United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

CODE 606

(ft)

DEFINITION

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

PURPOSE

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

- Remove or distribute excessive soil water
- Mitigate degraded plant condition, undesirable plant productivity, and health due to saturated soil, ponding, and flooding

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where a shallow water table exists and where a subsurface drainage system can mitigate one or more of the following adverse conditions caused by excessive soil moisture:

- Poor health, vigor, and productivity of plants***, when used in support of other conservation practices such as CPS 412 - Grassed Waterway***.
- Poor field trafficability.
- Health risk and livestock stress due to pests.
- Wet soil conditions around farmsteads, structures, and roadways.

This practice also applies to water distribution through subsurface drain pipe for utilization or treatment.***This practice should not be used to tile drain fields for crop production purposes in Vermont.***

CRITERIA

General Criteria Applicable to All Purposes

Use of this standard will comply with all applicable Federal, State, and local laws and regulations. The landowner must obtain all necessary permissions from regulatory agencies, or document that no permits are required. The landowner or contractor is responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

Capacity
Base design capacity on the following, as applicable:

- Recommendations from the State drainage guide.
- Application of a locally proven drainage coefficient for the acreage drained.
- The yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including leaching requirement.

- Comparison of the site to other similar sites with known subsurface drain yields.
- 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.
- Contributions from surface inlets based on hydrologic analysis or flow measurements.
- Drain inlet opening size versus drain intake rate.

Size
Compute the drain size by applying Manning's formula, using roughness coefficients recommended by the manufacturer of the conduit or coefficient adopted by the State. Base the size on the maximum design flow rate and compute using one of the following:

- 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).
- Conduit flowing partly full where a steep grade or other conditions require excess capacity.
- Conduit flowing under internal pressure with hydraulic grade line set by site conditions, which differs from the bottom grade of the subsurface drain.

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

Internal hydraulic pressure
Drains are normally designed to flow with no internal pressure, and the flow is normally classified as open channel. Maintain the design internal pressure of drains at or below the limits recommended by the manufacturer of the conduit.

Horizontal alignment
Accomplish a change in horizontal direction of the subsurface drain by one of the following methods:

- The use of manufactured fittings.
- The use of junction boxes or manholes.
- A gradual curve of the drain trench on a radius to accommodate 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 feet.

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 feet.

For flexible conduits, base maximum burial depth on the manufacturer's recommendations for the site conditions or on a site-specific engineering design consistent with methods in NRCS National Engineering Handbook (NEH) (Title 210), 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. Base the design load on the conduit from a combination of embedment, backfill, and live loads.

Base live loads on the maximum equipment or vehicle wheel loads. Equipment loads on the conduit may be neglected when the depth of cover exceeds 6 feet.

Minimum velocity and grade
In areas where sedimentation of fine sands and silts is not a hazard, design the minimum grade based on site conditions and velocity of not less than 0.8 feet per second. If a sedimentation potential exists, use a velocity of not less than 1.4 feet per second to establish the minimum grade. Otherwise, include 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. Prior to using high-pressure jetting systems, verify that the jetting system will not damage the pipe or the pipe embedment.

Maximum velocity
Limit the maximum velocity in a perforated corrugated plastic drainage pipe under open channel flow to 12 feet per second unless further restricted by the manufacturer's recommendation

Limit the maximum design velocities in open joint pipe (clay or concrete) to those given in table 1, unless protective measures are installed.

Table 1. Maximum Flow Velocities by Soil Texture

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

Protective measures for high velocities in open joint pipe may include the following, as appropriate:

- Bed the conduit in a sand and gravel envelope that is filter compatible with the joint openings and surrounding soil.
- Wrap the joints with nonwoven geotextile.

Releases from water control structures must not cause flow velocities in perforated or open joint drains to exceed allowable velocities in table 1, 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, that exceed soil-bearing strength.
- Reductions in pipe size.

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

Outlets
Provide drainage outlets adequate for the discharge quantity and quality of water.

Avoid submerged outlets unless intermittent submerged outlets are designed for protection from root clogging. For discharge to streams or channels, locate the outlet invert above the elevation of normal flow and at least 1.0 foot above the channel bottom.

