

CITY OF WOODLAND PARK, COLORADO

TITLE 4

DRAINAGE & EROSION CONTROL SPECIFICATIONS

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4.1 DESIGN

4.1.1 DRAINAGE DESIGN CRITERIA

Design for open channels, culverts, ponds, and storm sewers shall be in accordance with the ~~Colorado Springs/El Paso County Drainage Criteria Manual, Volume 1 and Volume 2 with the exception of Section I, Chapter 3 Drainage Basin Fees, Procedures and Layout~~ Pikes Peak Area Council of Governments Areawide Urban Runoff Control Manual. Said manual is hereby adopted and made as much a part of these specifications as if it were printed herein. Any deviation from this manual's standards shall be allowed only by permission of the City Engineer or appointed representative.

Stormwater detention facilities shall be designed for three flows resulting in three separate volumes to be incorporated into the detention pond design. The volume required for each flow scenario shall be added together with the others to obtain the total detention pond volume. Detention pond volume calculations shall be based upon the proposed or post development conditions. Historic discharge rates shall be based upon the historic or pre-development conditions.

Design Storm	Pond Volume Criteria
Low Flow	75% of the volume from the $Q_{2\text{-yr Proposed}}$; discharge = 0, entire volume to be retained
5-year (Initial/Minor Storm)	100% of the volume from the $Q_{5\text{-yr Proposed}}$ (one hour storm); discharge = $Q_{5\text{-yr Historic}}$
100-year (Major Storm)	100% of the volume from the $Q_{100\text{-yr Proposed}}$ (one hour storm); discharge = $Q_{100\text{-yr Historic}}$
Per City of Woodland Park Resolution No. 299, Series 1994	

4.1.2 DRAINAGE REPORT

The Final Drainage Report shall contain the information and calculations supporting the design of the storm drainage system detailed in the engineering drawings. Such information, assumptions and calculations shall be presented in a neat and orderly fashion to facilitate review. Format of the drainage report should follow the Colorado Springs/El Paso County Drainage Criteria Manual (*since no format is specified in the Pikes Peak Area Council of Governments Areawide Urban Runoff Control Manual*).

The report shall include an analysis of the area under consideration in reference to the zoning, historical and developed conditions, existing topography, contributing runoff from upstream areas, control facilities or features, and continuity with a master plan or with the existing drainage. Natural drainage ways are to be used whenever possible; however, when any open channel is to be used as part of the storm drainage system, the drainage report shall include a thorough hydraulic engineering analysis demonstrating that such use is without unreasonable hazard.

The report shall contain the hydrologic analysis including areas, storm frequencies, rainfall intensities, runoff coefficients, soils information, land use, times of concentration, adjustments for infrequent storms, and all runoff computations.

An optional design method, with approval of the City Engineer, for calculating street drainage may use Chapter 7 in the Colorado Springs/El Paso County Drainage Criteria Manual (amended October 12, 1994).

Engineering analyses of all culverts, open channels, and box culverts shall include the design criteria, and computations for any detention facility design. The Final Drainage Report shall include a soils analysis and water table elevations. All calculations, mass diagrams, and/or hydrographs (methods used will depend on the area of the basin to be analyzed) required to size the detention facility and determine its discharge shall also be included. Calculations for specific detention times shall be provided.

All drainage reports shall include a cover letter indicating the date, the name of the project or subdivision, the engineer or engineers designing the system, and shall be stamped and signed by a Colorado licensed professional engineer.

4.1.3 MINIMUM PIPE SIZE

Minimum circular pipe inside diameter shall be as follows:

Main storm sewer line	18"
Catch basin lateral	18"
Driveway or other culvert	18"

Equivalent sized arch pipe may be used upon written request.

4.1.4 MANHOLES

Maximum allowable manhole spacing shall be as follows:

<u>Horizontal pipe size (inches)</u>	<u>Maximum allowable distance Between Manholes</u>
18 to 30	400'
36 to 60	500'
Larger than 60	750'

Manholes (MH) shall be placed wherever there is a change in size, elevation or slope, where there is a junction of two (2) or more systems or laterals, or where the maximum distance above is reached.

Interior diameter of all storm sewer manholes shall be as follows:

<u>Horizontal pipe diameter (inches)</u>	<u>Minimum MH diameter (feet)</u>
18	4
21-48	5
Larger than 48	6

The City may require a larger MH sizing should conditions warrant.

