Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

CODE 606

(ft)

DEFINITION

A conduit installed beneath the ground surface to collect and/or convey excess water

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Remove or distribute excessive soil water
- Remove salts and other contaminants from the soil profile

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to agricultural land where a shallow water table exists and where a subsurface drainage system can mitigate the following adverse conditions caused by excessive soil moisture:

- Poor health, vigor and productivity of plants.
- Poor field trafficability.
- Accumulation of salts in the root zone.
- Health risk and livestock stress due to pests such as flukes, flies, or mosquitoes.
- Wet soil conditions around farmsteads, structures, and roadways.

This standard also applies where collected excess water can be distributed through a subsurface water utilization or treatment area.

CRITERIA

General Criteria Applicable to All Purposes

Capacity

Design capacity shall be based on the following, as applicable:

1. Application of a locally proven drainage coefficient for the acreage drained.

The drainage coefficient is the rate at which excess water must be removed from cropland in order to provide the proper degree of protection for crops to be grown. Coefficients are expressed in inches (millimeters) of water to be removed in 24 hours. Minimum coefficients are as follows:

- Subsurface Drainage Only (no open inlets)

Table M-1

Soil	Field Crops Inches (mm)	Truck Crops inches (mm)
Mineral	3/8 (9.5)	½ (12.7)
Organic	½ (12.7)	¾ (19.0)

This condition assumes that surface drainage is adequate. The selected drainage coefficient applies to the entire area being drained. If the runoff from an upland area spreads over the area to be drained and is likely to increase the drainage problem, the acres used in determining the drain (tile) size shall be proportionately increased.

- Subsurface and Surface Drainage (surface inlets in subsurface drains)

Table M-2

	Field Crops	Field Crops	Truck Crops	Truck Crops
Soil	Blind Inlets Inches(m m)	Open Inlets Inches (mm)	Blind Inlets Inches(m m)	Open Inlets Inches (mm
Mineral	3/8 (9.5)	½ (12.7)	½ (12.7)	1 (25.4)
Organic	½ (12.7)	¾ (19.0)	¾ (19.0)	2 (50.8)

Note: A ½ inch (12.7 mm) coefficient may be used if the organic soil occurs only as a small pocket in the vicinity of the inlet.

The selected drainage coefficient will apply to the entire watershed contributing runoff to the surface inlet, except where only a small amount of runoff will be impounded at the location of the inlet with the remainder flowing away in a confined channel. For the latter case, the drain (tile) shall be large enough to remove the impounded water in 24 hours, plus providing additional capacity for the required internal drainage. Blind inlets should only be used in areas where surface drainage will handle most of the surface water.

- Determine the minimum capacity using Figure 14-33 of the Engineering Field Handbook Chapter 14 (EFH14)(2001). Conduit size can be determined using Figures 14-34 and 14-35, as appropriate, in EFH14.

2. Yield of groundwater based on the expected deep percolation of irrigation water from the overlying fields.

3. 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 groundwater conditions.

5. Application of Darcy's law to lateral or artesian subsurface flow.

6. Contributions from surface inlets based on hydrologic analysis or flow measurements

Size
The size of subsurface drains shall be computed by applying Manning's formula, using roughness coefficients recommended by the manufacturer of the conduit. The size shall be based on the maximum design flow rate and computed using one of the following assumptions:

1. The hydraulic grade line parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow (normal condition, no internal pressure).
2. Conduit flowing partly full where a steep grade or other conditions require excess capacity.
3. Conduit flowing under internal pressure with hydraulic grade line set by site conditions, which differs from the bottom grade 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.

For assumptions 1 or 2 above, the minimum size of subsurface drains may be determined using the drainage charts in EFH14. Use Figure 14-34 on page 14-66 for corrugated plastic tubing, or Figure 14-35 on page 14-67 for clay and concrete tiles.

All subsurface drains shall have a nominal diameter that equals or exceeds 3 inches. When 3-inch (76 mm) diameter drains are used, any single line shall not exceed 1000 ft (305 m) in length.

