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.

PURPOSE

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

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to areas having a high water table where the benefits of lowering the water table or controlling ground water or surface runoff justify installing such a system.

This standard applies to areas suitable for the intended use after installation of required drainage and other conservation practices. The soil 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 water to be discharged.

CRITERIA

General. Subsurface drains shall not be used to convey or dispose of any waste or process water. Wells or sinkholes shall not be used as outlets for subsurface drains.

The design and installation shall be based on adequate surveys and investigations.

Outlets. Natural occurring channels or constructed ditches in good condition may be used as outlets for subsurface drains. The outlet of the subsurface drain shall be placed a minimum of 1.0 foot above the seasonal high base flow elevation or a minimum of 1.0 foot above the bottom for channels/ditches that only flow water during surface runoff events.

The outlet must be protected against erosion 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 shall be used at the outlet end of the line. Standard corrugated plastic tubing is not suitable for the outlet section.

Continuously submerged outlets shall be permitted for water table control systems if planned and designed according to Drainage Water Management (554).

The outlet pipe and its installation 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 outlet pipe is fabricated must be fire resistant. If the likelihood is great, the outlet pipe must be fireproof
- Two-thirds of the outlet pipe 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 protected from erosion. The minimum length of the pipe shall be 20 feet
- 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
- 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)

Capacity. The drainage coefficient (rate of water removal in inches per 24 hours) for all new mains and new laterals shall be a minimum of ½ inch.

Size. The diameter of corrugated plastic tubing, clay, and concrete drain tile for a known acreage of land can be obtained from the nomographs within NEH, Part 650, Chapter 14; NEH, Part 624, Chapter 10; or the Iowa Drainage Guide. The diameter of subsurface drains made of other materials may be calculated using Manning's Formula along with guidance from NEH, Part 650, Chapter 3.

All subsurface drains shall have a nominal diameter that equals or exceeds 4 inches. All 4-inch subsurface drains designed on grades flatter than 0.4 percent shall be limited to the following installation length restriction:

- Do not exceed 1,800 feet for clay or concrete drains
- Do not exceed 1,500 feet for plastic tubing drains

Larger diameter subsurface drains may be designed and installed if any of the following conditions exist or will exist:

- Potential groundwater movement from lower depths upward into the drainage zone
- An indefinite collection area of side hill seepage
- Potential loss of capacity from misalignment, non-uniform drain grade or build-up of sedimentation within the drain

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.

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.

Designers may use Table 2.2 “Drainage Guidelines for Iowa Soils” from the Iowa Drainage Guide for determining drain spacing and depth parameters.

The minimum depth of cover over subsurface drains, after initial settlement, shall be a minimum of 2.4 feet in mineral soils and 3.0 feet in organic soils. A minimum 2.0 feet of cover shall be allowed for sections of pipe near the outlet laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel.

The minimum depth of all drains in normal field conditions shall be 3.0 feet. Mains or laterals crossing under roads, railroads, canals, ditches or other man-made structures shall be designed and constructed of a watertight material that is engineered for the load and environmental condition to which it is exposed.

The maximum depth of cover for subsurface drains shall comply with the Table 3 parameters of Underground Outlets (620). Installations at depths beyond those listed in Table 3 will require an engineering analysis in accordance with NEH, Part 636, Chapter 52 “Structural Design of Flexible Conduits” and specific installation criteria.

All subsurface drains shall be designed with connections that are placed center to center or higher.

Minimum Velocity and Grade. In areas where sedimentation is not a hazard, minimum grade shall be based on site conditions and a velocity of not less than 0.5 feet 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 grade 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.

Minimum permissible grade shall be in accordance with the recommendations set forth in the Iowa Drainage Guide.

Maximum Velocity Without Protection. Design velocities shall not exceed those given in Table 1 unless special protective measures are installed.