4.1.5 CLEARANCE

The minimum clearance between storm sewer and water main, either above or below, shall be 18 inches. In all cases, suitable backfill and/or other protection as deemed necessary by the City Engineer or appointed representative shall be provided to prohibit settling or failure of either pipe system.

The minimum clearance between storm sewer and sanitary sewer, either above or below, shall also be 18 inches. However, when a sanitary sewer main lies above a storm sewer, or within 18 inches below, the sanitary sewer shall have an impervious encasement for a minimum of 10 feet on each side of where the storm sewer crosses.

4.1.6 CULVERT INLET AND OUTLET PROTECTION

Riprap and flared end sections shall be required at all transitions between culverts and ditches. Alternate means of protecting culvert ends from vehicle damage and channeling runoff into culverts will be reviewed on a case-by-case basis by the City Engineer or appointed representative.

4.2 MATERIALS

- A. All storm sewer systems within the City shall be constructed using Reinforced Concrete Pipe (RCP), Corrugated Steel Pipe, or High Density Polyethylene Pipe (HDPE, up to 30 inches in diameter) and meet the specifications as listed below.
- B. Residential driveway culverts may be Corrugated Steel Pipe (CSP) or HDPE (up to 30 inches in diameter) in lieu of RCP.

4.2.1 REINFORCED CONCRETE PIPE (RCP)

- A. Reinforced concrete pipe shall be a minimum of Class II and conform to the following American Society of Testing Materials designations listed below. The required pipe strength shall be determined from the actual depth of cover, true load, and proposed field conditions. A typical design strength calculation shall be submitted to the City for approval.
 1. Reinforced Concrete Pipe ASTM C-76/C-506/C-507/C-789/C-850
 2. Low-Head, ASTM C-361

3. Precast Manhole Sections, ASTM C-478
 4. Joints, using rubber gaskets, ASTM C-443
- B. Testing of materials to determine compliance with the specifications shall be the responsibility of the Contractor. Two (2) certified copies of test results indicating compliance shall be furnished for each lot or shipment prior to installation of the material. Reinforced concrete pipe shall be tested for strength by the three-edge bearing test to produce a crack of 0.01 inch. Each manufacturer furnishing pipe under these specifications shall be fully equipped to carry out the tests described in ASTM C-497. Upon the demand of the City Engineer or appointed representative and under his supervision, the manufacturer shall perform such number of tests, as the City Engineer or appointed representative may deem necessary within the requirements of the respective ASTM specifications to establish the quality of the pipe offered for use. Failure of any pipe to meet the test requirements shall be sufficient cause for rejection of all pipe of that size which the test specimen represents.

All pipes shall be subject to inspection at the factory and point of delivery by the City Engineer or appointed representative. The purpose of the inspection shall be to cull and reject pipes which, independent of the physical tests herein specified, fail to meet the requirements of these specifications, and rejection through inspection may be made on account of any of the following, but not limited to:

1. Fractures or cracks passing through the Bell Joint, except for a single crack that does not exceed the depth of the joint.
2. Defects that indicate imperfect proportioning, mixing and molding.
3. Damaged ends where damage would prevent the making of a satisfactory joint.
4. Surface defects indicating honeycomb or open texture.
5. Any continuous crack having a width of 0.01 inch or more and a length of 12 inches or more at any point in the wall of pipe.
6. Failure to give a clear ringing sound when tapped with a light hammer.
7. Exposure of the reinforcement when such exposure indicates that the reinforcement was misplaced.
8. Pipe damaged during shipment or handling may be rejected even if previously approved.

4.2.2 CONCRETE PIPE JOINING MATERIALS

- A. Gasket type joints for reinforced concrete pipe shall be as follows:
1. Bell and Spigot Pipe Type K Gasket for low pressure pipe and Type R3 and R4 for high-pressure pipe.
 2. Tongue and Groove Pipe Type-A gasket.
 3. Gaskets shall be manufactured of Buna N, Neoprene or natural rubber.
 4. The gasket shall comply with ASTM C-443.
- B. Rubber joint sealant: the rubber joint sealant shall be made of top grade vulcanized butyl rubber and meet the requirements of ASTM C-443 for physical properties. The sealant shall be compressible and have a tacky surface for adherence to the joint. The material shall be capable of being installed in the temperature range of zero (0) degrees Fahrenheit to one hundred-ten (110) degrees Fahrenheit.

The contractor shall submit to the City Engineer or appointed representative for approval a sample with specification sheets of the type of sealant proposed prior to ordering the material.

