NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(Ft.)

CODE 606

DEFINITION

A conduit, such as tile, pipe, or tubing, installed beneath the ground surface and which collect and/or convey drainage water.

SCOPE

This standard applies to the design and installation of conduits placed beneath the surface of the ground to provide drainage.

PURPOSE

A subsurface drain may serve one or more of the following purposes:

1. Improve the soil environment for vegetative growth by regulating the water table and ground water flow.
2. Intercept and prevent water movement into a wet area.
3. Relieve artesian pressures.
4. Remove surface runoff.
5. Facilitate leaching of saline and alkali soils.
6. Serve as an outlet for other subsurface drains.
7. Provide ground water regulation and control for sub-irrigated areas or waste disposal areas.
8. Collect ground water for beneficial uses.
9. Remove water from around buildings, roads, airports, play fields, and other physical improvements.
10. Provide water regulation to control health hazards caused by flies, mosquitoes, etc.

CONDITIONS WHERE PRACTICE APPLIES

Subsurface drains are used in areas having high water table where benefits of lowering or controlling ground water or surface runoff justify the installation of such a system.

All lands to be drained shall be suitable for the intended use after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system. The drainability and treatment of saline and alkali soils shall be considered where this is a problem.

An outlet for the drainage system shall be provided, either by gravity flow or by pumping. The outlet shall be adequate for the quantity and quality of effluent to be disposed of with consideration of possible damages above or below the point of discharge that might involve legal actions under Nebraska state laws.

NRCS Policy and Procedures Regarding Technical Assistance for Drainage of Wetlands will be followed.

DESIGN CRITERIA

The design and installation shall be based on adequate field surveys and investigations made as outlined in (1) Chapter 2 and 4, Section 16 of SCS National Engineering Handbook - Drainage of Agricultural Land, and (2) Chapter 14 of the SCS Engineering Field Manual.

Drainage Coefficient

Relief type subsurface drainage systems will be designed to remove a depth of ¼" to 3/8" of water

from the area to be drained in 24 hours. When surface water (storm runoff or irrigation) is introduced into the system, a coefficient of ½" to 1" in 24 hours shall be used.

Interceptor type systems shall be designed to fit the local conditions of the site.

Capacity

The required capacityshall of the system will be determined by one or more of the following:

1. Application of the appropriate drainage coefficient to the land area to be drained.
2. Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.
3. Survey and comparison of the site with other similar sites where subsurface drain yields have been measured.
4. Measurement of the rate of subsurface flow at the site during a period having adverse weather and ground water conditions.
5. The application of Darcy's law to lateral or artesian subsurface flow.
6. Estimates of lateral or artesian subsurface flow.

Size

All subsurface drainage conduits shall have a minimum nominal diameter of 3 inches. The size of subsurface drains shall be computed by applying Manning's formula as covered in Chapter 4, Section 16 of the SCS National Engineering Handbook - Drainage of Agricultural Land. The required capacity shall be determined as provided above and the size computed based on one of the following assumptions:

1. Hydraulic grade line parallel to the bottom grade of thesubsurface drain with the conduit flowing full as design flow.
2. The conduit flowing part full where a steep grade or other condition requires excess capacity.
3. Conduit flowing under pressure with hydraulic gradeline set by site conditions on a grade that differs from that of the subsurface drain. This procedure shall be used only if surface water inlets or nearness of the conduit to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

Depth

The minimum depth of cover over the drain will be 4 feet in saline and alkaline areas and 3.5 feet in all other areas, except that it will be permissible for 10 percent of the length of any single line to be less than these depths, provided that no point in any subsurface drain shall have less than 2 feet of cover, except as stated below.

For short lengths where it is impossible, impractical or uneconomical to provide 2 feet of cover either by deeper placement or by placing extra fill over the top, the drain should be metal pipe or other material of equal or greater durability, providing it meets all exposure and load requirements of the site.

Loading

The allowable loads on subsurface drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

The following table shows the maximum permissible laying depths in feet for standard and extra quality drains in a trench less than 24 inches wide.

