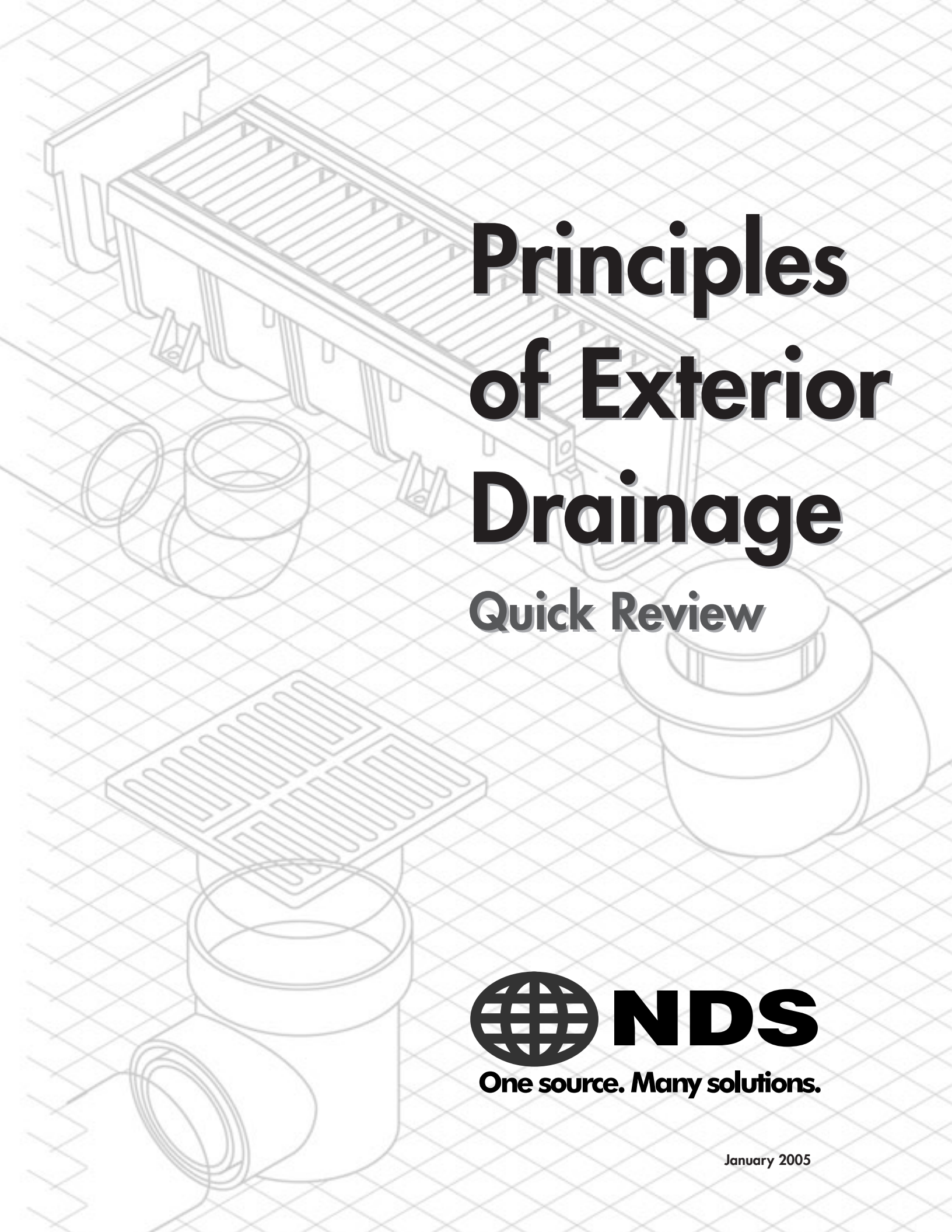


Principles of Exterior Drainage

Quick Review

NDS

One source. Many solutions.

January 2005

Contents

Forward

Company Information

NDS leads the exterior drainage industry with superior quality, design and service. NDS offers a full range of products, including catch basins, grates, channel drains, sewer fittings, flex couplings, and other related products. Our products are engineered to withstand extreme outdoor environments from the coldest Canadian winter to the hottest desert summer. NDS products are made with quality resin to maintain superior impact and load resistance. NDS products contain UV inhibitors to combat fading and to prevent brittleness that plagues inferior products.

Preface

The information in this manual is intended as a guideline for individuals interested in increasing their basic knowledge of exterior drainage projects. A landscape architect or engineer should be consulted in critical areas or matters of drainage design.

Refer to the following NDS references for further information:
a) NDS Installation Guide - for Basins, Grates, and Channel Drains.
b) NDS Drainage Calculator - for determining the size of pipe and grate to use.
c) NDS Principles of Drainage - Short Course - a comprehensive text on soils, grades, materials, design, and installation as they relate to drainage projects.

A. Background Information

Sources of Water

Surface water comes from rainfall or an irrigation event that does not infiltrate the soil. Surface water run-off increases as we develop more impervious surfaces such as roofs, driveways, and patios. Most subsurface water results from surface infiltration into the soil.

The Basic Problems

Subsurface water and surface water run-off may constitute excess water that is detrimental to turf and other plant life. This excess water retards plant growth. Surface run-off causes erosion and is retained in surface depressions. Excessive surface and subsurface water will create structural damage to foundations, concrete slabs, and other building structures. Drainage problems can be caused by surface obstructions such as tree roots, landscape edging, flatwork, driveways, sidewalks, and patios.

Indicators of Drainage Problems

1. Personal observations.
2. Standing water 24 hours after a hard rain or irrigation.
3. Yellowing plant life.
4. Water debris such as leaves, pine straw, trash, etc., that has accumulated in affected areas.
5. Mud or silt deposits on flatwork, porches, etc.
6. Structural damage related to moisture or excess water problems.
7. Water intrusion into the home through doors, sills, basements, garages, etc.