4.2.3 STEEL PIPE

- A. Corrugated steel pipe shall conform to Sections 603 and 707 of the Colorado Department of Transportation Standards. Minimum gage shall be 16-gage.

Cutouts may be provided in the field, providing that edges of plates so shaped shall be smooth, uniform and free of all loose slag and scale accumulations, and provided further that a smooth and uniform bearing surface is provided. Repair of damaged galvanized finishing shall conform to the following:

Galvanized surfaces that are abraded or damaged or cut at any time after the application of the zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which the cleaned areas shall be painted with two (2) coats of paint, high zinc dust content, conforming to the requirements of Federal Specifications MIL-P-21035.

- B. PROTECTIVE COATINGS. Where corrosive soil conditions require, additional protection to the galvanized steel pipe shall be applied. The pipe is to be precoated at the place of manufacture and inspected by the City Engineer or appointed representative prior to installation. Patching of damaged pipe may be performed at the job site as directed by the City

Engineer or appointed representative. All cutting and patching shall be made in accordance with the manufacturer's specifications. All fittings and elbows shall be fully coated.

The following coatings are approved:

1. Bituminous protected corrugated steel pipe shall conform to the requirements of AASHTO M-190, Type-A Coating.
2. Smooth lined bituminous protected corrugated steel pipe may be used where specified by the City Engineer or appointed representative. It shall conform to the requirements of AASHTO Designation M-36. In addition, the pipe shall be coated as required in AASHTO Designation M-190, Type-A, and shall be lined on the inside of the pipe so that a smooth surface will be formed by completely filling the corrugations to a minimum thickness of $\frac{1}{8}$ inch above the crest of corrugations. The interior liner shall be applied by a centrifugal or other approved method and shall be free from sags or runs. The pipe is to be precoated and inspected by the City Engineer or appointed representative prior to installation in the field. Riveted steel pipe shall be fabricated in such a manner as to have the rivets located in the inside of the valley of the corrugated pipe.
3. Precoated corrugated steel pipe shall conform to the requirements of AASHTO M-245 and M-246, Type B coating.

- C. TESTING AND INSPECTION OF PIPE. Mill Certifications to determine compliance with the specifications shall be the responsibility of the Contractor. Mill Certifications shall be furnished to the owner prior to final acceptance who in turn provides copies of the certifications to the City Engineer or appointed representative.

Failure of any pipe to meet the test requirements shall be sufficient cause for rejection of all pipe of that size which the test specimen represents.

All pipe shall be subject to inspection at the factory and/or point of delivery by the City Engineer or appointed representative. The purpose of the inspection shall be to cull and reject pipes, which, independent of the physical tests herein specified, fail to meet the requirements of these specifications, and rejection through inspection may be made on account of any of the following, but not limited to:

1. Undue deviation from true shape.
2. Uneven laps.
3. Variations from a reasonably true centerline.
4. Ragged or diagonally sheared edges.
5. Loose, unevenly lined or spaced rivets, bolts, or welds.

6. Poorly formed rivet heads.
7. Illegible brand, type and thickness.
8. Bruised, scaled, or broken zinc coating.
9. Spot welds-crack, tip pickup, pits, and metal expulsion.
10. Dents or bends, other than corrugations.
11. Manually deposited arc welds-cracks, and closely spaced in-line surface porosity.
12. Spiral machine welds-cracks, skips, or deficient welds.
13. Corroded or improperly cleaned and painted welds.
14. Poorly formed lock seams and damaged lock seam metal.
15. Inadequate, improperly applied, cracked, or loose asphalt coating.

D. Steel band joints for corrugated steel pipe shall be as follows:

Coupling bands shall conform to the requirements of AASHTO M-36 with the following exceptions:

1. The use of channel bands as described in 9.1 of AASHTO M-36 will not be allowed.
2. Connecting bands shall be at least 10½ inches wide.

4.2.4 HIGH DENSITY POLYETHYLENE PIPE (HDPE)

A. PIPE

HDPE storm water pipe shall meet ASTM F2648 and be manufactured from an engineered compound of virgin and recycled high density polyethylene conforming with the requirements of cell classification 424420C (ESCR Test Condition B) for 4-inch through 10-inch diameters, and 435420C (ESCR Test Condition B) for 12-inch through 30-inch diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4%. The recycled compounds used shall be those generated in the manufacturer's own plant from resin of the same specification from the same raw material. The pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, voids, or other injurious defects.