Four-inch (102 mm) diameter drains shall not exceed 1320 ft (402 m) in length. In peat and muck soil, when using clay or concrete tile, consider using the longest individual section length possible

Internal Hydraulic Pressure
Drains are normally designed to flow with no internal pressure, and the flow is normally classified as open channel. The design internal pressure of drains shall not exceed the limits recommended by the manufacturer of the conduit.

Horizontal Alignment
A change in horizontal direction of the subsurface drain shall be made by one of the following methods:

1. The use of manufactured fittings.
2. The use of junction boxes or manholes.
3. A gradual curve of the drain trench on a radius that can be followed by the trenching machine while maintaining grade.

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

The minimum depth of cover over subsurface drains may exclude sections of conduit near the outlet or through minor depressions, providing these sections of conduit are not subject to damage by frost action or equipment travel.

In mineral soils, provide a minimum depth of cover over subsurface drains of 2.0 ft.

In organic soils, provide a minimum depth of cover after initial subsidence of 3 feet. If water control structures are installed and managed to limit oxidation and subsidence of the soil, the minimum depth of cover may be reduced to 2.5 ft.

For flexible conduits, maximum burial depths shall be based on manufacturer's recommendations for the site conditions, or based on a site-specific engineering design consistent with methods in NRCS National Engineering Handbook (NEH), Part 636, Chapter 52, Structural Design of Flexible Conduits.

For computation of maximum allowable loads on subsurface drains of all materials, use the trench and bedding conditions specified, and the compressive strength of the conduit. The design load on the conduit shall be based on a combination of equipment loads, trench loads, and road traffic, as applicable.

Equipment loads shall be 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 ft. Trench loads shall be based on the type of backfill over the conduit, the width of the trench, and the unit weight of the backfill material.

Continuous pipe shall be used where it is not feasible to obtain cover as specified in the national standards, such as where drain lines cross waterways, or roads, the outlet end of mains, or near structures. The continuous pipe shall be of sufficient strength and durability to withstand expected loadings and weathering.

The minimum average depth of any drain through an area requiring continuous internal drainage shall be 3 ft (0.9 m).

The depth of laterals to intercept hillside seepage will vary according to the depth of the impervious layer. The drain line must be placed so that it intercepts the seepage flow.

The depth of mains will be adjusted so that the laterals can be joined to the main with a center-to-center connection or at a higher point. Where laterals are significantly above the main or more than one lateral joins the main at a point, refer to the section on “Auxiliary Structures and Protection.” A flowline-to-flowline connection is permissible when a center-to-center connection is not practical.

The maximum depth of cover for standard duty corrugated plastic tubing shall be 10 ft for trench widths of 2 ft or less (measured at tubing and to 1 ft above top of tubing). Heavy duty tubing shall be specified for depths greater than 10 ft, trench widths more than 2 ft, 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. The design load on the conduit shall be 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 ft. 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 shall 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, minimum grades shall be based on site conditions and a velocity of not less than 0.5 ft per second. If a sedimentation hazard exits, a velocity of not less than 1.4 ft per second shall be used to establish the minimum grades. Otherwise, provisions shall be made 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.

Minimum grades where no sediment hazard exists are as follows:

Drain Size, Inches (mm)	Grade, Percent
3 to 6 (102 to 152)	0.10
8 to 10 (203 to 254)	0.07

12 and larger (>305) 0.05

Maximum Velocity
Design velocities for perforated or open joint pipe shall not exceed those given in Table M-3, unless special protective measures are installed. Design velocities with protective measures shall not exceed manufacturer's recommended limits.

On sites where topographic conditions require drain placement on steep grades and design velocities greater than indicated in Table M-3, special measures shall be used to protect the conduit or surrounding soil.

