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, and
  - ◊ 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 effluent to be discharged.

CRITERIA

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

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

1. Application of a locally tried and proven drainage coefficient to the acreage drained, including added capacity required to dispose of surface water entering through inlets.
2. Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.

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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 ground water conditions.
5. Application of Darcy's law to lateral or artesian subsurface flow.
6. Estimates of lateral or artesian subsurface flow.
7. ***All pattern systems, without direct entry of surface water into the lines, shall provide for a drainage coefficient of at least 3/8 inch in 24 hours from the area to be drained for agricultural drainage and at least 3/4 inch in 24 hours for more intense uses.***
8. ***For random and interceptor systems or single lines, the drainage coefficient shall be based on the rate of flow of gravitational water through the particular soil in which the drain is laid. The inflow rates for all soils requiring drainage are shown by slope classes in the Drainage Guide for West Virginia and shall be used. However, where soils will be used for recreation or other intensive uses, the minimum inflow rate shall be 0.1 c.f.s. per 1000 feet of line.***
9. ***Where it is necessary to admit surface water into any system or line, the following drainage coefficients shall be used:***
    - ***Blind inlets or French drain - 1/2" in 24 hours***
    - ***Open inlets - 3/4" to 1" in 24 hours.***
10. ***The entire area contributing surface flow shall be used to determine capacity and shall be in addition to 7 or 8 above.***
11. ***When flows from springs or large seeps are to be carried by a drain, such flows will be measured or estimated and added to the required capacity as determined above.***

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

1. The hydraulic gradeline is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.

2. The conduit flowing partly full where a steep grade or other conditions require excess capacity.

3. Conduit 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.

The minimum depth of cover in organic soils shall be 2.5 feet for normal field levels, as defined above, after initial subsidence. Structural measures shall be installed if it is feasible to control the water table level in organic soils within the optimum range of depths.

The maximum depth of cover for standard duty corrugated plastic tubing shall be 10 feet for trench widths of 2 feet or less (measured at tubing and to 1 foot above top of tubing). Heavy-duty tubing shall be specified for depths greater than 10 feet, trench widths more than 2 feet, 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 feet. 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.

No computations of maximum loads are required for clay and concrete tile where a maximum depth of cover of 7.0 feet and trench widths of 20 inches or less exist.

Subsurface drain lines and systems will be located so that the required degree of drainage will be obtained with the minimum amount of materials. Economy is obtained by using long laterals and short mains. Laterals should generally be placed across the slope to intercept a maximum of ground water moving down the slope.

Subsurface drain lines should generally be laid out so that long, straight laterals result and curves are reduced to a minimum. Curves should be graded on a radius that the trenching machine can dig and maintain depth.

Where a complete system of pattern laterals is used for field crops, the spacing between laterals shall be within the range shown in the Drainage Guide for West Virginia for the particular soil.

On areas that will have intense use, such as recreation, the minimum spacing range shown in the Drainage Guide for West Virginia will be used.

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 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 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. 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:

1. Enclose continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel.

2. 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 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.

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.

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), American Association of State Highway and Transportation Officials (AASHTO), and the American Water Works Association (AWWA).

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 or 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:

1. Local experience indicated a need.
2. 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.
3. Deep soil cracking is expected, or
4. 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 National Engineering Handbook (NEH) Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters. ***The filter gradation will be based on the gradation of the base material surrounding the conduit within the following limits:***

- ***D_{15} size smaller than 7 times d_{85} 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, D_{15} size means that 15 percent of the filter material is finer than that size.

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. In all cases the resulting flow pattern through filter material shall be a minimum of 3 inches.

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 for concrete has been satisfactorily used 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.

Placement and Bedding. The conduit should not be placed on exposed rock or stones more than 1.5 inches in diameter for 6 inch or larger tile and stones no more than ¾ inch diameter for tile 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. 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 8 inches or less in diameter, one of the following bedding methods will be specified:

1. A shaped groove or 90° V-notch 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 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 will be met 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 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.

All subsurface drains, whether flexible conduit such as plastic or bituminized fiber or rigid conduit such as clay or concrete, shall be laid to a neat line and grade. The conduit shall be placed and bedded by one of the following methods:

Type of Conduit	Special Conditions	Method
1. Flexible	Filter not required	1 or 2
2. Flexible	Filter required	
	(a) Prefabricated	4
	(b) Sand & gravel filter	3
3. Rigid	Filter not required	5
4. Rigid	Filter required	
	(a) Prefabricated	7
	(b) Sand & gravel filter	6
5. Flexible or rigid	Envelope required	2 or 7

***Method 1** - Where it is not necessary to encase the pipe in a sand and gravel envelope, the bottom of the excavated trench shall be shaped to conform approximately to the shape of the pipe and the pipe shall be laid in this groove*.

***Method 2** - Where it is feasible and desirable to encase the pipe in a sand and gravel envelope, the pipe shall be laid on the bottom of a conventional trench (no special shaping or grooving) and the trench shall be filled with envelope material to a level flush with the top of the pipe. The trench must be completely filled so that there are no void spaces in the area between the sides of the pipe and the walls of the trench. Backfilling can be in the conventional manner.*

***Method 3** - Where the pipe is encased in a sand and gravel filter, a minimum of 3 inches depth of filter material shall be placed on the bottom of a conventional trench. The pipe shall be placed on this and the trench completely filled with filter material to a minimum depth of 4 inches above the top of the pipe. An acceptable optional method of placing the filter material will be to completely fill the trench to the top of the pipe and cover this with an acceptable plastic (not less than 6 mil.) sheet at least 6 inches wider than the pipe diameter, to separate the filter material from the backfill material.*