Conduit Size Diameter	Maximum Permissible Laying Depth (Feet)	
	Standard Quality	Extra Quality
3	7	9
4	7	9
5	7	9
6	7	9
8	6	8
10	6	8
12	6	8

Spacing

The spacing for relief type parallel subsurface drains will be determined by using formula or tables in Chapter 4, Section 16, SCS National Engineering Handbook - Drainage of Agricultural

Land. The permeability or hydraulic conductivity factor will be determined by the auger hole method. In those cases where the necessary data for solution of spacing cannot be obtained, the following general criteria based on local judgment and experience may be used:

Permeablity	Spacing
Very slow to slow (0.06-0.2 in/hr)	30 - 60 feet
Moderately slow to moderate (0.2-2.0 in/hr)	60 - 100 feet
Moderately rapid to rapid (2.0-6.0 in/hr)	100 - 300 feet

Minimum Velocity and Grade

In areas with no sedimentation hazard the minimum grades shall be based on site conditions and a velocity of not less than .5 feet per second. Where it is determined that a hazard exists, a velocity of not less than 1.4 feet per second shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for prevention of sedimentation by filters or collection and periodic removal of sediment from installed traps, or the periodic cleaning of the lines by high pressure jetting systems or cleaning solutions as specified in the plans.

Maximum Grade and Protection

On site where topographic conditions require the use of drain lines on grades steeper than 2 percent or where design velocities will be greater than indicated in the table below, special measures shall be specified for each job based on the particular conditions of the job site. The protective measures shall include one or more of the following:

1. Selecting rigid butt end pipe or tile with straight, smooth sections and square ends to obtain tight fitting joints.
2. Wrapping open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric type filter material.
3. Placing the conduit in a sand and gravel envelope or blinding with least erodible soil available.
4. Sealing joints or using a watertight pipe or nonperforated continuous tubing.
5. Enclosing continuous perforated pipe or tubing with fabric type filter material or properly graded sand and gravel.

Maximum Permissible Velocity in Subsurface Drains Without Protective Measures

Soil Texture	Velocity - Ft./Sec.
Sand and Sandy Loam	3.5
Silt and Silt Loam	5.0
Silty Clay Loam	6.0
Clay and Clay Loam	7.0
Coarse Sand or Gravel	9.0

Materials for Subsurface Drains

"Subsurface Drains" include conduits of clay, concrete, bituminized fiber, metal, plastic or other material of acceptable quality.

The conduit shall meet strength and durability requirements of the site. Current specifications as listed below, or as included in this standard, shall be used in determining the quality of materials used in drainage installations:

Type	Specification[1]
Clay drain tile	ASTM C-4
Clay drain tile perforated	ASTM C-498
Clay pipe and perforated clay pipe, extra and standard strength	ASTM C-700
Clay pipe, testing	ASTM C-301
Concrete drain tile	ASTM C-412
Concrete pipe for irrigation or drainage	ASTM C-118
Concrete pipe or tile, determining Physical Properites of concrete sewer, storm drain & culvert pipe	ASTM C-14
Reinforced concrete culvert, storm drain, and sewer pipe	ASTM C-76
Perforated concrete pipe	ASTM C-444
Portland cement	ASTM C-150
Asbestos cement nonpressure sewer pipe	ASTM C-428

[1] American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

Type	Specification
Asbestos cement perforated underdrain pipe	ASTM C-508
Asbestos cement pipe, testing	ASTM C-500
Asbestos cement storm drain pipe	ASTM C-663
Pipe, bituminized fiber (and fittings)	Federal Spec.[2] SS-P-1540
Homogeneous perforated bituminizedfiber pipe for general drainage	ASTM D-2311
Homogeneous bituminized fiber pipe, testing	ASTM D-2314
Laminated wall bituminized fiber perforated pipe for agricultural land, and general drainage	ASTM D-2417
Laminated wall bituminized fiber pipe, Physical testing of	ASTM D-2315
Styrene rubber plastic drain and building sewer pipe and fittings*	ASTM D-2852
Polyvinyl chloride (PVC) sewer pipe and fittings*	ASTM D-2729
Corrugated polyethylene drainage tubing	ASTM F-405
Pipe, corrugated, (aluminum alloy)	Federal Spec. WW-P-402
Pipe, corrugated, (iron or steel, zinc coated)	Federal Spec. WW-P-405
Corrugated polyvinyl chloride tubing*	See S-606

*Perforations, if needed, are to be as specified in ASTM D-2311.

The following additional tests shall be performed on corrugated polyethylene tubing according to "Specification for Corrugated Polyvinyl Chloride Drain Tubing" as defined in Specification 606.

