USDA
NATURAL RESOURCES
CONSERVATION SERVICE

MARYLAND CONSERVATION
PRACTICE STANDARD

# SUBSURFACE DRAIN

CODE 606
(Reported by Ft.)

## DEFINITION

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

## PURPOSE

The purpose of subsurface drainage is to:

1. Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
   a. Regulating water table and ground water flows;
   b. Intercepting and preventing water movement into a wet area;
   c. Relieving artesian pressures;
   d. Removing surface runoff;
   e. Leaching of saline and sodic soils;
   f. Serving as an outlet for other subsurface drains; and,
   g. Regulating sub-irrigated areas or waste disposal areas.
2. Collect ground water for beneficial uses;
3. Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal;
4. Regulate water to control health hazards caused by pests such as flukes, flies, or mosquitoes.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas having a high water table where benefits of lowering or controlling ground water or surface runoff justify installing such a system.

This standard applies to areas 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.

In areas where an outlet is available, either by gravity flow or by pumping, the outlet shall be adequate for the quantity and quality of effluent to be disposed.

## CONSIDERATIONS

Consider the drainability and treatment of saline and alkali soils where this is a problem.

Consider possible damages above or below the point of discharge that might involve legal actions under state laws.

Most subsurface drains eventually fail from sedimentation, either inside the conduit or against the external wall or envelope. Consider the soil types and locations when designing the system to prevent premature clogging of drainage product. The use of a filter between native material and the conduit is highly recommended.

There are many different types of drainage products available; consideration of product type and placement is critical in achieving a long lasting functional system.

Considerations must be given to preventing adverse impacts to delineated wetlands regulated by State and Federal regulations.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service - Maryland or visit the electronic Field Office Technical Guide (eFOTG).

## CRITERIA

Base the design and installation on adequate surveys and investigations and in accordance with the Maryland Drainage Guide.

### Capacity

The required capacity shall be determined by one or more of the following:

1. Application of a locally tried and proven drainage coefficient to the acreage drained. Include added capacity required to dispose of surface water entering through inlets;
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 of adverse weather and ground water conditions;
5. Application of Darcy's law to lateral or artesian subsurface flow;
6. Estimates of lateral or artesian subsurface flow;
7. Manufacturer's literature for estimating infiltration rates of product selected.

Section 1.3 of the Maryland Drainage Guide gives drainage coefficients for specific soils. The following drainage coefficients will be used where drainage is uniform over an area through a systematic pattern of drains:

| Inches to be Removed in 24 Hours | | | |
|---|---|---|---|
| **Soil** | **General Crops** | **Special Crops** | **Urban** |
| Mineral | 3/8 to 1/2 | 1/2 to 3/4 | 1" min |
| Organic | 1/2 to 3/4 | 3/4 to 1 1/2 | 1" min |

The following inflow rates may be used to determine the capacity of drains in random systems, except that the minimum inflow rate per 1,000 feet of line used for design purposes will be 0.05 cfs:

| Inflow Rates Based on Soil Textures | |
|---|---|
| **Soil Texture** | **Rate in cfs / 1,000 feet of line** |
| Coarse sands & gravel | 0.15 - 1.00 |
| Sandy loams | 0.07 – 0.25 |
| Silt loams | 0.05 - .010 |
| Clay or Clay loam | 0.05 – 0.20 |

Section 1.3 of the Maryland Drainage Guide gives drainage removal rates for specific soils.

For interceptor tile lines on sloping land, increase the inflow rates in the above table as follows:

| **Land Slopes** | **Increase Inflow Rate by** |
|---|---|
| 2-5 percent | 10 percent |
| 6-12 percent | 20 percent |
| Over 12 percent | 30 percent |

For Urban Areas, use a minimum inflow rate of 1.5 cfs per 1,000 feet of line.

### Size

Compute the size of subsurface drains by applying Manning's Formula. Base the size on the required capacity and computed by using one of the following assumptions:

1. The hydraulic gradeline parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow;
2. The conduit flowing part full where a steep grade or other conditions require 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. Use this procedure only if surface water inlets or nearness of the conduit to outlets with fixed water elevations permit satisfactory es-

timates of hydraulic pressure and flows under design conditions.

All subsurface drains shall have a nominal diameter that equals or exceeds 4 in.