Surface Drainage Benefits

1. Prevents erosion.
2. Removes excess rain or irrigation water.

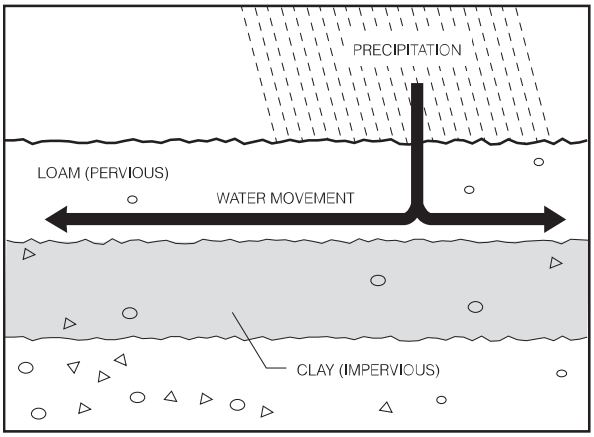
Common Drainage Problems and Solutions

Problems		Solutions
Down spouts from gutters empty near foundations	⟷	Tie down spouts into a drainage system
Water seeping through foundation walls	⟷	Surface and subsurface draingae system
Standing water in low spots of yard	⟷	Surface drains
Standing water in contoured landscape	⟷	Surface drains
Driveway slopes into garage	⟷	Install channel drain in front of garage
Patio slopes towards building	⟷	Install channel drain next to building
Retaining walls	⟷	Weep holes, french drains, and surface drains
Soggy flat turf areas	⟷	French drains

A. Background Information

Subsurface Drainage Benefits

1. Removal of excess subsurface water from the soil profile provides many benefits:
    a) Prevents soil compaction and improves traffic capacity.
    b) Provides increased aeration in the root zone. Air is necessary in the root zone for healthy growth.
    c) Increases the supply of available plant food by increasing the presence of air in the root zone.



Natural ability of the soil to absorb water may depend on an imperious layer of soil which inhibits the infiltration of surface water.

Soil Function

Soil basically acts as a pervious medium that provides passageways (voids in the soils) for water to move into the subsurface.

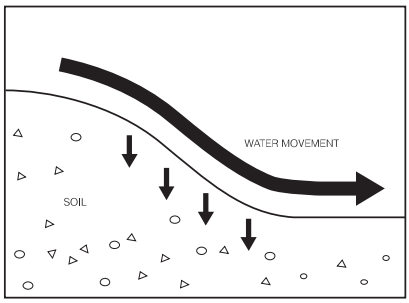
The passage of water depends greatly upon the size of the voids in the soil structure. Granular soils with higher void sizes like sand, allow better water movement than compact soils with smaller void sizes like clay, that have a flat configuration and small grain sizes. Loam soils are comprised of medium-sized particles.

Compaction, from pedestrian and vehicular traffic, can reduce the void size in any soil, to the detriment of proper drainage. The best way to determine drainage needs in the soil is to probe with a soil auger 3′ to 6′ deep. Soil should be evaluated to at least 6″ below the foundation depth for any building.

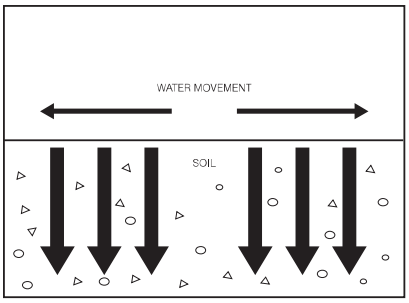
A. Background Information

Topography

Slopes have an influence on surface run-off and subsurface ground water. The greater the slope, the more surface run-off and less soil absorption. Conversely, the lesser the slope, the more soil absorption and less surface run-off are experienced. The boldness of the arrows illustrates run-off and filtration potential



More surface water runoff, less soil penetration



Less surface water runoff , more soil penetration

Influence of slope

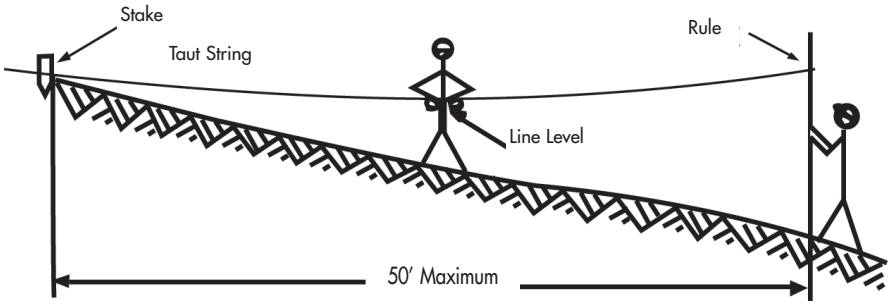
Grades and Pipe Slope

The slope or the grade of the surface can be identified by a line level for distances up to 50 feet where precision is not critical. A tripod level is ideal for precision measurements. Slope can be calculated using the following formula:

Rise ÷ Run = Slope. Example: 1′ elevation change ÷ 100′ distance = 1% Slope.

Line Level

A line level is a small level bubble enclosed in a metal case, which can be hooked over a taut string. With the string tied to a stake or held to the ground at one point and adjusted until it is level, the difference in elevation between the string and the ground can be measured with a rule, see below example.



B. DESIGN

Basic Drainage Design

The three basic functions of any storm drainage system are to:

1. Collect
2. Conduct
3. Dispose of storm run-off

Checklist for Drainage Design

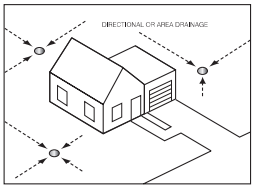
1. Analyze topography.
    a) Check off-site drainage pattern. Where is water coming onto site?
    b) Check on-site topography for surface run-off and percolation. Where is the water going? Where are the low spots?
    c) Check means of disposal. Check local codes.
        1) On-site: pond, creek, and/or retention basin
        2) Off-site: street and/or storm drains
        3) Natural drainage system: swales
        4) Existing drainage system: drain pipe(s)
2. Analyze areas for probable location of drainage structures.
3. Identify type and size drains required. Design the system using a combination of surface and subsurface drain systems and underground pipes. Design pipe layout to convey water from the drains to the discharge point in the most direct and simple manner possible.

Surface Drain Design

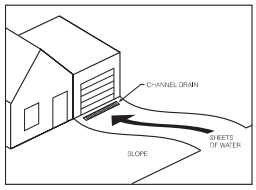
Directional Drains vs. Channel Drains

Directional or area drains, basins or inlets are ideal for landscaping applications. Water is directed to the drain by the contours of the landscape. Area drains are located in low spots or swales. Typically, the basin or inlet is connected to a pipe main or sub-main, utilizing a lateral pipe connection. Locating basins and inlets directly on top of the mains or sub-mains is less desirable, because they create more turbulence in the flow of run-off water through the pipe system.

Channel drains are ideal for hardscapes or concrete, brick, and paver flatwork applications. They operate on the same principle as a roof gutter. The channel drain acts as a perimeter drain at the edge of the slope. Sheets of water are intercepted by these linear drains.The open surface area of a channel drain is much greater than that of an area drain. Since hardscapes absorb so little run-off, the greater volume of surface run-off generated is better handled by the additional open surface area of a channel drain. Channel drains enable modest slopes in one direction or grade, as opposed to grading a deck surface to low areas or directional drains, which require numerous slopes and are often more extreme and difficult to install.