1. Perforations - slot length for 10, 12, and 15 inch diameter tubing shall not exceed 1 ¾ inches (Paragraph 5.14 and 7.5)
2. Brittleness - A high temperature strength test shall be performed on P.E. tubing. The only modification in the test shall be the use of a temperature of 120 degrees + degrees F to condition the samples. There shall be no fracture, cracking, rupture, splitting, or significant indentation of the tubing after impact. Indentations shall be considered significant if the depression left by the falling tup creates a restriction of more than 1 inch in nominal inside diameter (Paragraph 5.6 & 7.10).
3. Bending - See Paragraph 5.7 and 7.11 of specification for corrugated PVC drain tubing S-606.

Round perforations up to 5/8 inch in diameter with hole spacings to five inches on center may be used if special blinding, envelope, or filter requirements are used. The special requirements specified must be compatible with the perforation and soil situation to assure satisfactory drain performance.

Concrete Tile - The use of concrete tile under acid and sulfate conditions shall be in accord with the following guides:

Acid Soils

Class of Tile	Lower Permissible Limits of pH Values[3]	
	Organic and Sandy Soil	Medium and Heavy Textured Soils
ASMTC-412:		
Standard Quality	6.5	6.0
Extra Quality	6.0	5.5
Heavy-Duty		
Extra Quality	6.0	5.5
Special Qualtiy	5.5	5.0
ASTM C-14, C-118, C-444	5.5	5.0

[2] Superintendent of Document, U.S. Government Printing Office, Washington, D.C. 20402.

[3] Figures given represent lower readings of pH values for soil at tile depth.

Sulfate Soils

Permissible Maximum Limit of Sulfates Singly or in Combination4	Type of Tile And Cement (minimums)
(Parts per Million)	
7,000	Tile: ASTM C-412 Special Quality, C-14, C-118, C-444 Cement: ASTM C-150 Type V
3,000	Tile: ASTM C-412 Extra Heavy Duty Extra-Quality, C-14, C-118, C-444 Cement: ASTM C-150 Type II or V
1,000	Tile: ASTM C-412 Standard Quality C-14, C-118, C-444 Cement: ASTM C-150 Any Type

Other Clay and Concrete Pipe

Bell and spigot, tongue and groove, pipe which meets the strength, absorption, and other requirements of clay or concrete tile covered above, except for minor imperfections in the bell, the spigot, tongue or the groove, and ordinarily classed by the industry as "seconds," may be used for drainage conduits provided the pipe is otherwise adequate for the job.

Foundation Requirements

Soft or yielding foundations shall be stabilized where required and lines protected from settlement by adding gravel or other suitable material to the trench, by placing the conduit on plank or other rigid support, or by using long sections of perforated or watertight pipe with adequate strength to insure satisfactory subsurface drain performance.

Filters and Filter Material

Suitable filters shall be used around conduits where required by site conditions to prevent sediment accumulation in the conduit. The need for a filter shall be determined by the characteristics of the soil materials at drain depth and the velocity of flow in the conduit.

Not less than 3 inches of filter material shall be used for sand-gravel filters. The filter shall be designed to prevent the material in which the installation is made from entering the conduit. Not more than 10 percent of the filter shall pass the No. 60 sieve.

Artificial prefabricated filter materials such as fiberglass, spun bonded nylon fabric, and plastic filter cloth may be used provided the opening sizes, strength, durability, and permeability are adequate to provide constant filtering action in the soil material involved and to protect subsurface drain operation throughout the expected life of the system.

Where fiberglass filter material is used, it shall be manufactured from borosilicate type glass and the manufacturer of the material shall certify that it is suitable for underground use. The fiber shall be of variable size, with some larger fibers intertwined in the mat in a random manner. The material shall span all open joints and perforations without excessive stretch which would reduce its effectiveness as a filter.

Envelopes and Envelope Material

Envelopes shall be used around subsurface drains where required for proper bedding of the conduit, or where necessary to improve the characteristics of flow of ground water into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit. Envelope materials shall consist of sand-gravel material, all of which shall pass a 1 ½ inch sieve, 90 to 100 percent shall pass a ¾ inch sieve, and not more than 10 percent shall pass a No. 60 sieve.

Placement and Bedding

All subsurface drains, whether flexible conduit such as plastic or bituminized fiber or rigid

[4] Highest reading of sulfates for soil or soil water at tile depth.