Simple interceptor or random drains may be designed without calculating "Q" if the total length of drain does not exceed the following maximum lengths for minimum grades, and surface water or heavy spring flows are not added to the drain.

| Minimum Grade of Drain (%) | Maximum Length 4”Drain | Maximum Length of 6”Drain |
|---|---|---|
| 0.1 | 300 | 800 |
| 0.2 | 400 | 1,200 |
| 0.3 | 500 | 1,500 |
| 0.4 | 600 | 1,700 |
| 0.5 | 700 | 1,900 |
| 1.0 | 900 | 2,700 |
| 1.5 | 1,100 | 3,300 |
| 2.0 | 1,300 | 3,800 |
| 2.5 | 1,500 | 4,200 |
| 3.0 | 1,600 | 4,600 |
| 4.0 | 1,800 | 5,400 |
| 5.0 | 2,000 | 5,800 |

## Depth, Spacing, and Location

Design the depth, spacing, and location of the subsurface drain on site conditions, including soils, topography, ground water conditions, crops, land use, outlets, and saline or alkaline conditions.

The minimum depth of cover over subsurface drains in mineral soils is 2 ft. This minimum depth applies to normal field levels and may exclude sections of line near the outlet or sections laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel.

The minimum depth of cover in organic soils is 2.5 ft. for normal field levels, as defined above, after initial subsidence. Install structural measures if it is feasible to control the water table level in organic soil within the optimum range of depths.

The maximum depth of cover for standard duty corrugated plastic tubing is 10 feet for trench widths of 2 feet or less (measured at tubing and to 1 foot above top of tubing). Specify heavy-duty tubing for depths greater than 10 feet, trench widths more than 2 feet, or in rocky soils.

For computation of maximum allowable loads on subsurface drains, use the trench and bedding conditions specified and the crushing strength of the kind and class of drain. Base the design load on the conduit, on a combination of equipment loads and trench loads. Equipment loads are based on the maximum expected wheel loads for the equipment to be used, the minimum height of cover over the conduit, and the trench width. Equipment loads on the conduit may be neglected when the depth of cover exceeds 6 feet. Trench loads are based on the type of backfill over the conduit, the width of the trench, and the unit weight of the backfill material. Use a safety factor of not less than 1.5 in computing the maximum allowable depth of cover for a particular type of conduit.

## Minimum Velocity and Grade

In areas where sedimentation is not a hazard, base the minimum grades on site conditions and a velocity of not less and 0.5 ft/s. The following minimum grades and length of line on minimum grade are as follows.

| Drain Size | Grade | Length of Line |
|---|---|---|
| 4-inch | 0.001 | 1,300 feet |
| 5-inch | 0.0007 | 2,000 feet |
| 6-inch | 0.0005 | 3,000 feet |

If a hazard exists, use a velocity of not less than 1.4 ft/s to establish the minimum grades if site conditions permit. Otherwise, make provisions for preventing sedimentation by use of filters or by collecting and periodically removing sediment from installed traps, or by periodically cleaning the lines with high-pressure jetting systems or cleaning solutions, as specified in the plans.

## Maximum Grade and Protection

On sites where topographic conditions require that drain lines be placed on steep grades and de-

sign velocities will be greater than indicated under "Maximum Velocity Without Protection," use special measures to protect the conduit. Grades greater than two percent are considered steep grades. Specify these measures for each job according to the particular conditions of the job site. Include one or more of the following as protective measures:

1. Selecting rigid butt end pipe or tile with straight smooth sections and square (bell type) 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 conduit in a sand and gravel envelope wrapping entire drainage diaphragm in appropriately sized filter fabric;

4. Sealing joints or using a watertight pipe or non-perforated continuous tubing:

5. Enclosing continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel.

**Maximum Velocity Without Protection**

Excessive flow velocity in the drain may induce piping of soil material into the drain line.

| Soil Texture | Velocity (ft./sec) |
|---|---|
| Sandy 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 |

Drains to be installed in the following soil and slope conditions will be designed to flow half full with either the open joints wrapped or the entire drain enclosed in filter material:

1. Sand and Sandy Loam Profiles on grades 1 to 4 percent;

2. Silt and Silt Loam Profiles on grades 3 to 6 percent;

3. Clay, Clay Loam and Silty Clay Loam Profiles on grades 6 to 15 percent.

**Foundation**

If soft or yielding foundations are encountered stabilize and protect the drain line from settlement. Stabilize the drain line grade by adding gravel or other suitable materials to the trench, placing the conduit on a treated plank or other rigid supports, using long sections of perforated or watertight pipe having adequate strength to insure satisfactory subsurface drain performance. The use of a flat treated plank is not recommended for corrugated plastic tubing

**Iron Ochre Control.**

If drains are to be installed in sites where iron ochre and manganese dioxide problems are likely to occur, provisions should be made to provide access for cleaning the lines. Each drain line should outlet directly into an open ditch and/or should have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas should be installed during the dry season when the water table is low and the iron and manganese dioxide is in its insoluble form.