Directional Drainage

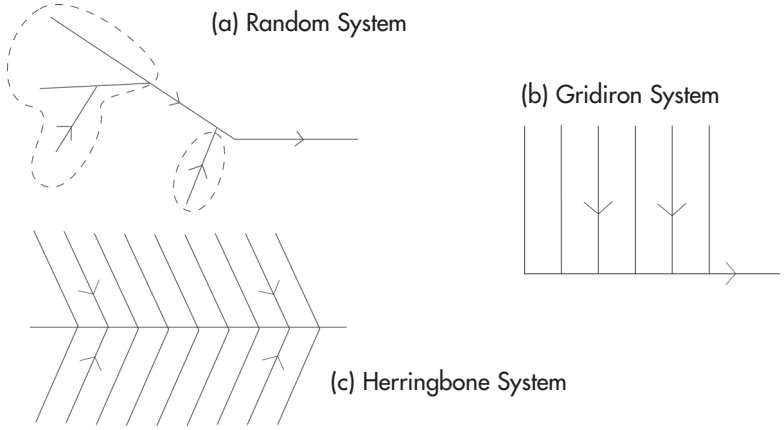


Channel Drainage

B. DESIGN

Subsurface Drain Design

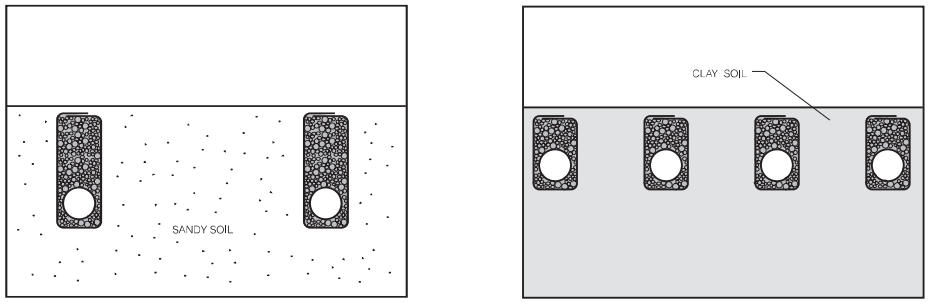
The major components of a subsurface drainage system are mains, submains, laterals, and drainage outlets. The laterals collect the free water from the soil and carry it to the submains and mains. These in turn, conduct the water to the drainage outlet.



Piping Patterns for Subsurface Drainage

The spacing of drainage lines depend on the texture of the soil to be drained. Sandy soils permit more rapid movement of water than do heavy clay soils, therefore lines may be spaced farther apart and deeper in sandy soils than in clay soils.

A very general spacing and depth guideline for recreational turf applications, is to install the 3 inches and/or 4 inches perforated drain pipe that should be buried from 18 inches to 3 feet deep and 15 to 20 feet apart. For rapid drainage, subsurface drain pipe may be placed 18 inches deep in 4 to 10 foot spacings. A qualified engineer should be consulted for some soils and critical areas.



For sandy soil, use wide spacings and deep trenches.

For clay soil, use narrow spacings and shallow trenches.

Spacing for subsurface drains

The NDS Principles of Exterior Drainage - Short Course offers more extensive design information including; pipe and grate size for surface drain systems and pipe and spacing for subsurface drain systems.

C. Drainage Materials and Installation

Drainage Materials

Drain Pipe

The two most common types of drain pipe systems for residential and commercial drainage applications are Corrugated and Sewer and Drain (smooth wall) pipe.

Labor savings and flexibility are two important advantages of corrugated pipe. Corrugated pipe is made of HDPE (High Density Polyethylene). Co-extruded dual wall corrugated pipe is a variation to single wall corrugated pipe. It is more rigid and has a smooth interior wall which gives it the characteristics of Sewer and Drain pipe.

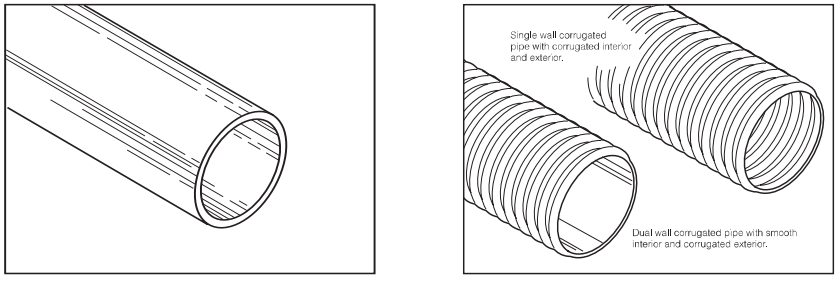
Sewer and Drain Pipe has a smooth interior giving it ideal flow characteristics. It is easier to maintain a continuous slope in critical areas with sewer and drain pipe. Drain snakes can be used if the pipe line becomes clogged. Sewer & drain pipe systems are available in Poly Vynil Chloride, Styrene, Acryllonitrile Butadiene Styrene and Polyethylene.

PVC and ABS connectors can be solvent-welded using PVC or ABS cement. Styrene fittings can be glued to PVC pipe using styrene, PVC, or multi-purpose pipe cement. Polyethylene connections do not glue together. Corrugated pipe connections snap together.

DWV or Schedule 40 pipe systems are seldom used to collect water for drainage projects because of their higher cost. A variety of adapters are available to connect DWV or Schedule 40 pipe systems to Sewer and Drain and/or Corrugated pipe systems.

Perforated pipe (holes or slits in the pipe) is used for subsurface drainage and solid pipe is used to convey water from surface and/or subsurface drainage systems to a discharge point.

Gravity is the primary vehicle for carrying run-off away. There must be a contin-ueous 1/8" per foot or 1% minimum slope for smooth interior pipe that is conveying water from one point to another. 25% more slope may be required for corrugated pipe to compensate for the corrugated interior. Sub-surface perforated drain pipe, used to collect sub-surface water, may be sloped between .01% and 1%. Consult an engineer or architect for minimum slope in critical applications.



Smooth wall sewer & drain pipe

HDPE corrugated pipe.

Type of Drain Pipesit

C. Drainage Materials and Installation

Subsurface Drainage

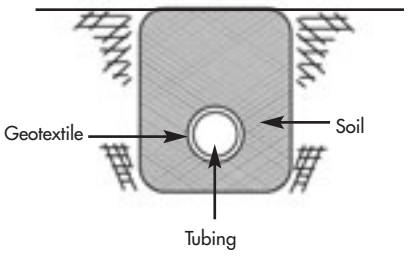
Subsurface drainage is accomplished by placing an artificial channel below the water table, so free water enters the drain and flows to a discharge point.

