10	0.11 0.14	0.14 0.18	0.10 0.12	0.13 0.16	0.16 0.20	0.12 0.15	0.16 0.20	0.20 0.25
Residential 1/8 acre	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Residential 1/4 acre	0.22 0.30	0.26 0.34	0.29 0.37	0.24 0.33	0.29 0.37	0.33 0.42	0.27 0.36	0.31 0.40	0.36 0.47	0.30 0.38	0.34 0.42	0.40 0.52
Residential 1/3 acre	0.19 0.28	0.23 0.32	0.26 0.35	0.22 0.30	0.26 0.35	0.30 0.39	0.25 0.33	0.29 0.38	0.34 0.45	0.28 0.36	0.32 0.40	0.39 0.50
Residential 1/2 acre	0.16 0.25	0.20 0.29	0.24 0.32	0.19 0.28	0.23 0.32	0.28 0.36	0.22 0.31	0.27 0.35	0.32 0.42	0.26 0.34	0.30 0.38	0.37 0.48
Residential 1 acre	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.29 0.35	0.35 0.46
Industrial	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial	0.71 0.88	0.71 0.88	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
Streets	0.70 0.76	0.71 0.77	0.72 0.79	0.71 0.80	0.72 0.82	0.74 0.84	0.72 0.84	0.73 0.85	0.76 0.89	0.73 0.89	0.75 0.91	0.78 0.95
Open Space	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Parking	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97

NOTES:

[a]Runoff coefficients for storm recurrence intervals less than twenty five (25) years.

[b]Runoff coefficients for storm recurrence intervals of twenty five (25) years or more.

Source: Rawls, W.J., S.L. Long, and R.H. McCuen, 1981. Comparison of Urban Flood Frequency Procedures Preliminary Draft Report prepared for the Soil Conservation Service, Beltsville, Maryland

RUNOFF CURVE NUMBERS (FROM NRCS (SCS) TR-55)

Runoff Curve Numbers for Urban Areas					
Cover Description		**Curve Numbers for Hydrologic Soil Groups**			
Cover Type and Hydrologic Condition	***Average Percent Impervious Area***	***A***	***B***	***C***	***D***
Fully Developed Urban Areas (Vegetation Established)					
Open Space (lawns, parks, golf courses, etc.):					
Poor Condition (grass cover < 50%)		68	79	86	89
Fair Condition (grass cover 50% to 75%)		49	69	79	84
Good Condition (grass cover > 75%)		39	61	74	80
Impervious Areas:					
Paved Parking Lots, Roofs, Driveways, etc.		98	98	98	98
Streets and Roads:					
Paved: Curbed and Storm Sewers		98	98	98	98
Paved: Open Ditches		83	89	92	93
Gravel		76	85	89	91
Dirt		72	82	87	89
Urban Districts:					
Commercial and Business	85%	89	92	94	95
Industrial	72%	81	88	91	93
Residential Districts by Average Lot Size:					
1/8 Acres or less	65%	77	85	90	92
1/4 Acre	38%	61	75	83	87
1/3 Acre	30%	57	72	81	86
1/2 Acre	25%	54	70	80	85
1 Acre	20%	51	68	79	84
2 Acres	12%	46	65	77	82

Runoff Curve Numbers for Cultivated Agricultural Lands

Cover Description			Curve Numbers for Hydrologic Soil Groups			
Cover Type	**Treatment**	**Hydrologic Condition**	**A**	**B**	**C**	**D**
Fallow	Bare Soil	--	77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & Terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close Seeded or Broadcast Legumes Or Rotation Meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80