For outlets into sumps, locate the discharge elevation above the elevation at which pumping is initiated

Protect outlets 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.

Use a continuous section of rigid pipe, without open joints or perforations and with stiffness necessary to withstand expected loads at the outlet end of the drain line. Table 2 shows minimum lengths for the outlet section of the conduit. Single-wall corrugated plastic pipe is not suitable for the section that outlets into a ditch or channel.

Table 2. 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 must conform to the following requirements:

- If burning vegetation on the outlet ditch bank is likely to create a fire hazard, select fireproof material for the pipe.
- Bury at least two-thirds of the rigid outlet pipe section 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 below the outlet pipe.
- If ice or floating debris may damage the outlet pipe, protect the pipe by recessing the cantilevered part of the pipe to protect from the current of flow in the ditch or channel.
- Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures.

For outlets into sumps, locate the discharge elevation above the elevation at which pumping is initiated.

Protection from biological and mineral clogging
Drains in certain soils are subject to clogging of 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, provide access points for cleaning the drain lines.

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.

Protection from root clogging
Problems may occur where drains are near 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.

Use one or more of the following steps to reduce the incidence of root intrusion:

- Install a continuous section of nonperforated pipe or tubing with sealed joints, through the root zone.
- Remove water-loving trees for a distance of at least 100 feet on each side of the drain and locate drains a distance of 50 feet or more from noncrop 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.

Utilize the intermittent submergence option only when the raised elevation of drain outlet will not adversely impact the performance of the conservation system supported by the subsurface drain, and where the raised elevation will not adversely impact flooding on neighboring properties.

Water quality
Do not connect septic systems to the subsurface drainage system, nor allow animal waste to 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 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 Transportation Officials (AASHTO), or the American Water Works Association (AWWA).

Foundation
If soft or yielding foundations are encountered, stabilize the conduit foundation and protect the area from settlement. The following methods are acceptable for the stabilization of yielding foundations:

- Remove the unstable material and provide 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 a conduit having adequate strength and stiffness to ensure satisfactory subsurface drain performance.
- Place conduit on a flat, treated plank. This method must not be used for flexible conduits (e.g., plastic pipe) without proper bedding between the plank and conduit.
- Use bedding to avoid laying the pipe on rock, rocky soil, or extremely hard soil.

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

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

The conduits must 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 suitable bedding material. For trench installations where a sand-gravel envelope or compacted bedding is not specified, the conduit embedment must be suitable backfill. Soil excavated from the trench may be used for backfill, as long as it contains no hard objects larger than the specified stone sizes above. Place initial backfill to a minimum of 3 inches above the conduit. Compact backfill to a density similar to the surrounding soil material. Mound the backfill over the trench to provide material for settling

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, specify one of the following bedding methods:

- Provide a shaped groove with an angle of support of 90 degrees or greater in the bottom of the trench for tubing support and alignment.
- Provide a sand-gravel envelope, at least 3 inches thick, for support.
- Provide compacted embedment 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 apply 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 apply except that a groove or notch is not required.

Filters and filter material
Design filters around conduits, as needed, to prevent movement of the surrounding soil material into the conduit. Determine the need for a filter by the characteristics of the surrounding soil material, site conditions, and the velocity of flow in the conduit. Use a suitable filter 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 to cracking by desiccation.
- The method of installation may result in inadequate consolidation between the conduit and backfill material.

If sand or sand-gravel filter is specified, design the filter gradation in accordance with NEH, Part 633, Chapter 26, “Gradation Design of Sand and Gravel Filters.”

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 will 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 path through the filter material must 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. Where the silt content in the soil exceeds 40 percent, ensure that the geotextile filter material will not clog during its design life.

Envelopes and envelope material
Use an envelope around subsurface drains if needed for proper conduit bedding or to improve flow characteristics into the conduit.

Materials used for envelopes must not contain materials that will cause an accumulation of sediment in the conduit, or render the envelope unsuitable for bedding of the conduit.

Envelope materials must consist of sand-gravel, organic, or similar material. Use an envelope gradation such that 100 percent of sand-gravel passes a 1.5-inch sieve, not more than 30 percent passes a number 60 sieve, and not more than 5 percent passes the number 200 sieve.