French Drain

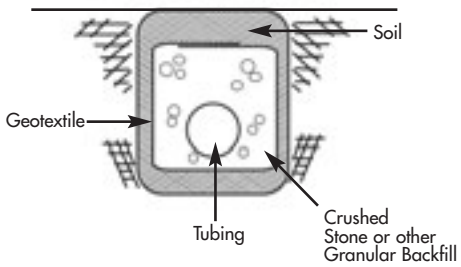
French drains, a form of subsurface drain, utilizes a buried perforated pipe installed in a gravel bed with a filter sock surrounding the pipe or geotextile fabric envelope lining the trench. Water from the surrounding soil enters the gravel bed, flows into the drain pipe and utilizes gravity to flow towards the discharge point. Perforated holes on sewer and drain pipe should always face downward.

French Drain

For sandy and silty soils either a sock pipe or geotextile filter fabric lining the gravel envelope should be used to prevent clogging and sediment build up inside the drain pipe. In some applications the sock pipe eliminates the need for a gravel envelope so soil can be used as backfill. Filter fabric lining the trench bed may be preferred to a filter sock surrounding the pipe. Filter fabric is typically non-woven fabric.



Filter Sock
Surrounding Pipe



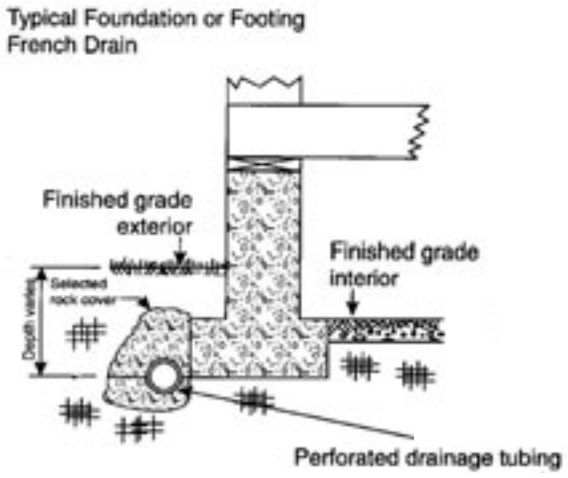
Geotextile Filter Fabric
Lining Trench

Soil lines may clog the filter. Since the filter fabric lining the trench offers considerably more surface area, clogging is less likely to be a problem. Critical installations may require a combination of sock pipe and filter fabric gravel envelope, to prevent soil fines from clogging the drain.

C. Drainage Materials and Installation

Foundation or Footing Drains

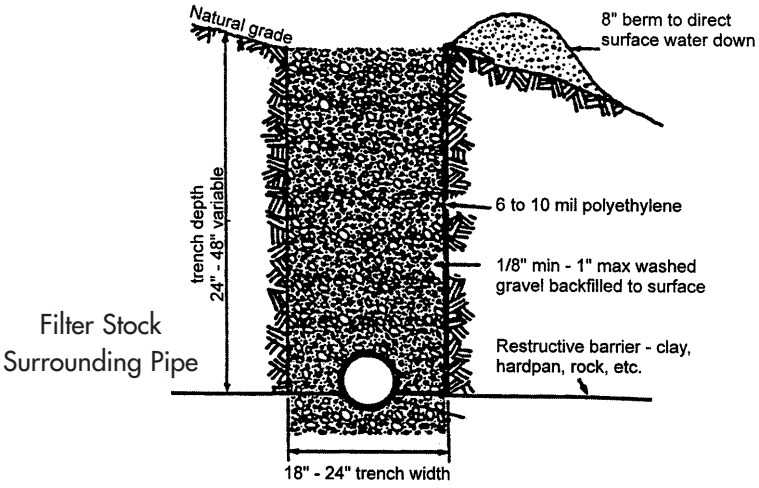
Of the many home and construction uses for drainage tubing, two of the most common are footing and curtain drains. The footing drain is designed to prevent ground water from entering either the basement or the foundation of a building. It should be installed slightly below the base of the footing.



Cross-section of Footing or Foundation Drains

Curtain Drain

Curtain drains intercept surface run-off on slopes and ground water in the soil. A curtain drain placed on a slope above and parallel to a building, will intercept run-off water before it reaches the foundation or creates wet spots in the yard. The "curtain" is created by the polyethylene film lining the downhill side of the trench ensuring water movement to the drain pipe.

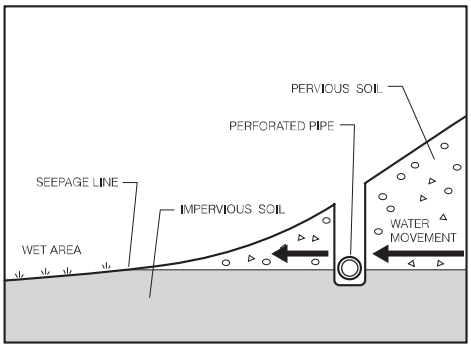


Typical Curtain Drain

C. Drainage Materials and Installation

Interceptor Drain

Interceptor drains can be constructed using French drains. These drains intercept ground water flowing laterally on top of impervious layers of soil.



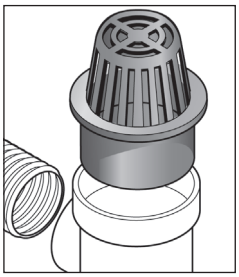
The size, depth and height of the drainage system is controlled by the depth of the impervious layer of soil.

Interceptor Drain Intercepts Water Flowing Laterally in the Soil

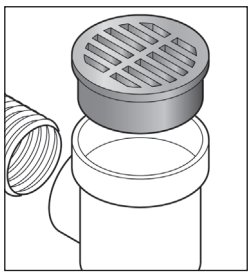
Catch Basins and Inlets

Catch basins or drain inlets (both a form of surface drains) used in conjunction with a non-perforated drain pipe system, will remove large amounts of surface water. These are typically used in low areas of turf landscapes, hardscapes, driveways, parking lots, etc.

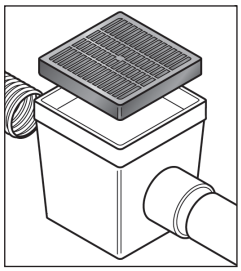
Atrium grates are used in landscape areas, planter beds, window wells, or where debris like mulch and leaves might clog a flat grate. They require less maintenance as a result. Atrium grates have larger open surface areas to handle more run-off as well. Round grates are used often in landscapes while square grates are easier to form around in concrete, pavers and other pavement applications.



