NATURAL RESOURCES CONSERVATION SERVICE

VIRGINIA CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(Ft.)

CODE 606

DEFINITION

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

PURPOSE

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

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to areas having a high water table where the benefits of lowering the water table 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 must 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 must be adequate for the quantity and quality of effluent to be discharged.

CRITERIA

Use adequate surveys and investigations to design and install subsurface drainage.

Capacity. Determine the required capacity by one or more of the following:

- Application of a locally tried and proven drainage coefficient to the acreage drained, including added capacity required to dispose of surface water entering through inlets.
- Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.
- Comparison of the site with other similar sites where subsurface drain yields have been measured.
- Measurement of the rate of subsurface flow at the site during a period of adverse weather and ground water conditions.
- Application of Darcy's law to lateral or artesian subsurface flow.

Conservation practice standards are reviewed periodically, and updated as needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

- Estimates of lateral or artesian subsurface flow.

Size. Compute subsurface drain size by applying Manning's formula. Base drain size on the required capacity and compute by using one of the following assumptions:

1. The hydraulic gradeline is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.

2. The conduit flowing partly 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. This procedure must 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.

All subsurface drains must have a nominal diameter that equals or exceeds 3 inches.

Depth, Spacing, and Location. The depth, spacing, and location of the subsurface drain is based on site conditions, including soils, topography, ground water conditions, crops, land use, outlets, and saline or sodic conditions.

The minimum depth of cover over subsurface drains in mineral soils is 2 feet. This minimum depth applies to normal field levels and may exclude sections of line near the outlet 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 feet for normal field levels, as defined above, after initial subsidence. Install structural measures when feasible to control the water table level in organic soils 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). Heavy-duty tubing is specified for depths greater than 10 feet, trench widths more than 2 feet, or in rocky soils.

Compute maximum allowable loads on subsurface drains using the specified trench and bedding conditions with the crushing strength for the type and class of drain. The design load on the conduit is based 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. A safety factor of not less than 1.5 must be used 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 than 0.5 feet per second (ft/s). 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, design 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.

Maximum Velocity without Protection. Design drains with velocities not exceeding those given in Table 1 unless special protective measures are installed.

Table 1. Maximum velocities by soil texture

Soil Texture	Velocity, ft/s
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

Maximum Grade and Protection. On sites where topographic conditions require that drain lines be placed on steep grades and design velocities will be greater than indicated

in Table 1, use special measures to protect the conduit or surrounding soil. Specify these measures for each job according to the particular conditions of the job site.

The protective measure must include one or more of the following:

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

2. Use non-perforated continuous tubing, a watertight pipe, or seal joints.

3. Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available.

4. Select rigid butt end pipe or tile with straight, smooth sections and square ends to obtain tight fitting joints.

5. Wrap open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric-type filter material.

6. Install open-air risers for air release or entry.

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.

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

The conduit must meet strength and durability requirements for the site. All conduits must meet or exceed the minimum requirements of the appropriate specifications published by the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and the American Water Works Association (AWWA).

Foundation. If soft or yielding foundations are encountered, stabilize these lines and protect from settlement by:

- adding gravel or other suitable materials to the trench,
- placing the conduit on a treated plank that will not readily decompose or on other rigid supports, or
- using long sections of perforated or watertight pipe having adequate strength to ensure satisfactory subsurface drain performance. The use of a flat treated plank is not recommended for corrugated plastic tubing.

Filters and Filter Material. Filters will be used around conduits, as needed, to prevent movement of the surrounding soil material into the conduit. The need for a filter will be determined by the characteristics of the surrounding soil material, site conditions, and

the velocity of flow in the conduit. A suitable filter should be specified if:

1. Local experience indicates a need;
2. Soil materials surrounding the conduit are dispersed clays, silts with a plasticity index less than 7, or fine sands with a plasticity index less than 7;
3. Deep soil cracking is expected; or
4. The method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, design the filter gradation in accordance with National Engineering Handbook (NEH) Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 inches of filter material except that the top of the conduit and side filter material may be covered by a sheet of plastic or similar impervious material to reduce the quantity of filter material required. In all cases the resulting flow pattern through filter material must be a minimum of 3 inches.

Artificial fabric or mat-type filter materials may be used, provided that the effective opening size, strength, durability, and permeability are adequate to prevent soil movement into the drain throughout the expected life of the system.

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.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they must not contain materials that will cause an accumulation of sediment in the conduit or that will render the envelope unsuitable for bedding of the conduit.