B. JOINTS

Pipe shall be joined using a bell and spigot joint meeting ASTM F2648. The joint shall be soil-tight and gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to insure the gasket is free from debris. A Joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.

C. FITTINGS

Fittings shall conform to ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the soil-tight joint performance requirements of ASTM F2306.

D. PIPE PACKAGING, HANDLING AND STORAGE

The manufacturer shall package the pipe in a manner designed to deliver the pipe to the project neatly, intact and without physical damage. The transportation carriers shall use appropriate methods and intermittent checks to insure the pipe is properly supported, stacked and restrained during transportation such that the pipe is not nicked, gouged, or physically damaged.

Pipe shall be stored on clean, level ground to prevent undue scratching or gouging. If the pipe must be stacked for storage, such stacking shall be done in accordance with the pipe manufacturer's recommendations. The pipe shall be handled in such a manner that it is not pulled over sharp objects or cut by chokers or lifting equipment.

Sections of pipe having been discovered with cuts or gouges in excess of ten (10) percent of the pipe wall thickness shall be cut out and removed. The undamaged portions of the pipe shall be rejoined using the heat fusion joining method.

4.2.5 MANHOLES

Manholes shall conform to Section 3.3.4 with exception of the size of manhole required which is covered in Section 4.1.4.

4.2.6 CONCRETE

All concrete shall conform to Section 6.2.

4.2.7 RIP-RAP

Rip-rap shall consist of hard, dense, durable stone, angular in shape and resistant to weathering. Rounded stone or boulders shall not be used as rip rap material. The stone shall have a specific gravity of at least 2.5. Each piece shall have its greatest dimension not greater than three (3) times its least dimension.

Material used for rip-rap may be approved by the Engineer if, by visual inspection, the rock is determined to be sound and durable. The Engineer may require the Contractor to furnish laboratory results if, in the Engineer's opinion, the material is marginal or unacceptable. Rip-rap shall conform to the gradation requirements given in Table 4-1.

TABLE 4-1

Pay Item		% of Material Smaller Than Typical Stone ²	Typical Stone Dimensions ³ (Inches)	Typical Stone Weight ⁴
Type	Stone Size d50 ¹ (Inches)			
Rip Rap	6	70-100	12	85
		50-70	9	35
		35-50	6	10
		2-10	2	0.4
Rip Rap	9	70-100	15	160
		50-70	12	85
		35-50	9	35
		2-10	3	1.3
Rip Rap	12	70-100	21	440
		50-70	18	275
		35-50	12	85
		2-10	4	3
Rip Rap	18	100	30	1280
		50-70	24	650
		35-50	18	275
		2-10	6	10
Rip Rap	24	100	42	3500
		50-70	33	1700
		35-50	24	650
		2-10	9	35

¹d50 = nominal stone size
²based on typical rock mass
³equivalent spherical diameter
⁴based on a specific gravity = 2.5

Nominal stone size and total thickness of the Rip-Rap shall be as shown on the plans. The use of broken concrete shall not be allowed as a substitute for Rip-Rap. Control of gradation will be by visual inspection. The Contractor shall provide two samples of rock at least five (5) tons each, meeting the gradation specified. One (1) sample shall be provided at the construction site and may be a part of the finished Rip-Rap covering. The other sample shall be provided at the quarry.

4.3 DRAINAGE CHANNEL CONSTRUCTION

4.3.1 CHANNEL EXCAVATION

- A. PERMIT RECEIVED. All excavation in the public right-of-way requires a permit and shall conform to Title 7 of these specifications.
- B. TOLERANCES. The profile of the invert of ditches and channels shall be +/- 0.3 feet of the lines and grades shown on the drawings. The extremes of such tolerances shall not be continuous over a distance of 100 feet measured at any place in any direction parallel to the excavated surface.

- C. EXCAVATION BEYOND ESTABLISHED LINES. Precautions shall be taken to preserve, in an undisturbed condition, material beyond the designated lines of the excavations except unsuitable material ordered removed by the City Engineer or appointed representative. Material loosened beyond the excavation limits as a result of excavation operations shall be considered defective work and be compacted or removed and replaced with compacted embankment as directed by the City Engineer or appointed representative.
- D. BOTTOM AND SIDE SLOPES. The bottom and side slopes of excavation in soil against which surfacing is to be placed shall be finished carefully to the elevations and dimensions shown on the drawings. If foundation material is loosened or disturbed it shall be compacted to not less than 95 percent of the maximum Proctor Density when tested to ASTM D-1557 for a depth of one (1') foot, or if directed, it shall be removed and replaced with compacted backfill, flowcrete, or concrete. Material, which will not provide a suitable foundation, shall be removed and replaced with compacted backfill, flowcrete, or concrete as directed.

