NATURAL RESOURCES CONSERVATION SERVICE

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.

PURPOSES

To 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.
- Regulating subirrigated areas or waste disposal areas.

To collect ground water for beneficial uses.

To remove water from heavy use areas (such as around buildings, roads, and play areas) and accomplish other physical improvements related to water removal.

To 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 shall have enough depth and permeability to permit installation of an effective and economically feasible system.

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

CRITERIA

General Criteria Applicable to All Purposes

The design and installation shall be based on adequate surveys and investigations. Criteria and tables in Chapter 14 of National Engineering Handbook (NEH) Part 650, Engineering Field Handbook, may be used.

Laws, rules, and regulations. This practice shall conform to all federal, state, and local laws, rules, and regulations. Laws, rules, and regulations of particular concern include those involving water rights, land use, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

Capacity. One or more of the following shall determine the required capacity:

- Application of a suitable 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
- Survey and 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
- Estimates of lateral or artesian subsurface flow

Drainage coefficient. The drainage coefficient is the rate of water removal necessary to provide the required degree of protection for crops. It is expressed as the depth of water in inches to be removed in 24 hours.

Where the land to be drained has complete surface drainage (either natural or artificial), the minimum drainage coefficient should be 3/8 inch.

Where it is necessary to admit surface water to the drain system through surface inlets, the minimum drainage coefficient should be 1/2 inch for field crops and 3/4 inch for truck crops.

Where high value truck crops might be damaged by water standing on them from 2 to 4 hours during hot weather, a higher coefficient than given above may be necessary to hold crop damage to a minimum.

Design drainage area. Where no surface water is admitted directly to the drain line, the selected drainage coefficient should apply only to the land area requiring drainage.

Where surface water is admitted directly to the drain line through surface inlets, the selected drainage coefficient should apply to the entire watershed contributing to the surface inlets.

An exception to the above should be made when only a small amount of the runoff will be impounded at the location of the inlet, and the remainder will flow away in a confined channel. The drain line should be designed to drain both the impounded and the internal water.

Size. The size of subsurface drains shall be computed by applying Manning's equation. The size shall be based on the required capacity and computed by using one of the following assumptions:

- The hydraulic gradeline is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.
- The conduit is flowing partly full where a steep grade or other conditions require excess capacity.
- The conduit is flowing under pressure with hydraulic gradeline set by site conditions on a grade that differs from that 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.

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

Depth, spacing, and location. The depth, spacing, and location of the subsurface drain shall be 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 shall be 2 feet. This minimum depth shall apply 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.

Loading. The allowable loads on subsurface drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Heavy-duty corrugated plastic drainage tubing shall be specified if the soil is rocky, if cover over the tubing is expected to exceed 10 feet, or if trench widths are expected to exceed 2 feet. (This refers to trench widths in the area of the tubing and at least 1 foot above the top of the tubing.)

Minimum velocity and grade. In areas where sedimentation is not a hazard, the minimum

grades shall be based on site conditions and a velocity of not less than 0.5 foot per second (ft/s). If a hazard exits, a velocity of not less than 1.4 ft/s shall be used to establish the minimum grades if site conditions permit. 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.

Maximum velocity without protection. Excessive flow velocity in the drain may induce piping of soil material into the drain line.

Maximum permissible velocity in subsurface drains without protective measures shall be as follows:

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 under "Maximum velocity without protection," special measures shall be used to protect the conduit or surrounding soil. These measures shall be specified for each job according to the particular conditions of the job site.

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

- Enclose continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel
- Use nonperforated continuous tubing or a watertight pipe
- Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available
- Select rigid butt end pipe or tile with straight, smooth sections and square ends to obtain tight-fitting joints
- Wrap open joints of the pipe or tile with tar-impregnated paper, burlap, or special fabric-type filter material
- 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.

The first consideration is to use nonperforated 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 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) and the American Association of State Highway and Transportation Officials (AASHTO).