Envelope materials will consist of sand-gravel, organic, or similar material. Sand-gravel envelope materials shall all pass a 1.5-inch sieve; not more than 30 percent shall pass a No. 60 sieve; and not more than 5 percent shall pass the No. 200 sieve. ASTM C33 fine aggregate for concrete has been satisfactorily used and is readily available.

Only use organic or other compressible materials around a rigid wall conduit and above the centerline of flexible tubing. All organic or other compressible material must be of a type that will not readily decompose.

Placement and Bedding. 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.

If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in such materials as quicksand or silt slurry.

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.

All installations must meet the minimum requirements of the appropriate ASTM specification.

Auxiliary Structures and Protection. Structures installed in drain lines must not unduly impede the flow of water in the system. Their capacity must be no less than that of the line or lines feeding into or through them. The use of internal couplers for corrugated plastic tubing will be allowed.

If the drain system is to carry surface water flow, the capacity of the surface water inlet must not be greater than the maximum design flow in the drain line or lines. Covers or trash racks should be used to ensure that no foreign materials are allowed in the drain lines.

The capacity of a relief well system will be based on the flow from the aquifer, the well spacing, and other site conditions and will be adequate to lower the artesian water head to the desired level.

The size of relief wells is generally based on the available materials rather than on hydraulic considerations. Such wells will not be less than 4 inches in diameter.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2 feet will be provided in either circular or rectangular structures.

The drain system must be protected against velocities exceeding those given in Table 1 and against turbulence created near outlets, surface inlets or similar structures. Continuous or closed-joint pipe must be used in drain lines adjoining the structure where excessive velocities will occur.

Construct junction boxes where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover should be used, and the junction box should have a minimum of 1.5 feet of soil cover.

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

The outlet must be protected against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain. A continuous section of rigid pipe without open joints or perforations will be used at the outlet end of the line and must discharge above the normal elevation of low flow in the outlet ditch. Standard corrugated plastic tubing is not suitable for the outlet section. Minimize the visual impact of projecting outlets.

Continuously submerged outlets will be permitted for water table control systems if planned and designed according to Virginia Conservation Practice Standard *Drainage Water Management (Code 554)*.

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

1. If burning vegetation on the outlet ditch bank is likely to create a fire hazard, the material from which the outlet pipe is fabricated must be fire resistant. If the likelihood is great, the outlet pipe must be fireproof.
2. Two-thirds of the pipe will be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch side slope or the side slope protected from erosion. The minimum length of the pipe will normally be 8 feet. Under certain conditions, shorter sections are appropriate; e.g., steep-sided main and laterals (1 (horizontal) : 1 (vertical) or less) with a narrow bottom width of 3 feet, commonly referred to as “minimum ditches,” for outletting individual subsurface drain laterals. For conduits 10 inches in diameter and greater, consider longer outlet sections, such as:

- 12 feet for 10 inch and 12 inch diameter pipe.
- 16 feet for 15 inch and 18 inch diameter pipe.
- 20 feet for all diameters larger than 18 inches.

3. If ice or floating debris may damage the outlet pipe, recess the outlet to the extent that the cantilevered part of the pipe will be protected from the current in the ditch.
4. Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures.

Watertight conduits strong enough to withstand the expected loads will be used if subsurface drains cross under irrigation canals, ditches, or other structures. Conduits under roadways must be designed to withstand the expected loads. Shallow subsurface drains through depressed or low areas and near outlets must be protected from damage caused by farm machinery and other equipment and from freezing and thawing.

VEGETATION

Establish permanent vegetation as soon as practical on all disturbed areas other than cropland. Seedbed preparation, seeding, fertilizing, and mulching shall be appropriate for the site-specific conditions. Refer to the NRCS, Plant Establishment Guide for Virginia for allowable species, seeding mixtures, and recommended seeding dates. Maintain the vegetation and remove trees and shrubs by hand, machine, or chemicals as necessary.

ENVIRONMENTAL CONCERNS

All required federal, state, and local permits must be obtained by the owner prior to NRCS construction assistance.

Potential impacts to adjacent wetland areas must be addressed. USDA wetland conservation provisions apply. The practice must comply with NRCS wetland technical assistance policy contained in GM 190, Part 410.26.

Planning and implementation of this practice will be preceded by an environmental evaluation using the “Environmental Evaluation Data Sheet”, form VA-EE-1 and related guidelines found in GM-190, Part 410 (Virginia Amendments).