Table 1. Maximum Velocities By Soil Texture

Soil Texture	Velocity, ft/s
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silty clay loam	6.0
Clay and clay loam	7.0
Coarse sand or gravel	9.0

Maximum Grade and Protection. On sites where topographic conditions require that drain lines be placed on steep grades and design velocities will be greater than indicated in Table 1, 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 non-perforated continuous tubing, a watertight pipe, or seal joints
- 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 shall be made to provide access for cleaning the lines. Each drain line should outlet directly into an open ditch and/or should have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas should be installed during the dry season when the water table is low and the iron and manganese dioxide is in its insoluble form.

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

Protection Against Root Clogging. Problems may occur where it is necessary to place drains in close proximity to perennial vegetation. Roots of water loving trees, such as willow, cottonwood, elm, and soft maple, or some shrubs and grasses growing near subsurface drains may enter and obstruct the flow.

Where possible, use non-perforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be removed from a distance of at least 100 feet on each side of the drain. A distance of 50 feet should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drain lines located close to the fruit trees.

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), American Association of State Highway and Transportation Officials (AASHTO), and the American Water Works Association (AWWA). A detailed listing of these material standards and specifications can be found in NEH, Part 650, Chapter 14.

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, or by using long sections of perforated or watertight pipe having adequate strength to ensure satisfactory subsurface drain performance.

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 shall be specified if:

- Local experience indicates a need
- Soil materials surrounding the conduit have a plasticity index less than 7 or are dispersed clays
- 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 the procedural guidance in NEH, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 inches of filter material. Not more than 10 percent of the filter material shall pass the No. 60 sieve.

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, organic, or similar material. Sand-gravel envelope materials shall all pass a 1.5-inch sieve; not more than 30 percent shall pass a No. 60 sieve; and not more than 5 percent shall pass the No. 200 sieve. ASTM-C-33 fine aggregate may be used in lieu of the aforementioned gradation.

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.

Placement and Bedding. All subsurface drains shall be laid to a neat line and grade. Conduits shall not be placed on exposed rock or stones more than 1.5 inches in diameter for 6 inch or larger pipe and stones no more than ¾ inch diameter for pipe less than 6 inches. Where such conditions are present the trench must be over-excavated a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit must be placed on a firm foundation to ensure proper alignment. 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 8 inches or less in diameter, one of the following bedding methods shall be specified:

- A shaped groove or 90° V-notch 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 trench installations of corrugated plastic tubing larger than 8 inches, the same bedding requirements shall apply except that a semi-circular or trapezoidal groove shaped to fit the conduit will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements shall apply 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.

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 shall 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 water head to the desired level.The minimum size of relief wells shall be 5 inches in diameter.

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

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

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover shall be used, and the junction box shall 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.

CONSIDERATIONS

Consider installation of tile blocks, stoppable catch basins, or other temporary flow blocking devices if the subsurface drain may pick up polluted water from manure spreading.

Use grass filter strips around inlets to reduce downstream impacts of water quality.

Where the roots of 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.

PLANS AND SPECIFICATIONS

Plans and specifications for installing subsurface drains shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

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-11	Removal of Water
IA-21	Excavation
IA-23	Earthfill
IA-24	Drainfill
IA-26	Topsoiling
IA-27	Diversions
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

A site-specific operation and maintenance (O&M) plan shall be provided to, and reviewed with, the landowner(s) before this practice is installed. The plan shall adequately guide the landowner(s) in the routine maintenance and operational needs of subsurface drains. The plan shall also include guidance on periodic inspections and post-storm inspections to detect and minimize damage.

REFERENCES

USDA-NRCS, National Engineering Handbook (NEH), Part 650, Engineering Field Handbook (EFH), Chapters 3 and 14

USDA-NRCS, National Engineering Handbook (NEH), Part 624, Chapter 10

Iowa Drainage Guide, Iowa State University Special Report 13

USDA-NRCS, National Engineering Handbook (NEH), Part 633, Chapter 26