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 may be applied as part of a resource management system to achieve 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 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.
- Poor field trafficability.
- Accumulation of salts in the root zone.
- Health risk and livestock stress due to pests.
- 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

Base design capacity on the following, as applicable:

- Application of a locally proven drainage coefficient for the acreage drained.
- Guidance for the selection of an appropriate drainage coefficient can be found in the Iowa Drainage Guide and NEH, Part 650, Chapter 14. For new installations, the minimum drainage coefficient shall be 3/8 inch per day. If surface water enters the system, the minimum drainage coefficient shall be 1 inch per day for the area contributing surface runoff.
- Yield of groundwater based on the expected deep percolation of irrigation water from the overlying fields.
- 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

groundwater conditions.

- Application of Darcy's law to lateral or artesian subsurface flow.
- 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, or guidance from the National Engineering Handbook (NEH), Part 650, Chapter 3. The size shall be based on the maximum design flow rate and computed using one of the following assumptions:

- 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 shall have a nominal diameter that equals or exceeds 3 inches.

The maximum length of a single drain shall be based on its capacity and area drained. Refer to the Iowa Drainage Guide for guidance. Do not exceed 1,500 feet for 4-inch diameter corrugated plastic pipe drains designed on grades flatter than 0.4 percent.

Use a minimum 6-inch nominal diameter segmented non-flexible drain pipe or minimum 5-inch nominal diameter flexible non- segmented drain pipe in peat and muck soils greater than 4 feet deep.

Use a minimum 5-inch nominal diameter drain for collecting spring or side hill seepage from an area greater than 1.0 acre or when draining non-cohesive loess and sandy soils, including soils that contain pockets or layers of sand in the upper 5 feet.

The diameter of corrugated plastic tubing, clay, and concrete drain tile for a known area can be obtained from the nomographs within NEH, Part 650, Chapter 14; NEH, Part 624, Chapter 10; or the Iowa Drainage Guide.

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

The location, depth, and spacing of the subsurface drain shall be based on site conditions including soils, topography, groundwater conditions, crops, land use, outlets, saline or sodic conditions, and proximity to wetlands.

Designers may use Table 2-2 "Drainage Guidelines for Iowa Soils" from the Iowa Drainage Guide for determining drain spacing and depth parameters for sites with no unusual conditions.

The minimum depth of cover over subsurface drains may be reduced to 2.0 feet for 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, the minimum depth of cover over subsurface drains shall be 2.4 feet.

In organic soils, the minimum depth of cover after initial subsidence shall be 3.0 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, 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 NEH, Part 636, Chapter 52, Structural Design of Flexible Conduits. The maximum depth of cover for certain pipe and conditions can be found in Underground Outlets (620), Table 3.

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 feet. 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.

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 feet per second. If a sedimentation hazard exits, a velocity of not less than 1.4 feet 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.

The minimum permissible grade for 3- to 6- inch pipe can be found in the Iowa Drainage Guide.

Maximum Velocity
Design velocities for perforated or open joint pipe shall not exceed those given in Table 1, 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 1, special measures shall be used to protect the conduit or surrounding soil.

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
Ref: NEH 624, Chapter 4, "Subsurface Drainage."	

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 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, 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. The minimum length of the pipe shall be 20 feet. 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.

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

- 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.
- 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.
- 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.

- Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures.

Existing subsurface main(s) in good condition may be used as outlets for new subsurface laterals if the in situ mainline is positioned such that installed laterals meet all applicable criteria found within this standard. Existing subsurface main(s) to be utilized as an outlet shall have a minimum capacity for the greater of either:

- ⅜ inch per day for the sum of the existing tiled area and the area drained by the new laterals, or
- 1 inch per day for the area(s) draining into surface intakes (i.e.: Terraces and Water and Sediment Control Basins)

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. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction.

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 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 feet on each side of the drain, and locate drains a distance of 50 feet or more from non-crop tree species. Orchards can often be drained by drain lines located close to the fruit trees.
- 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.

Filters and Filter Material
Filters 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.

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 may be used in lieu of the aforementioned gradation.

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.

All subsurface drains shall be laid to the neat line and grade. All subsurface drains shall be designed with connections that are placed center to center or higher.

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 8 inches or larger, 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 (blinding) 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 6 inches above the conduit.

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. The use of internal couplers for corrugated plastic pipe shall be allowed.

Structures for water table management, with provisions to elevate the outlet and allow submergence of the upstream drain, shall meet applicable design criteria in 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.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2.0 feet 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 feet 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 and 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.

The following list of Construction Specifications is intended as a guide to selecting the appropriate specifications for each specific project. The list includes most, but may not contain all, of the specifications needed for a specific project:

IA-1 Site Preparation

IA-5 Pollution Control

IA-6 Seeding and Mulching for Protective Cover

IA-45 Plastic (PVC, PE) Pipe

IA-46 Tile Drains for Land Drainage

IA-51 Corrugated Metal Pipe

IA-52 Steel Pipe Conduits

IA-61 Loose Rock Riprap

IA-95 Geotextile

IA-620 Underground Outlets

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

Iowa State University. Special Report 13 - Iowa Drainage Guide,

USDA-NRCS, National Engineering Handbook, Part 624, Chapter 10, Water Table Control.

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 (NEH), Part 650, Engineering Field Handbook (EFH), Chapters 3 and 14