Runoff Curve Numbers for Other Agricultural Lands					
Cover Description		***Curve Numbers for Hydrologic Soil Groups***			
Cover Type	***Hydrologic Condition***	***A***	***B***	***C***	***D***
Pasture, Grassland, or Range – Continuous Forage for Grazing	Poor	*77*	*86*	*91*	*94*
	Fair	*76*	*85*	*90*	*93*
	Good	*74*	*83*	*88*	*90*
Meadow – Continuous Grass, Protected from Grazing and Generally Mowed for Hay	--	*30*	*58*	*71*	*78*
Brush – Brush, Weed, Grass Mixture with brush the major element	Poor	*48*	*67*	*77*	*83*
	Fair	*35*	*56*	*70*	*77*
	Good	*30*	*48*	*65*	*73*
Woods – Grass Combination (orchard or tree farm)	Poor	*57*	*73*	*82*	*86*
	Fair	*43*	*65*	*76*	*82*
	Good	*32*	*58*	*72*	*79*
Woods	Poor	*45*	*66*	*77*	*83*
	Fair	*36*	*60*	*73*	*79*
	Good	*30*	*55*	*70*	*77*
Farmsteads – Buildings, Lanes, Driveways and Surrounding Lots.	--	*59*	*74*	*82*	*86*

MANNING'S EQUATION "n" ROUGHNESS COEFFICIENTS

Description	Manning's "n"[1]
Smooth-Wall Plastic Pipe	0.011
Concrete Pipe	0.012
Smooth-Lined Corrugated Metal Pipe	0.012
Corrugated Plastic Pipe	0.024
Annular Corrugated Steel And Aluminum Alloy Pipe (Plain or Polymer Coated)	
68 mm x 13 mm (2 2/3 in x 1/2 in) Corrugations	0.024
75 mm x 25 mm (3 in x 1 in) Corrugations	0.027
125 mm x 25 mm (5 in x 1 in) Corrugations	0.025
150 mm x 50 mm (6 in x 2 in) Corrugations	0.033
Helically Corrugated Steel And Aluminum Alloy Pipe (Plain or Polymer Coated)	
75 mm x 25 mm (3 in x 1 in), 125 mm x 25 mm (5 in x 1 in), or 150 mm x 50 mm (6 in x 2 in) Corrugations	0.024
Helically Corrugated Steel And Aluminum Alloy Pipe (Plain or Polymer Coated)	
68 mm x 13 mm (2 2/3 in x 1/2 in) Corrugations	
a. Lower Coefficients*	
450 mm (18 in) Diameter	0.014
600 mm (24 in) Diameter	0.016
900 mm (36 in) Diameter	0.019
1200 mm (48 in) Diameter	0.020
1500 mm (60 in) Diameter or larger	0.021
b. Higher Coefficients**	0.024
Annular or Helically Corrugated Steel or Aluminum Alloy Pipe Arches or Other Non- Circular Metal Conduit (Plain or Polymer Coated)	0.024
Vitrified Clay Pipe	0.012
Ductile Iron Pipe	0.013
Asphalt Pavement	0.015
Concrete Pavement	0.014
Grass Medians	0.050
Grass - Residential	0.030
Earth	0.020
Gravel	0.030
Rock	0.035
Cultivated Areas	0.030 - 0.050
Dense Brush	0.070 - 0.140
Heavy Timber (Little undergrowth)	0.100 - 0.150
Heavy Timber (with underbrush)	0.40
Streams:	
Some Grass And Weeds (Little or no brush)	0.030 - 0.035
Dense Growth of Weeds	0.035 - 0.050
Some Weeds (Heavy brush on banks)	0.050 - 0.070

Notes:

* Use the lower coefficient if any one (1) of the following conditions apply:

A. A storm pipe longer than twenty (20) diameters, which directly or indirectly connects to an inlet or manhole, located in swales adjacent to shoulders in cut areas, shoulders in cut areas or depressed medians.