Where possible, in areas where the potential for such problems is high, protection against their development can be provided by designing an outlet facility to ensure permanent submergence of the drain line.

**Protection Against Root Clogging**

Problems may occur where it is necessary to place drains in close proximity to perennial vegetation. Roots of water-loving trees, such as willow, cottonwood, elm, and soft maple, or some shrubs and grasses growing near subsurface drains may enter and obstruct the flow.

Where possible, use non-perforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be

removed from a distance of at least 100 feet on each side of the drain. A distance of 50 feet should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drain lines located close to the fruit trees.

Where crops and grasses may cause trouble on drain lines, facilities may be installed to provide a means for submerging the line to terminate the root growth as desired or to maintain a water table above the drain lines to prevent growth into the system.

**Filters and Filter Material**

Use suitable filters around conduits if they are needed because of site conditions to prevent sediment accumulation in the conduit. Determine the need for a filter by the characteristics of the soil material and the velocity of flow in the conduit. Always use a filter when drain is placed in dispersed clays, silts and fine sands.

Use a minimum of 3 inches of filter material for sand-gravel filters. Design the filter to prevent either the native soil or the filter material from entering the conduit. Not more than 10 percent of the filter material shall pass the No. 60 sieve. Design guidance is available in NEH Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.

Artificial fabric or mat-type filter materials may be used, provided that the effective opening size (EOS), strength, durability, and permeability are adequate to constantly filter the soil and protect subsurface drain operation throughout the expected life of the system. Do not place filter fabrics directly against conduits because they will rapidly load with sediment and seal off conduit.

**Envelopes and Envelope Material**

Use envelopes around subsurface drains if they are needed for proper bedding of the conduit or to improve the characteristics of flow of ground water into the conduit.

Envelope materials shall consist of sand-gravel, organic, or other compressible material. Sand-gravel envelopes shall all pass a 1½-in. sieve; 90 to 100 percent shall pass a ¾ in. sieve; and not more than 10 percent shall pass a No. 60 sieve.

Where organic or other compressible materials are used, they shall be used only around a rigid wall conduit and above the centerline of flexible tubing. All organic or other compressible material shall be of a type that will not readily decompose.

**Placement and Bedding**

Install all subsurface drains to a neat line and grade. Place and bed the conduit as described in ASTM-F-449, "Standard Recommended Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control," or as described below.

The conduit should not be placed on exposed rock or stones more than 1.5 inches in diameter for 6 inch or larger tile and stones no more than ¾ inch diameter for tile less than 6 inches. Where such conditions are present the trench must be over-excavated, a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit must be placed on a firm foundation to ensure proper alignment. Prevent runoff and surface water from entering the trench.

For trench installations of corrugated plastic tubing 8 inches or less in diameter, one of the following bedding methods will be specified:

1. A shaped groove or 90° V-notch in the bottom of the trench for tubing support and alignment;

2. A sand-gravel envelope, at least 3 inches thick, to provide support;

3. Compacted soil bedding material beside and to 3 inches above the tubing.

For trench installations of corrugated plastic tubing larger than 8 inches, the same bedding requirements will be met except that a semi-circular or trapezoidal groove shaped to fit the conduit will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements will be met except that a groove or notch is not required.

All trench installations should be made when the soil profile is in its driest possible condition in order to minimize problems of trench stability, conduit alignment, and soil movement into the drain.

For trench installations where a sand-gravel or compacted bedding is not specified, the conduit should be blinded with selected material containing no hard objects larger than 1.5 inches in diameter. Blinding should be carried to a minimum of 3 inches above the conduit.

**Auxiliary Structures and Protection**

Structures installed in drain lines must not unduly impede the flow of water in the system. Base the structure capacity on that of the line or lines feeding into or through them. The use of internal couplers for corrugated plastic tubing is allowed. Consider taping joints with an industrial grade duct tape to prevent separation during construction.