Atrium Grate



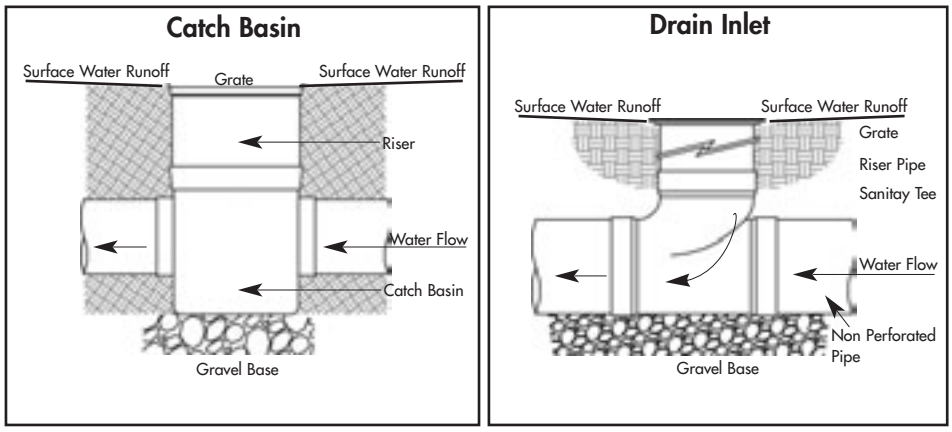
Round Grate



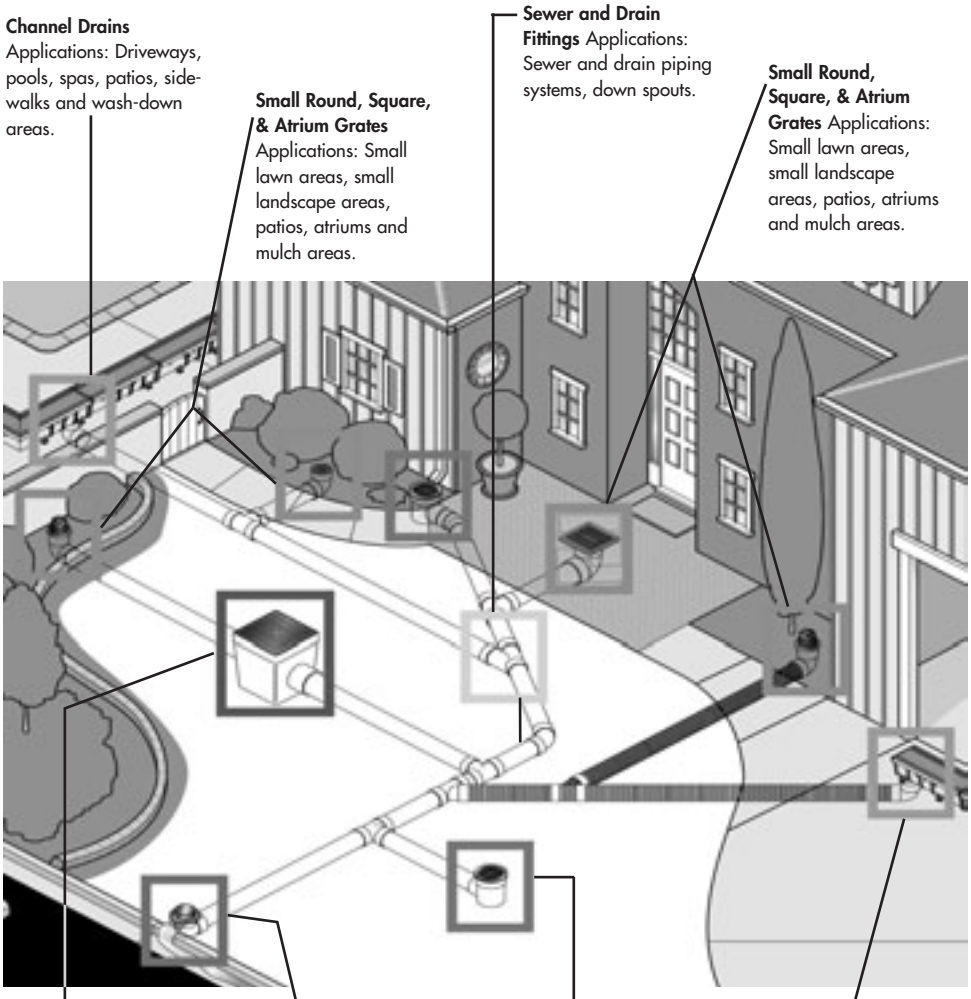
Square Grate

The sump area of a catch basin collects debris from run-off water that might clog drain lines. The debris is cleaned out periodically. A catch basin should be used in areas where debris like mulch, leaves, sand, silt or grass clippings are prevalent. NDS Grates and Basins are flexible by design and easy to install. NDS grates come in sizes ranging from 3" to 15" round, 4" to 24" x 24" square, and 2" to 18" x 18" atrium. Basins range in size from 6" Spee-D and 9" x 9" to 24" x 24" square basins.

C. Drainage Materials and Installation



Catch Basin and Inlets



C. Drainage Materials and Installation

All NDS grates fit directly into corrugated pipe, sewer and drain fittings, or NDS catch basins, adapters, and risers. All NDS catch basin outlets fit directly into corrugated or sewer and drain pipe and may be adapted to SCH 40 or DWV pipe.

NDS universal outlets allow the installer to customize basins with 3", 4", 6", 8", 10" or 12" connections in 1, 2, 3, and 4 outlet configurations.

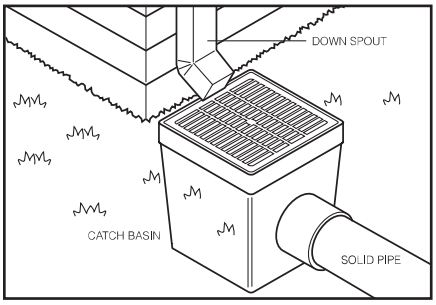
Riser extensions allow the installer to vary the depth of the basin outlets to maintain the proper slope in the drain line. Additional sump area may be created by using risers with universal outlets. Low profile adapters simplify installation in difficult soil conditions, or in areas where a sump area is not required.

Basin and Grate Installation

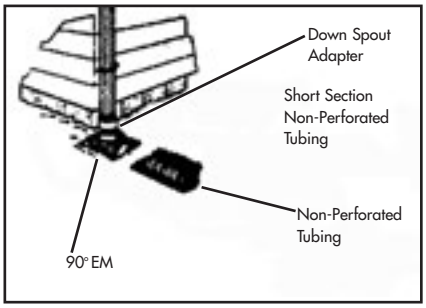
1. Choose grate or basin size according to amount of rainfall, surface area, and type. It may be necessary to install more than one grate or basin to accommodate excessive run-off or a combination of low spots. Use catch basins in applications where it is necessary to collect debris from run-off water in a sump area. This helps minimize clogging of drainage pipes.
2. Locate low spot or any area where excess water will accumulate.
3. Dig hole deep enough for overall height of basin and grate. Install basin in hole on top of a firm base. Work from the discharge point back to the grate. Excavate the base of the trench with a minimum 1% slope to ensure drain pipe slopes to the discharge point.
4. Connect pipe to the basin. Backfill trench and area around basin.
5. Finish off landscaping surrounding project area.