Protective measures for high velocities shall include one or more of the following, as appropriate:

1. Enclose continuous perforated pipe or tubing with fabric type filter material or properly graded sand and gravel.
2. Use non-perforated continuous conduit or a watertight pipe, and sealed joints.
3. Place the conduit in a sand and gravel envelope, or initial backfill 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 conduit with tar-impregnated paper, burlap, or special fabric-type filter material.
6. Install larger diameter drain conduit in the steep area to help assure a hydraulic grade line parallel with the conduit grade.
7. Install open air risers for air release or entry at the beginning and downstream end of the high velocity section.

Releases from drainage water management structures shall not cause flow velocities in perforated or open joint drains to exceed allowable velocities in Table M-3, unless protective measures are installed.

Thrust Control
Follow pipe manufacturer's recommendations for thrust control or anchoring, where the following conditions exist:

- Axial forces that tend to move the pipe down steep slopes.
- Thrust forces from abrupt changes in pipeline grade or horizontal alignment, which exceed soil bearing strength.
- Reductions in pipe size.

In the absence of manufacturer's data, thrust blocks shall be designed in accordance with NEH, Part 636, Chapter 52, Structural Design of Flexible Conduits.

Outlets
Drainage outlets shall be adequate for the quantity and quality of water to be discharged.

Outlets to surface water shall be designed to operate without submergence under normal conditions.

For discharge to streams or channels, the outlet invert shall be located above the elevation of normal flow and at least 1.0 foot above the channel bottom.

Outlets shall 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 pipe without open joints or perforations, and with stiffness necessary to withstand expected loads, shall be used at the outlet end of the drain line. Minimum lengths for the outlet section of

conduit are provided in Table M-4. Single-wall Corrugated Plastic Pipe is not suitable for the section that outlets into a ditch or channel.

For outlets into sumps, the discharge elevation shall be located above the elevation at which pumping is initiated.

Table M-4. Minimum Length of Outlet Pipe Sections

Pipe Diameter (in.)	Minimum Section Length (ft.)
8 and smaller	10
10 to 12	12
15 to 18	16
Larger than 18	20

The use and installation of outlet pipe shall 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 pipe is fabricated must be fireproof.
2. At least two-thirds of the pipe section shall be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch side slope, or the side slope shall be protected from erosion. The minimum length of the pipe shall be 10 ft (3 m). Under certain conditions shorter sections are appropriate; e.g., steep-sided main and laterals (1:1 or less) with a narrow bottom width of 3 ft, commonly referred to as “minimum ditches,” for outletting individual subsurface drain laterals. For 15 in. and 18 in. diameter pipe, use 16 ft minimum length. Use 20-ft outlet pipe for all diameters larger than 18 inches.
3. If ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered part of the pipe will be protected from the current of flow in the ditch or channel.
4. When surface water must enter the channel at the location of the outlet pipe, some approved type of structure shall be installed to safely lower the surface water into the ditch and protect the outlet. Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures. At least 8 ft (2.4 m) of rigid pipe shall be used to connect the drain line with the structure.
5. The minimum thickness for metal pipe shall be 0.064 inches (1.63 mm).

An adequate outlet shall be available and shall meet thefollowing requirements:

Open Channel

The outlet channel shall be large enough to remove surface runoff from the watershed in a period of time sufficient to prevent serious crop damage. Required capacity will be based on NRCS design criteria for open channels. The channel shall be deep enough to provide the minimum of one foot of clearance between the invert of the drain at its outlet and low-water stage in the channel. This clearance may be reduced: (1) where the outlet channel is on such a grade that silting will not occur; (2) where the tile will flow freely within 24 hours after a storm; or (3) where definite scheduled plans have been made for outlet improvement within the next 12 months.

Existing Mutual or Private Drains

When existing mutual or private tile mains are used as an outlet, the tile shall be in good condition, free of failure, and working properly. The minimum capacity of an existing mutual tile main shall be ¼ inch (6.4 mm) per 24 hours for the area to be served (wet acres if no inlets). The minimum capacity of a private tile main (one that is under the control of a farmer for which the proposed system will serve) must have the capacity as shown in Table M-1 or Table M-2, as the case may be.