The size of relief wells is generally based on the available equipment rather than on hydraulic consideration. The minimum size for relief wells is 4 inches in diameter.

Protect the drain system against velocities exceeding those provided under "Maximum Velocity Without Protection" and against turbulence created near outlets, surface inlets, or similar structures. Use continuous or closed-joint pipe in drain lines adjoining the structure where excessive velocities will occur.

Use junction boxes if more than two main drains join or if two main drains join at different elevations.

If surface water is to be admitted to subsurface drains, design the inlets to exclude debris and prevent sediment from entering the conduit. Design lines flowing under pressure to withstand the resulting pressures and velocity of flow. Use auxiliary surface waterways where feasible.

If not connected to a structure, cap the upper end of each subsurface drain line with a tight-fitting cap of the same material as the conduit or other durable materials.

Protect the outlet against erosion and undermining of the conduit, against entry of tree roots, against damaging periods of submergence, and against entry of rodents or other animals into the subsurface drain. Use a continuous section of pipe, either schedule 40 or steel without open joints or perforations at the outlet end of the line and discharge above the normal elevation of low flow in the outlet ditch. Corrugated plastic tubing is not suitable for the outlet section.

Size the outlet channel with adequate depth and capacity for removing the design discharge in a period of time sufficient to prevent crop damage. Provide a minimum clearance of one (1) foot between the invert of the subsurface drain outlet and the bottom of the channel or normal low water stage, whichever is higher.

Where the outlet channel has sufficient grade to prevent siltation, or where flow in the outlet channel recedes within a few hours following peak runoff allowing a free outlet for the subsurface drain, this clearance may be reduced to five tenths (0.5) of a foot.

Any outlets not having the minimum clearances listed above must be approved by an engineer.

Continuously submerged outlets shall be permitted for water table control in organic and sandy soils if planned and designed according to the standard for Drainage Water Management (Code 554).

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

1. If burning vegetation on the outlet ditch bank is likely to create a fire hazard, use a fireproof outlet pipe;

2. Bury two-thirds of the pipe in the ditch bank, and extend the cantilever section to the toe of the ditch side slope or protect the side slope protected from erosion. The minimum length of the outlet pipe is 8 feet;

3. Do not use cantilevered outlets in locations where they may be damaged by ice or other floating debris;

4. Design headwalls used for subsurface drain outlets to be adequate in strength and to avoid washouts and other failures.

Use watertight conduits strong enough to withstand the expected loads if subsurface drains cross under irrigation canals or other ditches. Design conduits under roadways to withstand the expected loads. Protect shallow subsurface drains through depressed or low areas and near outlets from damage by farm machinery and other equipment and freezing and thawing.

## Materials

Subsurface drains include conduits of clay, concrete, bituminized fiber, metal, plastic, filter fabrics or other materials of acceptable quality.

The following specifications pertain to products currently acceptable for use as subsurface drains or for use in determining the quality of materials used in drainage installations:

| Type of Product | Specification |
|---|---|
| Clay drain tile | [1]ASTM-C-4 |
| Clay drain tile, perforated | ASTM-C-498 |
| Clay pipe, perforated, standard and extra 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 properties of | ASTM-C-497 |
| Concrete sewer, storm drain, and 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 storm drain pipe | ASTM-C-663 |
| Asbestos-cement nonpressure sewer pipe | ASTM-C-428 |
| Asbestos-cement perforated underdrain pipe | ASTM-C-508 |
| Asbestos-cement pipe, testing | ASTM-C-500 |
| Pipe, bituminized fiber, (and fittings) | [2]Federal Specification SS-P-1540 |
| Homogeneous bituminized fiber 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 pipe and fittings | ASTM-D-2852 |
| Polyvinyl chloride (PVC) sewer pipe and fittings | ASTM-D-2729 |
| Polyvinyl chloride (PVC) pipe | ASTM-D-3033 or D-3034 type PSM or PSP |
| Corrugated polyvinyl chloride tubing | (See specifications for corrugated polyvinyl chloride tubing) |
| Corrugated polyethylene tubing and fittings | ASTM-F-405 |
| Corrugated polyethylene tubing and fittings 10-15 in. | ASTM-F-667 |
| Pipe, corrugated (aluminum alloy) | Federal Specification WW-P-402 |
| Pipe, corrugated (iron or steel, zinc coated) | Federal Specification WW-P-405 |

[1]Specification can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

[2]Specification can be obtained from the Superintendent of Documents U.S. Government Printing Office, Washington, D.C. 20402.