Organic or other compressible envelope materials must not be used below the centerline of flexible conduits. If organic or other compressible materials are used, they must be of a type that will not readily decompose.

Auxiliary structures and protection
The capacity of any structure installed in the drain line must be no less than that of the line or lines feeding into or through the structure.

Structures for water table management, with provisions to elevate the outlet and allow submergence of the upstream drain, must meet applicable design criteria in NRCS Conservation Practice Standard (CPS) Structure for Water Control (Code 587). Mark buried boxes with surface evidence or referenced to fixed above ground markings or structures.

Underground outlets connected to the subsurface drainage system must meet the applicable provision of NRCS CPS Underground Outlet (Code 620). Design the capacity of the surface water inlet to be no greater than the maximum design flow in the downstream drain line or lines. If sediment may pose a problem, install sediment traps.

Specify pressure relief wells as needed to allow excess flow to escape the conduit and flow over the ground surface. Use pressure relief wells where there is a stable outlet for the flow from the relief well. Cover the relief well with a grate or other appropriate means to prevent the accidental entry (i.e., machines, animal, humans) and debris. Design the subsurface drain system to have a positive hydraulic grade to the relief well flow line. Base the relief well system capacity on the flow from the drainage system and other site conditions. Capacity must be adequate to lower the water head to the desired level. Relief wells must not be less than 4 inches in diameter.

Junction boxes, manholes, catch basins, and sediment traps must be accessible for maintenance. Provide a clear opening of not less than 2.0 feet in diameter or 2.0 feet by 2.0 feet square.

Protect the drain system against turbulence created near outlets, surface inlets, or similar structures. Use continuous nonperforated or closed-joint pipe in drain lines adjoining the structure where excessive velocities will occur.

As an alternative to manufactured fittings, install a junction box where three or more lines join or if two lines join at different elevations. If the junction box is buried, use a solid cover, and the junction box should have a minimum of 1.5 feet of soil cover. Protect buried boxes from traffic.

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

Use watertight conduits designed to withstand the expected loads where subsurface drains cross under irrigation canals, ditches, or other structures.

CONSIDERATIONS

When planning, designing, and installing this practice, consider—

- Protection of shallow drains, auxiliary structures, and outlets from damage due to freezing and thawing.
- Proper surface drainage to reduce the required capacity of the subsurface drainage system.
- Designs that can incorporate drainage water management practices (or facilitate future incorporation of drainage water management) 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 augering 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, especially potential or delineated wetlands and existing wetland easements.

- Subsoiling or ripping of soils with contrasting texture layers to improve internal drainage. Where this treatment is needed use NRCS CPS Deep Tillage (Code 324).
- 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 the risk of drain water contamination from surface applications of manure.
- Where removal of nitrate nitrogen in subsurface drainage is needed use NRCS CPSs Drainage Water Management (Code 554), Constructed Wetland (Code 656), Saturated Buffer (Code 604), or Denitrifying Bioreactor (Code 605) in conjunction with this standard.
- The potential existence of a hazardous atmosphere in junction boxes or manholes.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for installing subsurface drains according to the applicable criteria that describe the requirements for implementing the practice to achieve its intended purpose.

At a minimum, plans and specifications must include, as applicable:

- location and plan view of the drainage system
- conduit lengths, grades, spacing, sizes, and type of materials
- structure locations, dimensions, and elevations
- outlet locations, elevations, and protection required
- location of utilities and notification requirements

OPERATION AND MAINTENANCE

Provide an operation and maintenance (O&M) plan with specific instructions for operating and maintaining the system to ensure proper function as designed. At a minimum, the O&M plan must 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 (if applicable) for drainage systems in cold climates.

REFERENCES

USDA NRCS. National Engineering Handbook (NEH) (Title 210), Part 624, Chapter 4, Subsurface Drainage. (https://directives.sc.egov.usda.gov/)

USDA NRCS. NEH, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.
(https://directives.sc.egov.usda.gov/)

USDA NRCS. NEH, Part 636, Chapter 52, Structural Design of Flexible Conduits.
(https://directives.sc.egov.usda.gov/)