Down Spouts

Down Spouts remove a tremendous volume of water from roofs. The down spout can be either placed over a drain basin to prevent debris from entering the pipe or directly connected to the pipe utilizing a down spout adapter.



Down Spout with Catch Basin



Down Spout Adapter

C. Drainage Materials and Installation

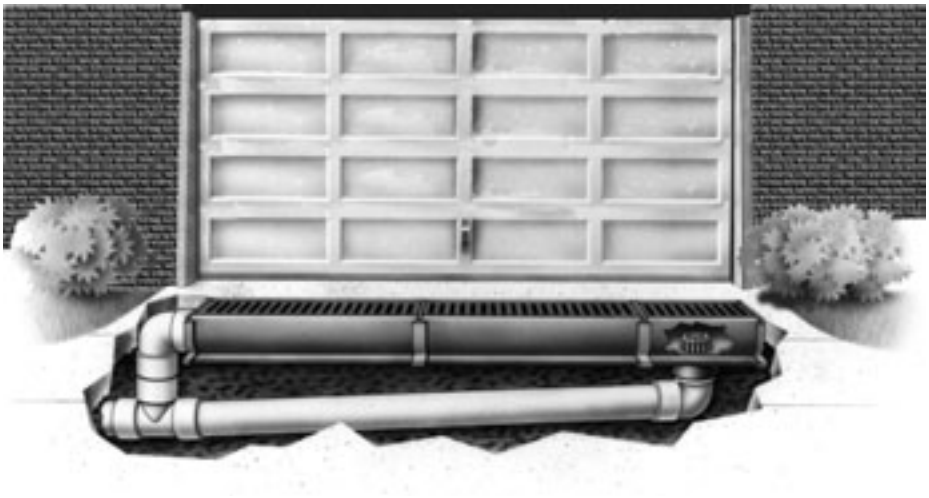
Channel Drains

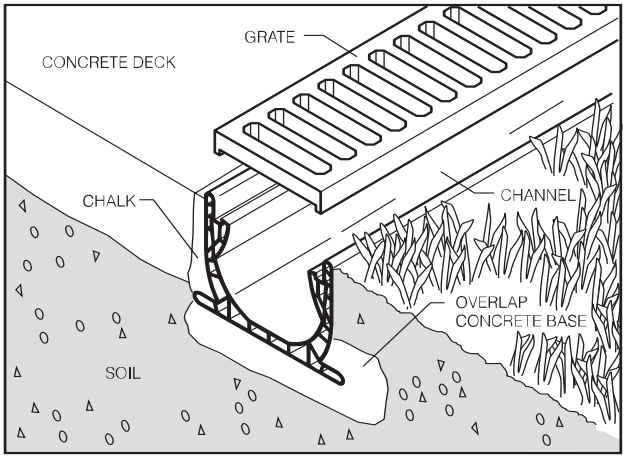
Channel drains are linear surface drains, connected together to a length appropriate for the specific installation. Run-off water collected in the drain is discharged to bottom or end outlets.

Recommended Applications

1. Driveways
2. Patios
3. Swimming pools and spas
4. Wash down areas
5. Sidewalks

NDS offers non-sloped channel systems with many advantages over sloped channel systems. The NDS non-sloped system is less expensive and simplifies inventory by eliminating the need to stock various sloping channel sections. Multiple outlets provide safety through redundancy, should any individual outlet become clogged. The channel may be installed level. Proper flow is assured by use of sloped drain pipe.





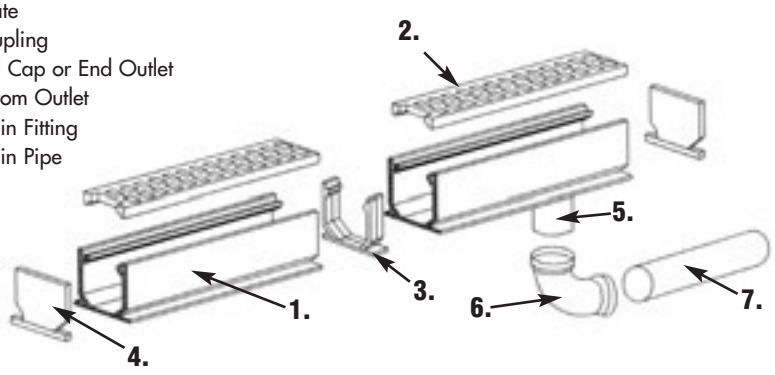
Use an overlapping concrete base for installation next to a concrete deck. This installation will pin the channel against the concrete deck.

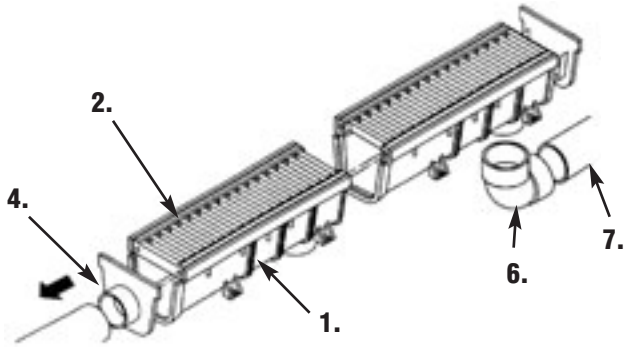
C. Drainage Materials and Installation

Modular and Profile Channel

Profile Channel and Modular components enable a comprehensive professional installation.

Profile Channel Drain
1. Channel
2. Grate
3. Coupling
4. End Cap or End Outlet
5. Bottom Outlet
6. Drain Fitting
7. Drain Pipe





Modular Channel Drain
1. Channel with Interlocking Mechanical Joint
2. Grate
4. End Cap/End Outlet
5. Drain Fitting
6. Drain Fitting
7. Drain Pipe

Installation

1. Standard Installation

Excavate a wide and deep trench to accommodate the channel and bedding concrete. Erect a string line at each end of the drain run, as a guide for laying the channels to the required level. Begin channel installation at the evacuation or discharge end of the run where the outlet or outlets are located.

Install channel end-to-end PVC cementing sections together. Design bottom or end outlets into the channel run in the appropriate location and glue to the drain pipe or fittings. PVC cement end caps where appropriate.

Using either NDS stakes, 1/2" or 5/8" rebar, or wood stakes, anchor channel to the trench bed every 24" on each side of channel. Backfill with either concrete, sand, or soil, depending on the application. Pour slab to grade and finish concrete.

C. Drainage Materials and Installation

1. Standard Installation (continued)

Figure 1A illustrates a light vehicular installation in which a concrete base may not be required. Compact soil in a 1" sand base.