CONSIDERATIONS

When designing subsurface drainage systems, consider the effects the system will have on water quantity and quality.

Effects on quantity to consider include: water budget, base flow and runoff to water uses and users, groundwater recharge, and volume of soil water needed to improve plant growth.

Water quality effects that should be considered include delivery of sediment; changes in the delivery of dissolved salts, such as nitrates; downstream water uses and users; changes in delivery of dissolved substances to the aquifer; downstream water temperatures; and the effects on the visual quality of downstream water.

When tile lines could collect polluted water from manure spreading, consider installing tile blocks, stoppable catch basins, or other temporary flow blocking devices.

Consideration should be given to using subsurface drainage to control high water tables in areas where septic tanks and leach fields exist.

Consider adding collector mains to minimize the visual impact and potential ice or debris damage, and to facilitate maintenance of the grassed ditch bank.

Consider the ability to drain and treat saline and sodic soils where this is a problem.

Consider possible damages above or below the point of discharge that might involve legal actions under federal, state, or local laws. Consider maintaining or enhancing environmental values.

PLANS AND SPECIFICATIONS

Plans and specifications for installing subsurface drains must be in keeping with this standard and describe the requirements for

applying the practice to achieve its intended purpose.

Record all required information in an engineer field book, on a plan sheet or design computation sheet, or in another appropriate location.

DESIGN DATA

1. Completed Environmental Evaluation (Form VA-EE-1) and subsequent requirements.
2. Soils investigation.
3. Survey with sufficient ground elevations to show that the system may be installed as designed. Provide location map including tract number, field number(s), and acreage in field(s). Include plan view of drainage in relation to identifiable land features.
4. Specifications for filters or covers where applicable.
5. Design computations, including the area drained, drainage coefficient or inflow rate used and the design flows used.
6. Standard Cover Sheet (VA-SO-100A).
7. Materials and quantities needed.
8. Vegetation and/or ground cover requirements.
9. Supplemental practices required.
10. Virginia Conservation Practice Specifications (700 Series).
11. Operation and Maintenance Plan.

CHECK DATA

As a minimum, record and maintain the following check data:

1. As-built survey or location map with sketch of lines installed.
2. Type and manufacturer of the installed materials and the length of tile line by sizes and minimum grades used.
3. Length, type and size of outlet pipe. Also document other outlet requirements including size and depth of outlet channel, improvements needed to ensure adequacy, vertical distance between invert of outlet pipe and normal water in outlet channel, and need for diversion of surface water.
4. Type of material used for filter or cover where applicable.
5. Documentation of the adequacy of the outlet pipe.
6. Sufficient elevations to ensure that the system is installed correctly.
7. Minimum depth of cover.
8. Certification that practice meets standards and specifications. Note any exceptions. Include justification for variations.
9. Locations of appurtenant practices.
10. Adequacy of vegetation and/or ground cover.
11. Complete as-built section of Cover Sheet.

OPERATION AND MAINTENANCE

Prepare an Operation and Maintenance plan specific to the facilities installed for use by the landowner or operator responsible for operation and maintenance. Provide specific instructions for operating and maintaining the drains to ensure proper function. Include provisions to address the following, as a minimum:

- At least semi-annually inspect the system to ensure proper function. Observe outlets and maintain a stable outlet.
- Maintain the design depth of cover over the drainage system. All settlement or cracks in the soil should be investigated to determine their cause and immediately repaired.
- Avoid travel by heavy equipment over drain lines when the soil is saturated except at designed crossings. Avoid travel over pipelines by tillage equipment when the soil is saturated. Limit traffic to sections that were designed for traffic loads.

- Avoid any sub-soiling operation that may disturb the drain, its filter, and/or envelope materials.
- Remove all foreign debris that hinders system operation. Immediately remove any obstructions or blockage of trash racks, drain inlets, or drain outlets.
- Maintain all outlets, rodent guards, inlets and man-hole accesses in good operating condition.
- Eradicate or otherwise remove all rodents and/or burrowing animals that have damaged or can potentially damage any part of the system. Immediately repair any damage caused by their activity.
- Immediately repair any vandalism, vehicular or livestock damage to any outlets and appurtenances.

REFERENCES

USDA-Natural Resources Conservation Service. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 1, Engineering Surveys and Chapter 14, Water Management (Drainage).

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USDA-Natural Resources Conservation Service. Virginia 700 Series Construction Specifications. [On-line]. Available at http://www.nrcs.usda.gov/technical/eFOTG.

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