Legal Closed Drain
A legal closed drain (county or judicial) intended to serve as an outlet for the proposed drainage system shall be administratively considered adequate, provided it is in good repair, free of failure, working properly and the owner has secured required permits to use the legal drain as an outlet.

Sink Holes and Wells
Sink holes and wells are not considered adequate outlets.

Pump Outlet
The pump capacity and setting shall be capable of providing the appropriate drainage coefficient for the area drained.

Surface Drains
The area to be drained must have adequate surface drainage or provisions must be developed, if feasible and practical, for removing surface water overland to the outlet channel. When it is not feasible or practical to remove impounded surface water by surface drains, surface inlets to subsurface drains may be used.

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. 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 the standard for Drainage Water Management (554).

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.

Alignment
The change in horizontal direction of the tile shall be made by one of the following methods:

1. The use of manufactured fittings.
2. The use of junction boxes or manholes.
3. A gradual curve of the drain trench on a radius that can be followed by the trenching machine and maintain grade. A gradual curve may be made by hand shaping the inner side of the trench, but in no case shall the radius be less than 5 ft (1.5 m). In either case, rigid tile must then be shaped or chipped so that no crack between tile exceeds 1/8 inch, unless adequately covered.

Protection from Biological and Mineral Clogging
Drains in certain soils are subject to clogging of drain perforations by bacterial action in association with ferrous iron, manganese, or sulfides. Iron ochre can clog drain openings and can seal manufactured (fabric) filters.

Manganese deposits and sulfides can clog drain openings.

Where bacterial activity is expected to lead to clogging of drains, access points for cleaning the drain lines shall be provided.

Where possible, outlet individual drains to an open ditch to isolate localized areas of contamination and to limit the translocation of contamination throughout the system.

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 is in its insoluble form.

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

Protection from Root Clogging
Problems may occur where drains are in close proximity to perennial vegetation. Drain clogging may result from root penetration by water-loving trees, such as willow, cottonwood, elm, soft maple, some shrubs, grasses, and deep-rooted perennial crops growing near subsurface drains.

The following steps may reduce the incidence of root intrusion:

- Install a continuous section of non-perforated pipe or tubing with sealed joints, through the root zone.
- Remove water-loving trees for a distance of at least 100 ft on each side of the drain, and locate drains a distance of 50 ft or more from non-crop tree species.
- Provide for intermittent submergence of the drain to limit rooting depth by installing a structure for water control (e.g. an inline weir with adjustable crest) that allows for raising the elevation of the drain outlet

Water quality
Septic systems shall not be directly connected to the subsurface drainage system, nor shall animal waste be directly introduced into the subsurface drainage system.

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

The conduit shall meet strength and durability requirements for the site. All conduits shall 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 Transportation Officials (AASHTO), or the American Water Works Association (AWWA).

Foundation
If soft or yielding foundations are encountered, the conduits shall be stabilized and protected from settlement. The following methods are acceptable for the stabilization of yielding foundations:

- Remove the unstable material and provide a stable bedding of granular envelope or filter material.
- Provide continuous cradle support for the conduit through the unstable section.
- Bridge unstable areas using long sections of conduit having adequate strength and stiffness to ensure satisfactory subsurface drain performance.
- Place conduit on a flat, treated plank. This method shall not be used for flexible (e.g. Corrugated Plastic Pipe) without proper bedding between the plank and conduit.

Loading
See the EFH14 Table 14-6 on page 14-63 for determining maximum trench depths for corrugated plastic tubing buried in loose, fine-textured soils. Special designs using reinforced concrete pipe or other pipe of similar strength will be used where drainage tile or tubing will not provide adequate strength.

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

site conditions, and the velocity of flow in the conduit. A suitable filter shall be used if any of the following conditions exist:

- Local experience with soil site conditions indicates a need.
- 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.
- The soil is subject cracking by desiccation.
- The method of installation may result in inadequate consolidation between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation shall be designed in accordance with NEH, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters or the following:

- D15 size smaller than 7 times d85 size but not smaller than 0.6 mm,
- D15 size larger than 4 times d15 size,
- Less than 5% passing No. 200 sieve,
- Maximum size smaller than 1.5 inches, where D represents the filter material and d represents the surrounding base material.