4.3.2 CONCRETE CHANNEL CONSTRUCTION

All concrete work shall conform to Title 6 of these specifications except as follows:

- A. SLUMP. Limitations for concrete lining shall be as follows:
On side slopes, slumps of over 2½ inches will be grounds for rejection of the load. On channel bottom, the slump shall be held to a maximum working limit of four (4") inches.
- B. WEEP HOLES. Weep holes shall be constructed of minimum two (2") inch diameter plastic or galvanized steel pipe inserted to the thickness of the concrete lining.
- C. JOINTS. Expansion joints shall be a minimum of 100 foot spacing unless specified otherwise by the City Engineer or appointed representative.
- D. PLACEMENT AND FINISH. The concrete shall be placed in the form and thoroughly spaced or tamped so that there will be no air spaces in the mass. The surface shall be floated with a wood float to draw the mortar to the surface. Just before the concrete takes its initial set, the surface shall be brushed with a soft bristle brush so as to remove all trowel marks and leave a uniform appearance. Brushing shall be perpendicular to the ditch line on side slopes and parallel to the ditch line on the bottom.
- E. TESTING. The contractor shall bear all costs of compaction, concrete and other tests ordered by the City Engineer or appointed representative. Test results shall be furnished verbally to the City Engineer or appointed

representative as soon as available, with a written, certified confirmation as soon as possible.

4.3.3 EARTH CHANNEL CONSTRUCTION

- A. **RIP RAP.** Rip rap shall be placed at all points where drainage is required to change directions more than 30 degrees horizontally or as directed by the City Engineer or appointed representative. Rip rap shall be placed a minimum of ten (10') feet on each side of said changes of direction.

Rip rap shall be placed in such a manner as to produce a well-graded mass of rock with a minimum of voids. The larger stones shall be well distributed and the finished protection shall be free from pockets of small stones and clusters of larger stones. Rearranging of individual stones by equipment or by hand shall be required if necessary to maintain a well-graded distribution of rock conforming to the contour specified.

- B. **ROLLED EROSION CONTROL MATERIAL.** Erosion control materials shall be used when the slope of ditch or the velocity of water is determined to be great enough to cause erosion based on the soil conditions of the channel.

Fastening pins shall be non-metallic, such as wood or plastic, when erosion control material is placed over existing underground utility alignments.

4.3.4 GROUTED CHANNEL CONSTRUCTION

When grouted rip rap is required, the riprap shall be grouted with concrete grout conforming to the requirements of these specifications except that a minimum of five (5) sacks of cement per cubic yard shall be used. The maximum size of coarse aggregate shall be $\frac{3}{4}$ inches, and may be mixed by a method that will produce properly mixed concrete grout. The grout shall be used within one (1) hour after mixing.

Concrete mortar shall be placed in conformance with Section 601.12 of the Colorado Department of Transportation Standards with the following exceptions:

The grout slump shall be between six (6") inches and eight (8") inches. The surfaces of the rock or stone to be grouted shall be cleaned of adhering dirt or other deleterious material. All concrete mortar shall be delivered by means of a low pressure (less than 10 psi) grout pump using a two (2") inch diameter nozzle. Full depth penetration of the concrete mortar into the rip rap is required. To achieve this, a pencil vibrator shall be used. After placement of grout the boulders shall be thoroughly washed to remove all residual grout. All grout between boulders shall be finished with a broom finish. The edge of grouted boulders shall be formed to present a neat line to spread topsoil. All concrete mortar shall be sprayed with a clear liquid membrane curing compound as approved by the City Engineer or appointed representative.

4.4 STORM SEWER CONSTRUCTION

4.4.1 EXCAVATION

All excavation in the public right-of-way requires a permit and shall conform to Title 7 of these specifications.

4.4.2 PIPE CONSTRUCTION

All main lateral and manhole installation shall conform to Section 3.3 of these specifications.

4.4.3 INITIAL ACCEPTANCE

Refer to Title 1, Section 1.3.7.2 for Initial Acceptance Requirements.