B. A storm pipe which is specially designed to perform under pressure.

** Use the higher coefficient if any one (1) of the following conditions apply:

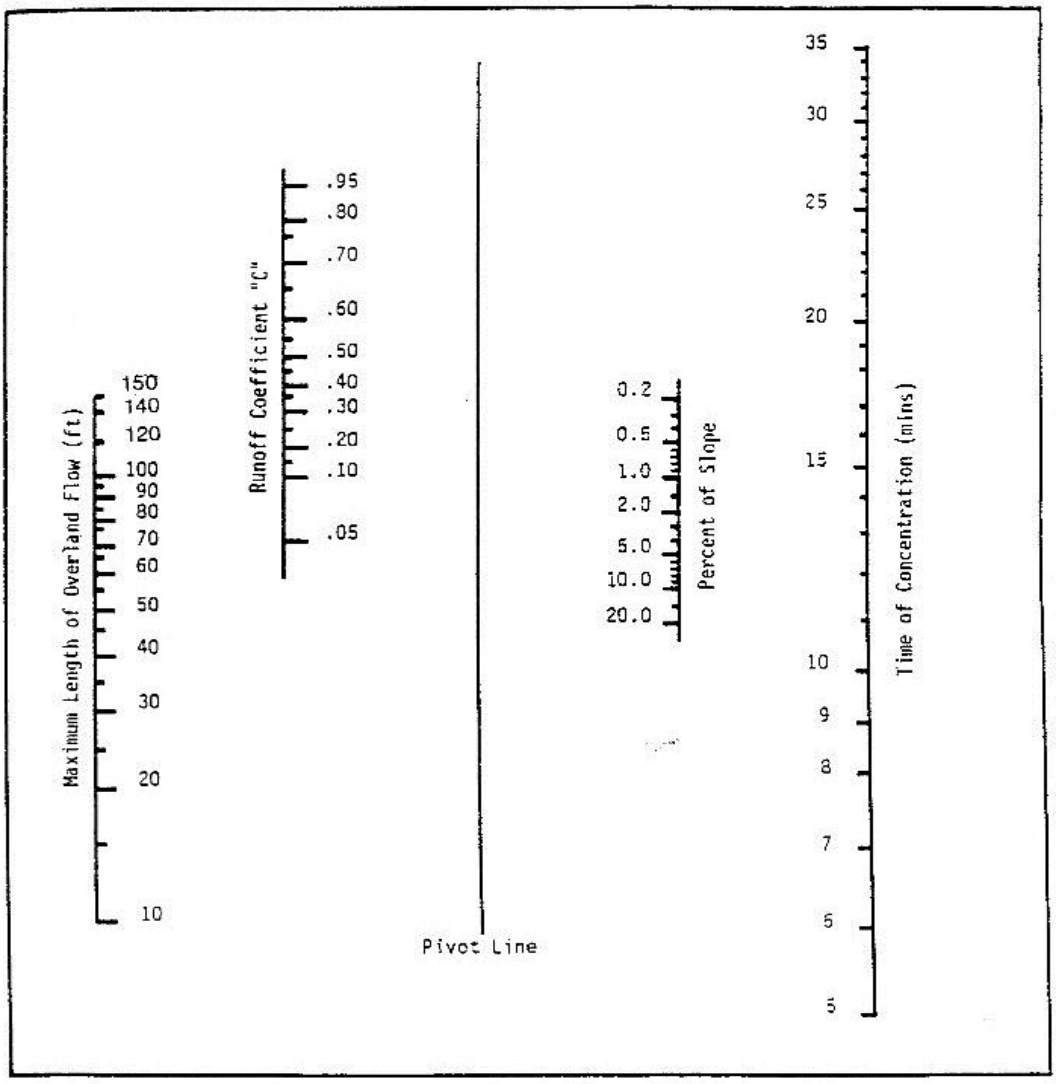
A. A storm pipe which directly or indirectly connects to an inlet or manhole located in highway pavement sections or adjacent to curb or concrete median barrier.