The number following each letter is the percent of the sample, by weight, that is finer than that size. For example, D15 size means that 15 percent of the filter material is finer than that size.

Specified filter material must completely encase the conduit such that all openings are covered with at least 3 inches of filter material, except where the top of the conduit and side filter material are 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 shall be a minimum of 3 inches in length.

Geotextile 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.

Geotextile filter material shall not be used where the silt content of the soil exceeds 40 percent.

Envelopes and Envelope Material
Envelopes shall be used around subsurface drains if needed for proper conduit bedding or to improve flow characteristics 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 materials that will render the envelope unsuitable for bedding of the conduit.

Envelope materials shall consist of sand-gravel, organic, or similar material. 100 percent of sand-gravel envelope materials shall all pass a 1.5-inch sieve; not more than 30 percent shall pass a Number 60 sieve; and not more than 5 percent shall pass the Number 200 sieve. ASTM-C-33 fine aggregate for concrete has been satisfactorily used and is readily available.

Organic or other compressible envelope materials shall not be used below the centerline of flexible conduits. All organic or other compressible materials shall be of a type that will not readily decompose.

Placement and Bedding
Placement and bedding requirements apply to both excavation trenching and plow type installations.

Place the conduit on a firm foundation to ensure proper alignment.

Conduits shall not be placed on exposed rock, or on stones greater than 1½ inches for conduits 6 inches or larger in diameter, or on stones greater than ¾ inch for conduit less than 6 inches in diameter. Where

site conditions do not meet this requirement, the trench must be over-excavated a minimum of 6 inches and refilled to grade with a suitable bedding material.

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 materials such as soil slurries.

For the installation of Corrugated Plastic Pipe with diameters of 8 inches or less, one of the following bedding methods shall be specified:

1. A shaped groove providing an angle of support of 90 degrees or greater shall be provided 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 bedding material beside and to 3 inches above the conduit.

For the installation of Corrugated Plastic Pipe with diameters larger than 8 inches, the same bedding requirements shall be met except that a semi-circular or trapezoidal groove shaped to fit the conduit with a support angle of 120 degrees will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements shall be met except that a groove or notch is not required. For trench installations where a sand-gravel or compacted bedding is not specified, the initial backfill for the conduit shall be selected material containing no hard objects (e.g. rocks or consolidated chunks of soil) larger than 1.5 inches in diameter. Initial backfill shall be carried to a minimum of 3 inches above the conduit.

Information on placing and bedding conduit is also contained in EFH14 on page 14-87. The minimum trench width at the top of the drain should be adequate to permit installation and provide bedding conditions suitable to support the load on the tile.

Auxiliary Structures and Protection

The capacity of any structure installed in the drain line shall be no less than that of the line or lines feeding into or through them.

Manufactured connections of junctions for joining two tile lines should always be used when available. If manufactured connections are not available, the junction should be cut and fitted and the cracks sealed with concrete mortar around the entire circumference of the fitted junction.

Structures for water table management, with provisions to elevate the outlet and allow submergence of the upstream drain, shall meet applicable design criteria in conservation practice standards, Structure for Water Control (587), and Drainage Water Management (554).

If the drain system is to include underground outlets, the capacity of the surface water inlet shall not be greater than the maximum design flow in the downstream drain line or lines. Covers or trash racks shall be used to ensure that no foreign materials are allowed in the drain lines. Inlets shall be protected from entry of animals or debris. If sediment may pose a problem, sediment traps shall be installed.

The capacity of a relief well system shall be based on the flow from the aquifer, the well spacing, and other site conditions, and shall be adequate to lower the artesian water head to the desired level. Relief wells shall not be less than 4 inches in diameter.

Surface water inlets will be installed using manufactured intakes or an approved equal method. See 650.1426 in EFH14.