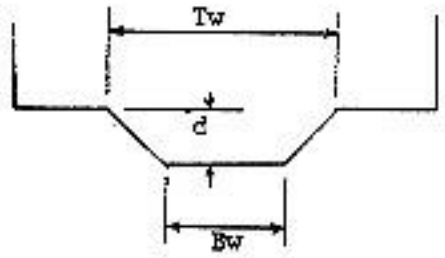
conduit such as clay or concrete shall be laid to a neat line and grade. The conduit shall be placed and bedded by one of the following methods:

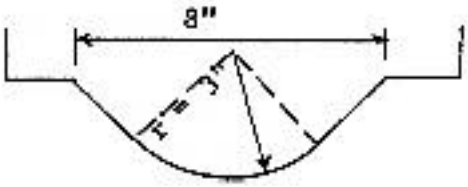
Type of Conduit	Special Conditions	Method
1. Flexible	Filter not required	10 or 4
2. Flexible	Filter required	
	(a) Prefabricated	1
	(b) Sand and gravel filter	2
3. Rigid	Filter not required	10 or 3
4. Rigid	Filter required	
	(a) Prefabricated filter	10 or 3
	(b) Sand and gravel filter	2
5. Flexible or rigid	Envelope required	4

ALLOWABLE TRAPEZOIDAL GROOVES FOR BEDDING CORRUGATED POLYETHYLENE DRAINAGE TUBING

Nominal Tube Diameter (d) (Inches)	Groove (d) Depth (Inches)	Groove (Tw) Top Width (Inches0	Groove (Bw) Bottom Width (Inches)
4 & 5	1.5	5.1	2.1
4, 5 & 6	3.0	6.2	2.3
4, 5, 6 & 8	2.8	8.0	2.4*
6 & 8	2.4	8.0	3.3
5, 6 & 8	2.5	8.0	3.0

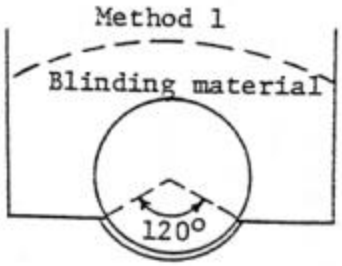
These trapezoidal grooves with 45 degree side slopes will provide support similar to that provided with a circular groove shaped to fit the lower 120 degrees of circumference.





*The groove dimensions shown on this line are for use with the semi-trapezoidal groove shown below. Bottom radius of curvature must be 6 inches or less.

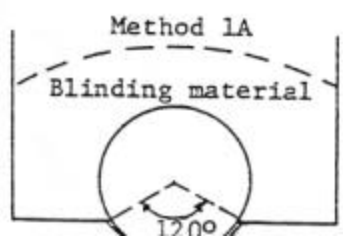
Methods 1 & IA - Where it is not necessary to encase the conduit in a sand and gravel envelope or filter the bottom of the excavated trench shall be shaped to conform approximately to the shape of the conduit and the conduit shall be laid in this groove. The groove may be semi-circular or trapezoidal-shaped and shall be of such dimensions that the bottom 120



degrees of the conduit is supported by undisturbed soil. Blinding and backfilling operations can be in the conventional manner using soil from the sides of the trench and excavated material.

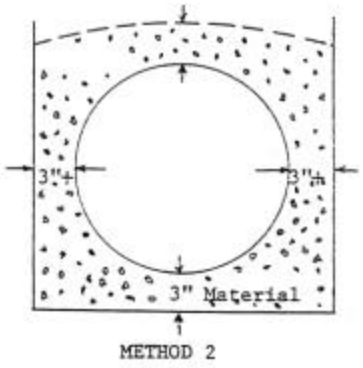
Method 1

Method 1A



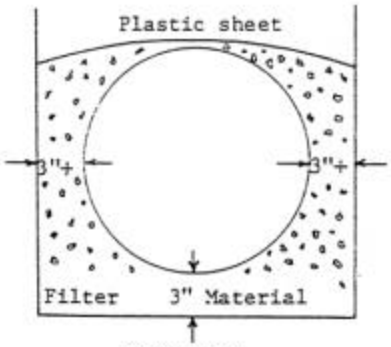
Methods 2 or 2A - Where the conduit is encased in a sand and gravel filter, a minimum of 3 inches depth of filter material shall be placed on the bottom of a conventional trench. The conduit shall be placed on this and the trench completely filled with filter material to a minimum depth of 3 inches above conduit. An acceptable optional method of placing the filter material will be to fill the trench as indicated in 2A and cover this with an acceptable plastic (not less than 6 mil.) sheet at least 6 inches wider than the conduit diameter, to separate the filter material from the backfill material.