Other Products may be approved by the NRCS Engineer.

## PLANS AND SPECIFICATIONS

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

Install all subsurface drains to lines and grades as specified and covered with approved blinding, envelope, or filter material to a depth of not less than 3 in. If an impervious sheet is used over the drain, at least 3 in. of blinding material must cover the sheet. Reversals in grade of the conduit are not permitted.

If the conduit is to be laid in a rock trench or if rock is exposed at the bottom of the trench, remove the rock so that the conduit is not less than 2 inches from rock.

Joints between drain tiles shall not exceed 1/8 in. except in sandy soils, where the closest possible fit must be obtained, and in organic soil where some of the more fibrous types make it desirable to slightly increase the space between tiles.

Place earth backfill material in the trench in a manner to insure that the conduit does not become displaced and so that the filter and bedding material, after backfilling, meet the requirements of the plans and specifications.

When sand-gravel filter material is required, use a mixture of sand and gravel within the gradation required by the base material in the trench. Over excavate the trench 3 inches and backfill to grade with filter material. After the conduit is placed on the filter material, place additional filter material over the conduit to fill the trench to a depth of 3 inches over the conduit. A plastic sheet and friable soil may be used as backfill over the subsurface drain if specified.

## OPERATION AND MAINTENANCE

Provide a site-specific operation and maintenance plan and review with, the landowner(s) before the practice is installed. The plan shall adequately guide the landowner(s) in the routine maintenance and operation of the drainage system. Include guidance on periodic inspections and post-storm inspections to detect and minimize damage to outlets. A written operation and maintenance plan shall include but not limited to the following:

1. Checking outlet to ensure free flow and a stable outlet condition;

2. Repairing eroded areas as necessary;

3. Controlling trees and shrubs by hand, machine, or chemicals as necessary.

## SUPPORTING DATA AND DOCUMENTATION

### Field Data and Survey Notes

Record the following minimum information on survey note sheets, SCS-ENG-28 and 29 or appropriate engineering paper.

1. Profile of mains (hand level or abney survey allowed for all lines over 2%;
2. Profile or grade of laterals (hand level or abney survey for all lines over 1%);
3. Freehand sketch of system layout showing staked length of each line;
4. Special control or outlet conditions affecting.

### Design Data

Record on appropriate MD forms and engineering paper. For guidance on the preparation of engineering plans see Chapter 5 of the EFH, Part 650. The following is a list of the minimum required design data:

1. Soil type being drained;
2. Inflow rate per 1,000 feet, compute "Q";
3. Plot profile of ground surface and determine proposed grade, complete sketch on MD-DEL-ENG-5;
4. Record and complete design data on size and capacity using MD-DEL-ENG-5;
5. Complete materials section MD-DEL-ENG-5;
6. Prepare cut-grade card for system (if needed);
7. Vegetative plan. This must meet the criteria, specifications, and documentation requirements of the Maryland conservation practice standard for Critical Area Planting, Code 342. Show on plan.

### Construction Check Data

Record on survey notepaper, SCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted on plans in red. The following is a list of minimum data required for As-builts:

1. Documentation of site visits on CPA-6. Include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom;
2. Measurements to show the drain was installed as planned (actual vs. planned cut at various stations);
3. Length and type of each size drain installed;
4. Length, kind and size of outlet pipe and type of animal guard;
5. Vertical distance between invert of outlet pipe and normal water level in the outlet ditch or stream;
6. Method of binding and minimum cover;
7. Kind and thickness of envelope (if filter was used);
8. Final quantities and documentation for quantity changes, and materials certification;
9. Location and dimensions of any drain system structure;
10. Sign and date checknotes and plans by someone with appropriate approval authority. Include statement that practice meets or exceeds plans and NRCS practice standards.

## REFERENCES

1. USDA Natural Resources Conservation Service, *National Engineering Handbook*, Part 650 Chapter 4, "Elementary Soil Engineering" and Chapter 14, "Water Management";
2. USDA, Natural Resources Conservation Service, *Maryland Field Office Technical Guide, Section IV, Standards and Specifications*;
3. USDA Natural Resources Conservation Service, *National Handbook of Conservation Practices*.