Figure 1B illustrates a concrete base underneath the channel recommended for heavy load applications or freeze/thaw zones, where heaving may be a problem.

2. Suspended Installation

Suspended installation is ideal for retrofit installations with an existing concrete slab or new construction where forms can be used to suspend the channels. Prepare the trench excavation. Using 2″ x 4″ boards, span the width of the trench and bolt the channel grates to the boards. Pour and compact concrete under and around the channels. Finish to the proper grade. Figure 2.

3. Suspended Installation

This installation may be used in lieu of the standard installation. Prepare the trench excavation and pull a string line to the proper elevation. Pour a slurry of concrete in the trench to a depth that will insure at least 4″ of concrete underneath the channels. Lay the channels in the bedding slurry. Check channel alignment and grade again. After the slurry sets, concrete can be poured around the channel and finished to the proper grade. Figure 3.

Figure 1A

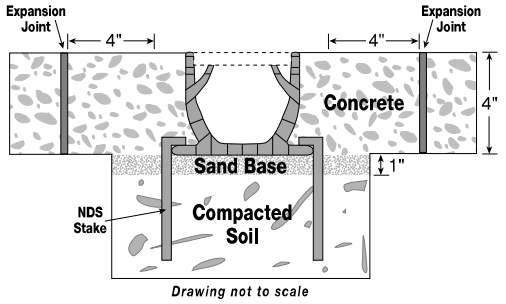


Figure 1B

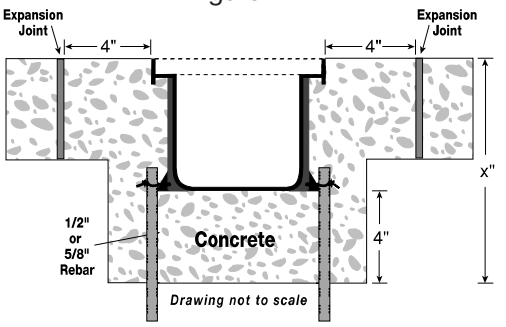


Figure 2

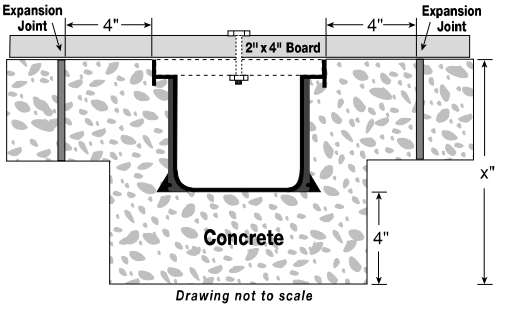
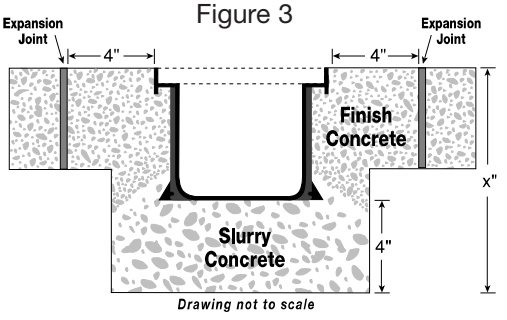


Figure 3



NOTES

1. Grate must be installed prior to pouring concrete or backfill.

2. Grate should be recessed 1/8″ below finish grade in non-traffic applications. Grate should be recessed 1/4″ in traffic applications.

3. In asphalt or hot mastic applications, the channel must be encased in concrete for strength and to prevent distortion of the channel.

4. Grates should be taped prior to pouring concrete to prevent debris from entering channel during installation.

5. Refer to load classification chart for proper application.

6. Expansion joints must be provided parallel, but not immediately adjacent to each side of the drain and crack control joints utilized at right angles to the channel for installation in concrete.

7. PVC Primer and Medium Body Fast Set PVC solvent cement must be used to cement all components.

8. Grate must be installed on channel at all times, except for cleaning.

NDS offers grates, basins, and channel drains in plastic, cast iron, steel, and brass which are available in the following load classifications. Refer to the NDS Drainage Product Catalog for individual grate load recommendations.

NOTE: Loads are based on encasing product in concrete.

Class A
- Loads of 1-60 psi. Recommended for pedestrians, bicycles and wheel chair traffic.

Class B
- Loads of 61-175 psi. Recommended for medium-duty pneumatic tire traffic, autos and light trucks at speeds less than 20 m.p.h.

Class C
- Loads of 176-325 psi. Recommended for heavy-duty pneumatic tire forklifts and tractor trailers at speeds less than 20 m.p.h., H-20 rated

Class D
- Loads of 326-575 psi. Recommended for heavy-duty hard tire forklifts at speeds less than 20 m.p.h., H-20 rated.

Comprehensive Drainage System

A complete drainage system incorporates both surface and subsurface drains. Surface drains are used to remove heavy volumes of rainfall that fall in short spans of time. Subsurface drains are used to remove water which percolates into the soil. Soil has a natural ability to absorb a limited amount of water. At the point the soil becomes 100% saturated with water, it cannot absorb anymore. With no place to go, additional rainfall accumulates on the surface resulting in flooding and erosion. This is another reason it is critical to incorporate surface drains into any drainage plan.

Discharge Outlet Design

Discharge Collected Water

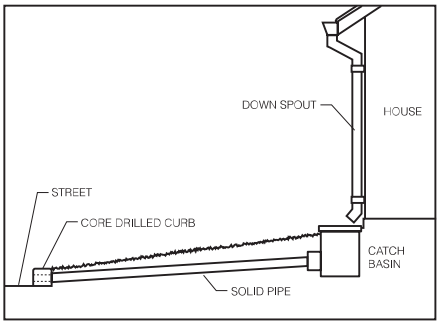
Once the storm water is collected and conveyed in the drain pipe, it must be discharged to a safe location. Several options are available to discharge water. You can discharge on-site, into a pond for example; or discharge off site, into the street gutter or directly into the storm sewer.

Pop-Up Drainage Emitter

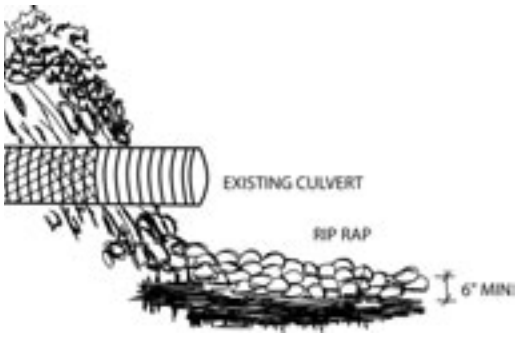
Pop-Up Drainage Emitter allows water to be diverted and released to water-safe areas away from structures, erosion-prone landscapes and poor drainage areas. For example, water can be routed from a low area next to a foundation to a water-safe area such as a street curb, or a lawn area. The pop-up emitter is opened by the hydrostatic pressure of water flowing through the drain pipe. As flow diminishes, the emitter closes again. The top of the emitter should be installed at a lower elevation than the invert of the pipe inlet (downspout connection, connection to a basin, etc.), to ensure proper flow. A 10' length of perforated pipe installed between the drain pipe and emitter will allow excess water in the drain pipe to leach into the soil.