Method 2



METHOD 2

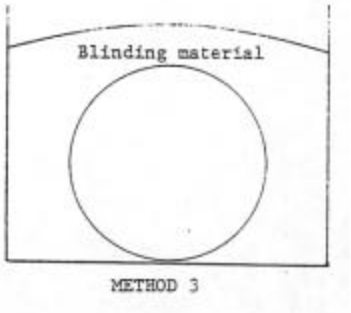
Method 2A



METHOD 2A

Method 3 - Where rigid conduit is to be used, it can be placed in a conventional trench and blinded and backfilled in the conventional manner using soil from the sides of the trench and excavated material.

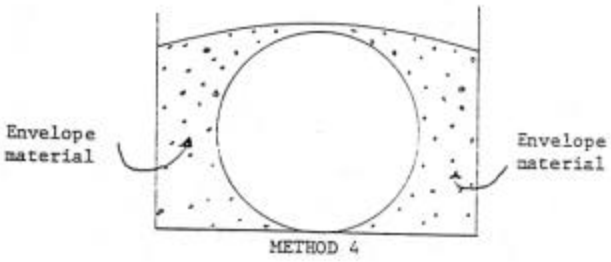
Method 3



METHOD 3

Method 4 - Where it is feasible and desirable to encase the conduit in a sand and gravel envelope, the conduit shall be laid on the bottom of a conventional trench (no special shaping or grooving) and the trench shall be filled with envelope material to a level flush with the top of the conduit. The trench must be completely filled so that there are no void spaces in the area between the sides of the pipe and the walls of the trench. Back-filling can be in the conventional manner. With this method it is desirable to excavate a narrow trench to conserve on envelope material. The minimum envelope depth shall be equal to the out-side diameter of the conduit.

Method 4



METHOD 4

Use of Heavy Duty Corrugated Polyethylene Drainage Tubing

Heavy duty corrugated polyethylene drainage tubing shall be specified where rocky soils are expected to be encountered during installation operations. This quality of tubing will also be specified when cover over the tubing is expected to exceed 10 feet or trench widths are expected to exceed 24 inches. (This refers to trench width

in the area of the tubing and at least 1 foot above the top of tubing.)

Auxiliary Structures and Subsurface Drain Protection

The outlet shall be protected against erosion and undermining of the conduit, against damaging periods of submergence, and against entry of rodents or other animals into the subsurface drain. A continuous section of pipe without open joints or perforations shall be used at the outlet end of the line and shall outlet above the normal elevation of low flow in the outlet ditch. Corrugated plastic tubing is not suitable for the outlet section.

Continuously submerged outlets will be permitted for water table control in organic and sandy soils if planned and designed in accordance with the standards for “Regulating Water in Drainage Systems.” (554)

The outlet pipe and its installation shall conform to the following requirements:

1. Where there is a hazard of vegetation burning on the outlet ditch bank, the material from which the outlet pipe is fabricated shall be fire resistant. Where the hazard of burning is high, the outlet pipe shall be fireproof.
2. Two-thirds of the pipe shall be buried in the ditch bank and the cantilevered section shall extend to the toe of the ditch side slope or the side slope shall be protected from erosion. The minimum length of pipe shall be 8 feet.
3. Where ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered portion of the pipe will be protected from the current in the ditch.
4. Headwalls which are used for subsurface drain outlets shall be adequate in strength and designed to avoid washouts and other failures.

Watertight conduits strong enough to withstand the loads upon it shall be used where subsurface drains cross under irrigation canals or other ditches. Conduits under roadways shall be designed to withstand the expected loads. Shallow subsurface drains through depressional areas and near outlets shall be protected against hazards of farm and other equipment, and freezing and thawing.

Junction boxes shall be used where more than 2 main lines join. They must have a clear opening of 2 feet and be accessible for maintenance.

Where surface water is to be admitted to subsurface drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. Auxiliary surface waterways shall be used where feasible.

The upper end of each subsurface drain line shall be capped with a tight fitting cap of the same material as the conduit 0” other durable material unless connected to a structure.

PLANS AND SPECIFICATIONS

Plans and specifications for installation of subsurface drains shall be in keeping with this standard and shall describe the requirements for installation of the practice to achieve its intended purpose.

Refer to S-606 for Guide Specifications.