The capacity of a relief well system for reducing artesian waterhead shall be based on the flow from the aquifer, the

well spacing, and other site conditions and will be adequate to lower the artesian waterhead to the desired level.

Breathers or vents shall be constructed according to Figure 14-42 in EFH14.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2.0 ft will be provided in either circular or rectangular structures.

The drain system shall be protected against turbulence created near outlets, surface inlets or similar structures. Continuous non-perforated or closed-joint pipe shall be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. If the junction box is buried, a solid cover should be used, and the junction box should have a minimum of 1.5 ft of soil cover. Buried boxes shall be protected from traffic.

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

Watertight conduits designed to withstand the expected loads shall be used where subsurface drains cross under irrigation canals, ditches, or other structures.

CONSIDERATIONS

When planning, designing, and installing this practice, the following items should be considered:

- Protection of shallow drains, auxiliary structures, and outlets from damage due to freezing and thawing.
- Proper surface drainage to reduce the required intensity of the subsurface drainage system.
- Designs that incorporate drainage water management practices (or facilitate its future incorporation) to reduce nutrient loading of receiving waters.
- Drainage laterals oriented along elevation contours to improve the effectiveness of drainage water management structures.
- The effects of drainage systems on runoff volume, seepage, and the availability of soil water needed for plant growth.
- Confirmation of soil survey information with site investigation, including auguring and shallow excavations to identify soil profile hydraulic characteristics, soil texture layering, water table depth, etc.
- The effects of drainage systems on the hydrology of adjacent lands.
- Subsoiling or ripping of soils with contrasting texture layers to improve internal drainage.
- Installations in dry soil profile to minimize problems of trench stability, conduit alignment, and soil movement into the drain.
- The effects to surface water quality.
- Use of temporary flow blocking devices to reduce risk of drain water contamination from surface applications of manure.

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.

At a minimum, plans specifications shall include, as applicable: location of drainage system; wetland delineation(s); conduit lengths, grades, sizes, and type of materials; structure locations, dimensions, and elevations; outlet locations, elevations, and protection required; and normal water level elevations in outlet ditches or streams.

OPERATION AND MAINTENANCE

The Operation and Maintenance (O&M) Plan shall provide specific instructions for operating and maintaining the system to insure proper function as designed. At a minimum, the O&M Plan shall address:

- Necessary periodic inspection and prompt repair of system components (e.g. structures for water control, underground outlets, vents, drain outlets, trash and rodent guards).
- Winterization protection from freezing conditions for drainage systems in cold climates.

REFERENCES

USDA-NRCS, National Engineering Handbook, Part 624, Chapter 4, Subsurface Drainage.

USDA-NRCS, National Engineering Handbook, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.

USDA-NRCS, National Engineering Handbook, Part 636, Chapter 52, Structural Design of Flexible Conduits.

USDA-NRCS, National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 14, Water Management (Drainage).

Table M-3. Maximum Velocities in feet/second (to convert to m/s, multiply by 0.305)

Soil Texture 4)	Drains without protection	Draintile with filter 2), 3)	Continuous pipe or sewer pipe with sealed joints (nonperforated)
Sand/loamy sand/fine sandy loam/loamy coarse sand/loamy very fine sand/fine sand/very fine sand/muck (sapric)/coarse loam/sandy loam	3.5	5.0	no limit
Silt/silt loam/mucky peat (hemic)/very fine sandy loam	5.0	6.0	no limit
Loam/silty clay/silty clay loam/sandy clay/sandy clay loam	6.0	7.0	no limit
Clay/clay loam/peat (fibric)	7.0	9.0	no limit
Coarse sand or gravel	9.0	10..0	no limit

The use of tile longer than 12 inches (305 mm) is recommended to reduce the number of joints.

Includes corrugated plastic drainage tubing installed with filter.

Graded gravel filter shall be a minimum of 3 inches (76 mm) thick around drain pipe and reasonably graded for the surrounding soil. The d85 of the envelope shall be larger than the perforations.

Where a soil horizon includes more than one texture, the most restrictive texture will be used.