B. A storm pipe which is shorter than twenty (20) diameters long.

C. A storm pipe which is partly lined helically corrugated metal pipe.

NOMOGRAPH FOR DETERMINING SHEET FLOW

(for use with the Rational Method)



Worksheet #1: Time of concentration (T_C) or travel time (T_t)

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	**Segment ID**			
1. Surface description (table 3-1)				
2. Manning's roughness coeff., n (table 3-1)				
3. Flow length, L (total L ≤ **150 ft) ft				
4. Two-yr 24-hr rainfall, P_2 in				
5. Land slope, s ft/ft				
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t hr		+		=
Shallow concentrated flow	**Segment ID**			
7. Surface description (paved or unpaved)				
8. Flow length, L ft				
9. Watercourse slope, s ft/ft				
10. Average velocity, V (figure 3-1) ft/s				
11. $T_t = \frac{L}{3600\,V}$ Compute T_t hr		+		=
Channel flow	**Segment ID**			
12. Cross sectional flow area, a ft^2				
13. Wetted perimeter, P_w ft				
14. Hydraulic radius, $r = \frac{a}{P_w}$ Compute r ft				
15. Channel slope, s ft/ft				
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\,r^{\frac{2}{3}}\,s^{\frac{1}{2}}}{n}$ Compute V ft/s				
18. Flow length, L ft				
19. $T_t = \frac{L}{3600V}$ Compute T_t hr		+		=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) hr				

*Table 3-1 per latest TR-55, Urban Hydrology for Small Watershed

**150' sheet flow length per latest TR-55 revision

AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR SHALLOW CONCENTRATED FLOW

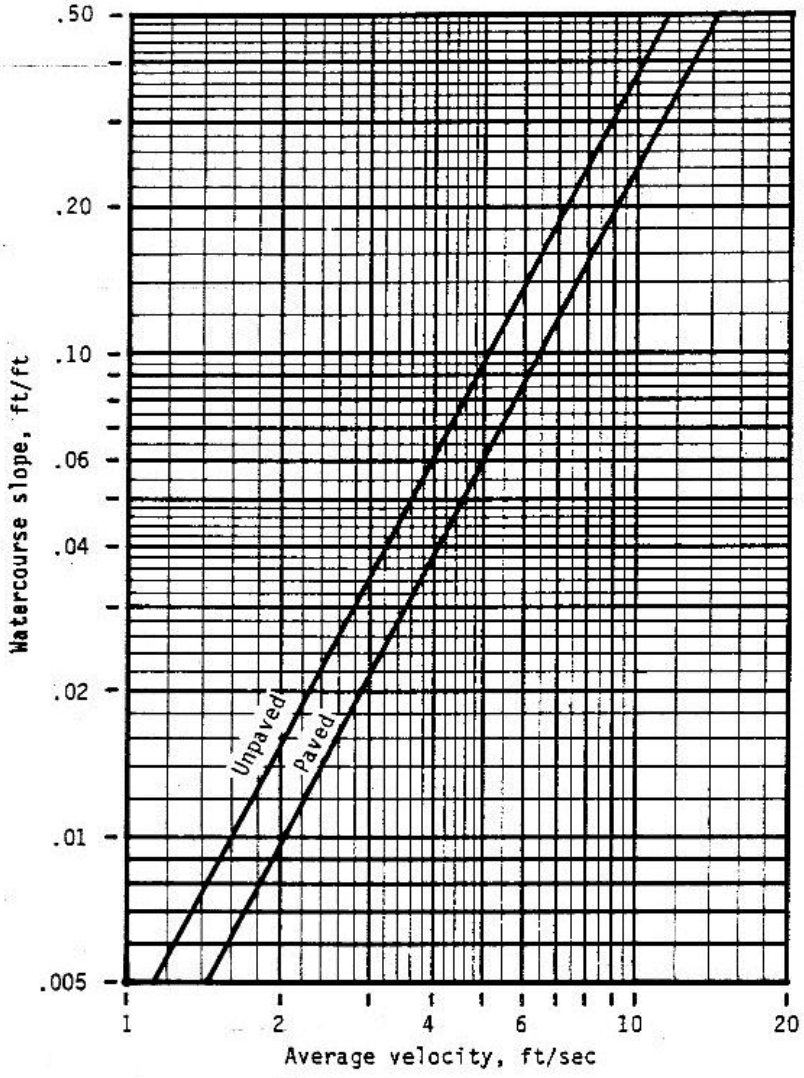


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.