4.4.4 MAINTENANCE BETWEEN INITIAL AND FINAL ACCEPTANCE

The City may consider assuming the maintenance of surface and subsurface drainage systems and erosion control structures after a minimum one (1) year maintenance period (detention ponds after a minimum of two (2) years maintenance period) or upon the establishment of substantial vegetative ground cover by the developer if the following are met:

- A. All of the requirements of the City of Woodland Park Engineering Specifications.
- B. The City has completed an inspection of the facilities.
- C. All necessary easements and/or R.O.W., entitling the City to properly maintain the facility, have been conveyed to the City.

4.5 EROSION CONTROL

There are two (2) types of water erosion control measures; those that prevent initial movement (cover factor) and those that reduce sediment content in moving water (practice factor). Erosion control measures must be properly designed, installed and maintained if they are to accomplish their intended purpose and effectiveness. Timing of implementing measures is one of the most critical factors involved in the control of erosion from developing and redeveloping sites. Erosion Control requirements shall be in accordance with the conditions of the City Code, Sections 18.40.020 and 18.40.140 and City Guidelines for developing Erosion and Sediment Control Plan (ESCP).

4.5.1 NON-STRUCTURAL EROSION CONTROL MEASURES

Non-structural erosion control measures provide the best means of managing sediment from disturbed lands by preventing soil movement. The more effective practices are the use of vegetation.

Vegetative measures can provide temporary cover to help control erosion during construction and permanent cover to stabilize a site after construction is completed. The measures include the use of sod, planting of temporary cover crops and establishing permanent cover crops.

When establishing a permanent dry land grass cover, seeded areas shall be protected with mulch or other acceptable measures (e.g. crimped straw, excelsior fabric, hydraulic mulch, mulched tactifier, etc.) and the mulch shall be adequately secured. It is important to establish vegetative cover as soon as possible in order to reduce erosion.

Reestablishing vegetation within City R.O.W. shall be accomplished using a seed mix suitable for the mountain environment and approved by the City Engineer or appointed representative. Arkansas Valley seeds “Low Grow Mix” is preferred.

Hydro mulching or the use of rolled erosion control materials, is essential in establishing good stands of grass on moderate to steep slopes, and on other areas where it is difficult to establish vegetation.

4.5.2 STRUCTURAL EROSION CONTROL MEASURES

Once erosion commences due to water, structural measures have to be utilized to reduce sediment from disturbed lands. Below are some of the more practical and cost effective measures used in implementing an erosion control plan. These are some of the common structural Best Management Practices for controlling erosion.

- Sediment trap basins
- Diversions
- Terraces
- Berms
- Surface roughening
- Filter berms
- Sediment barriers
- Erosion logs or waddles
- Filtered inlets
- Contour wind row

4.6 LOW IMPACT DEVELOPMENT

The Low Impact Development (LID) approach combines a hydrologically functional site design with pollution prevention measures to compensate for land development impacts on hydrology and water quality.

The use of Low Impact Development (LID) techniques are encouraged so the site meets the following criteria:

- Post-development hydrograph essentially mimics or matches the pre-development hydrograph in peak flow and volume.
- Source (on-site) control of both water quantity and water quality.

The goal of LID is to design the site in a way that mimics hydrologic functions. The first step is to minimize the generation of runoff (reduce the change in the runoff curve number (CN)). In many respects, this step is very similar to traditional techniques of maximizing natural resource conservation, limiting disturbance and reducing impervious areas. The major difference with LID is the need to consider how best to make use of the hydrologic soil groups and site topography to help reduce and control runoff. These considerations would include:

1. Maintain natural drainage patterns, topography and depressions,
2. Preserve as much existing vegetation as possible in pervious soils; hydrologic soil groups A and B,
3. Locate BMP's in pervious soils; hydrologic soil groups A and B,
4. Where feasible construct impervious areas on less pervious soil groups C and D,
5. Disconnect impervious surfaces, maintain pre-development times of concentration,
6. Direct and disburse runoff to soil groups A and B,
7. Flatten slopes within cleared areas to facilitate on lot storage and infiltration and
8. Re-vegetate cleared and graded areas.

Where ground water recharge is particularly important (to protect well, spring, stream and wetland flows) it is important to understand the source and mechanisms for ground water recharge. When using the LID design concepts to mimic the hydrologic regime the designer must determine how and where ground water on the site is recharged and where necessary protect and utilize the recharge areas in the site design.

Source: Low –Impact Development Design: A New Paradigm for Stormwater Management Mimicking and Restoring the Natural Hydrologic Regime *An Alternative Stormwater Management Technology*