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

Type	Specifications
Polyvinyl chloride (PVC) sewer pipe and fittings	ASTM D 2729
Polyvinyl chloride (PVC) pipe	ASTM D 3034 type PSM
Corrugated polyethylene tubing and fittings 3-6"	ASTM F 405
Corrugated polyethylene tubing and fittings 8-24"	ASTM F 667
Corrugated HDPE pipe 4-10"	AASHTO M 252
Corrugated HDPE pipe 12-24"	AASHTO M 294
Corrugated pipe (aluminum)	ASTM B 745
Corrugated iron or steel pipe (galvanized)	ASTM A 760

Foundation. If soft or yielding foundations are encountered, the lines shall be stabilized and protected from settlement by adding gravel or other suitable materials to the trench, by placing the conduit on a treated plank that will not readily decompose or on other rigid supports, or by 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 at least one of the following exists:

- Local experience 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
- Deep soil cracking is expected
- The method of installation may result in voids between the conduit and backfill material

If a sand-gravel filter is specified, the filter gradation shall be designed in accordance with Chapter 26 in NEH Part 633, Soil Engineering.

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.

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. Envelopes shall be used 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 shall consist of sand-gravel. Sand-gravel envelope materials shall all pass a 1.5-inch sieve; 90 to 100 percent shall pass a ¾-inch sieve; not more than 30 percent shall pass a No. 60 sieve; and not more than 5 percent shall pass a No. 200 sieve. Fine aggregate for concrete (ASTM C 33) meets these requirements and is readily available.

Where organic or other compressible materials are used, they shall be used only around a rigid wall conduit and above the centerline of flexible

tubing. All organic or other compressible material shall be of a type that will not readily decompose.

Refer to Figure 14-39 in Chapter 14 of NEH Part 650, Engineering Field Handbook, for typical bedding or envelope installations.

Placement and bedding. For 6-inch or larger pipe, the pipe should not be placed on exposed rock or stones more than 1½ inches in diameter. For pipe less than 6 inches, it should not be placed on exposed rock or stones more than ¾ inch in diameter. 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 a silt slurry.

For trench installations of corrugated plastic tubing, one of the following bedding methods will be specified:

- A semi-circular or trapezoidal groove shaped in the bottom of the trench for tubing support and alignment
- A sand-gravel envelope, at least 3 inches thick, to provide support
- Compacted soil bedding material beside and to 3 inches above the tubing

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 shall 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 shall 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 waterhead 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 provided under **"**Maximum velocity without protection**"** 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.

Junction boxes shall be installed where 3 or more lines join or if 2 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.

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--for example, steep-sided main and laterals (1:1 or less) with narrow bottom widths of 3 feet (commonly referred to as “minimum ditches”) for outletting individual subsurface drain laterals. For conduits 10 inches in diameter and greater, longer outlet sections shall be considered as follows:
    - Conduits 10 inches and 12 inches in diameter - Use 12-foot outlet sections.
    - Conduits 15 inches and 18 inches in diameter - Use 16-foot outlet sections.
    - Use 20-foot outlet pipe for all conduit 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 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.

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, baseflow and runoff to water uses and users, ground water 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) on 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.

If a concern exists of tile lines picking up polluted water from manure spreading, consider installing tile blocks, stoppable catch basins, or other temporary flow-blocking devices.

The ability to drain and treat saline and sodic soils shall be considered where this is a problem.

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.

A plan shall be prepared for each installation. The plan will show accurate location and size of all the lines together with a profile of the mains and submains. Include typical bedding or envelope installations (if required). The plan shall also show location, control elevation, and pertinent features of junction boxes, drops, control gates, or other appurtenances that are a part of the drain facility.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed and reviewed with the landowner or individual responsible for operation and maintenance.

Subsurface drains shall be maintained by:

- Keeping junction boxes, drops, control gates, or other appurtenances clean and free of materials that can reduce the flow.
- Repairing leaks and broken or crushed lines to ensure proper functioning of the lines.
- Checking outlet conduit and animal guards to ensure proper functioning of the conduit.
- Keeping adequate backfill over the conduit.
- Repairing any eroded areas at the pipe outlet.