Water can be discharged directly into the street by piping through the curb. Check local codes for approval.

Pop-up Drainage Emitter



Core Drilled Curb



Water can be discharged directly into the street by piping through the curb. Check local codes for approval.

Principles of Exterior Drainage

Quick Review Quiz

Take the quiz on the next two pages to check your understanding of the drainage principles.

Once your test is completed, fax it back to NDS for scoring and to receive your "Certificate of Completion" and a NDS cap.

Fax *both sides* of the quiz to:
1-800-726-1998
Attention Marketing Department

Only one cap per student please.

Don't forget to visit our website for more information on drainage products and solutions at www.ndspro.com.

Fax both sides to 1-800-726-1998
Attention Marketing Department

Principles of Exterior Drainage

Quick Review Quiz

One source. Many solutions.

Name: _____ **Date:** _____

Company Name: _____ **Store #:** _____

Company Address: _____ **Phone:** _____

City: _____ **State:** _____ **Zip:** _____

Please complete the following exam and return to NDS. A certificate of Completion and an NDS Cap will be forwarded to you for a 70% or higher score. **Good Luck!**

Matching:

1. _____Catch Basin	**A.** A surface made of concrete, blacktop, wood, or rock, such as sidewalks, driveways, etc.
2. _____Channel Drains	**B.** These are strainer covers that are installed on the top of a catch basin or drainage pipe. They are used to filter large pieces of debris that may otherwise enter the catch basin or piping system. They are available in round square, and atrium configurations.
3. _____Surface Water	**C.** Detachment & movement of soil or rock fragments by water, wind, ice & gravity.
4. _____ Erosion	**D.** A trench filled with coarse aggregate, and most commonly a perforated pipe, for intercepting and conveying ground water.
5. _____ French Drains	**E.** This is the attachment from the gutters that run vertically down the building or structure in which rain water is routed from the roof-mounted gutters to grade level.
6. _____ Grates	**F.** That water that is below the first layer of soil, turf, etc., but cannot permeate any lower due to the tightness of the soil. It is not part of the water table.
7. _____Gutter Downspout	**G.** A structure with a grate on top used to collect and divert surface runoff to an underground drain pipe system. At the base is a sump or sediment trap to collect debris.
8. _____ Hardscape	**H.** Ideal grate configuration for preventing clogged inlets due to leaves, mulch, and debris in planters.
9. _____ Subsurface Water	**I.** Water that is deposited by rainfall or irrigation, which has not permeated the soil, flowing on top of turf, landscapes and hardscapes.
10. _____ Atrium Grate	**J.** A linear perimeter drain with a grate on top used to collect surface water along flatwork or hardscapes, such as: driveways, patios, parking lots, swimming pools, etc.

Multiple Choice:

11. _____ When do you need a drainage system?

A. When your in-laws are coming to town
B. Everyone needs a drainage system
C. For excess ground water or surface runoff
D. Never

12. _____ Which type of surface drainage system is ideal for hardscapes like driveways, patios and swimming pools?

A. French Drains
B. Channel Drains
C. Catch Basins & Grates
D. Pump & hoses

Fax both sides to 1-800-726-1998
Attention Marketing Department

Principles of Exterior Drainage

Quick Review Quiz

13. _____ Which type of surface drainage system is used in landscapes & turf areas?

- **A.** Catch Basins & Grates
- **B.** Channel Drains
- **C.** Grass Pavers
- **D.** All of the above

14. _____ What are the most common type of drain pipes which NDS products fit?

- **A.** Corrugated
- **B.** Sewer & Drain
- **C.** A & B
- **D.** None of the above

15. _____ What is the minimum recommended slope for corrugated pipe?

- **A.** 2%
- **B.** 3%
- **C.** 5%
- **D.** 7%

16. _____ What type of soil typically requires more drainage devices?

- **A.** Sand
- **B.** Clay
- **C.** Loam
- **D.** Soil in your shoes

17. _____ The three basic drainage design criteria are:

- **A.** Conduct, filter, and dispose
- **B.** Dispose, conduct, and filter
- **C.** Collect, conduct, and dispose
- **D.** Stop, look, and listen

18. _____ The sump area of a catch basin is used for what purpose:

- **A.** For an irrigation pump
- **B.** For catching large insects
- **C.** For collecting debris & preventing clogged pipes
- **D.** For breeding mosquitos

19. _____ The topography of a site:

- **A.** Influences surface runoff
- **B.** Can prevent soil absorption
- **C.** Both A & B
- **D.** Neither A nor B

20. _____ The influence of vegetation on a drainage system includes:

- **A.** It provides denser & larger cover that intercepts rain that won't reach the soil surface.
- **B.** It helps to prevent erosion
- **C.** It develops deep roots that improve soil structure.
- **D.** All of the above

S-M NDSDRN 05-031

NDS

One source. Many solutions.

- **Catch Basins & Grates**
- **Channel Drains**
- **Agrifim Drip Irrigation**
- **Equipment Pads**
- **Flo-well Stormwater Leaching Systems**
- **Flo Control Specialty Fittings**
- **Flo Control Check Valves**
- **Flo Control Ball Valves**
- **Backwater & Diverter Valves**
- **Sewer & Drain Fittings**
- **Grass Pavers**
- **Root Barriers**
- **Valve & Meter Boxes**
- **Flexible Couplings**
- **Flexible Saddles**

NDS Product Catalogs

Drainage Catalog • Drip & Micro Irrigation Catalog • Equipment Pad Catalog • Fittings Catalog
Landscape Catalog • Specialty Valves and Fittings Catalog • Valve Box Catalog •Meter Box Catalog

Address/Telephone
P.O. Box 339 • 851 N. Harvard Avenue
Lindsay, CA 93247
Phone: 800-726-1994
Fax: 800-726-1998
International Phone: 559-562-9888
International Fax: 559-562-4488
e-mail: NDS@NDSPRO.net

www.NDSPRO.com

FOR TECHNICAL INFORMATION, CONTACT:
Technical Services
(888) 825-4716
Tech Service@NDSPRO.net

Regional Warehouses:
- Lindsay, CA
- Dallas, TX
- Atlanta, GA
- Philadelphia, PA
- Puerto Rico
- Chicago, IL