***Method 4** - Where the pipe is to be wrapped with a prefabricated mat, sheet type fiberglass, spun bonded nylon fabric, or plastic filter, it must be placed and bedded in accordance with Methods 1 or 2 to provide the necessary support for the pipe.*

***Method 5** - Where rigid pipe is to be used, it can be placed in a conventional trench and blinded and backfilled in a conventional manner using soil from the sides of the trench and excavated material. The use of envelope material is optional, depending on hydraulic considerations.*

***Method 6** - Where the rigid pipe is to be encased in a sand and gravel filter, a minimum of 3 inches depth of filter material shall be placed on the bottom of a conventional trench. The pipe shall be laid on this and filter material placed around the top and sides of the pipe to insure a minimum thickness (4" top, 3" sides) around the periphery of the pipe. Blinding and backfilling can be in the conventional manner using soil from the sides of the material. The option to use a plastic sheet which is noted in Method 3 is also acceptable on installations using this method.*

***Method 7** - Where the rigid pipe is to be wrapped or otherwise covered with a prefabricated mat, spun bonded nylon fabric, sheet type fiberglass, or plastic filter, it must be placed and bedded in accordance with Method 5. The use of envelope material is optional depending on hydraulic considerations.*

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 water head 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.

Relief wells are to be installed on subsurface drains at or near locations where the grade of a line decreases by 5 percent or more, unless the flatter section has a flow capacity 25 percent greater than the steeper section. Wells should be located in fence lines or other places where they have minimum effects on farming operations. They are to be constructed of slip seal tile, belled tile with mortared joints, or steel. The junction to the drain will be a manufactured connection having a length along the drain of at least 3 feet. The minimum diameter of the well will be 4 inches and extend at least 1 foot above the normal ground surface. The well will have a wire mesh or perforated cover installed on the exposed pipe.

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. 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 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 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.

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

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; e.g., steep-sided main and laterals (1 (horizontal) : 1 (vertical) or less) with a narrow bottom width 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, such as:

- 10 inches and 12 inches in diameter, use 12 feet.
- 15 inches and 18 inches in diameter, use 16 feet.
- Use 20 feet 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 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, base flow and runoff to water uses and users, groundwater 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.

Consideration should be given to using subsurface drainage to control high water tables in areas where septic tanks and leach fields exist.

Consider adding collector mains to minimize the visual impact, potential fear from ice or debris damage, and to facilitate maintenance of the grassed ditch bank.

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

Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under federal, state, or local laws. Consideration shall be given to maintaining or enhancing environmental values.

Considerations must be given to preventing adverse impacts to delineated wetlands regulated by State and Federal regulations.

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. ***Reference WV5-Engineering Field Handbook, Appendix A- Quick Reference Design and Construction Support Data for Conservation Practices***

Operation and Maintenance

An operation and maintenance plan shall be developed which will insure that the area remains in a condition suitable for its intended use.

1. ***Surface drainage shall be maintained.***
2. ***Outlets shall be maintained in their original condition.***
3. ***Cover shall be replaced over drain lines as needed.***
4. ***Damaged drain lines shall be repaired or replaced promptly as needed.***

REFERENCES

WV5-Engineering Field Handbook, Appendix A- Quick Reference Design and Construction Support Data for Conservation Practices

WV Conservation Practice Subsurface Drain (606) Scope of Work

NEH-20 or WV "700" Series Specifications

NRCS National and State Utility Safety Policy (NEM Part 503-Safety, Subpart A - Engineering Activities Affecting Utilities 503.00 through 503.06)

http://policy.nrcs.usda.gov/ Handbooks: Title 210 – Engineering; NRCS National Engineering Handbook; Part 650 Engineering Field Handbook

Title 190- Ecological Sciences; Part 601- National Cultural Resources Procedures Handbook

610- Environmental Compliance Handbook

WV e-FOTG Section IV- Practice Standards and Specifications
http://www.nrcs.usda.gov/technical/efotg/
(click on WV from the US map)
Drainage Guide for West Virginia

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CONSERVATION PRACTICE GENERAL SPECIFICATIONS
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Installation

Inspecting and handling materials. Material for subsurface drains shall be carefully inspected before the drains are installed. Plastic pipe and tubing shall be protected from hazard-causing deformation or warping. Plastic pipe and tubing with physical imperfections shall not be installed. A damaged section shall be removed and a suitable joint made connecting the retained sections. Clay and concrete tile shall be checked for damage from freezing and thawing before it is installed. All material shall be satisfactory for its intended use and shall meet applicable specifications and requirements.

Materials

The following specifications pertain to products currently acceptable for use as subsurface drains. These specifications are also to be applied in determining the quality of materials referenced by other standards:

Type	Specification
Plastic	
Corrugated polyethylene (PE) tubing and fittings 3-6 inch	***ASTM-F-405***
Corrugated polyethylene (PE) tubing and fittings 8-24 inch	***ASTM-F-667***
Polyvinyl chloride (PVC) corrugated sewer pipe with a smooth interior and fittings 4-8 inch	***ASTM-F-949***
Polyvinyl chloride (PVC) sewer pipe and fittings	***ASTM-D-2729***
Polyvinyl chloride (PVC) pipe	***ASTM D-3034 type PSM***
Clay	
Clay drain tile	***ASTM-C-4***
Clay drain tile, perforated	***ASTM-C-498***
Clay pipe, perforated, standard and extra strength	***ASTM-C-700***
Clay pipe, testing	***ASTM-C-301***
Concrete	
Concrete drain tile	***ASTM-C-412***
Concrete pipe for irrigation or drainage	***ASTM-C-118***
Concrete pipe or tile, determining physical properties of	***ASTM-C-497***
Concrete sewer, storm drain, and culvert pipe	***ASTM-C-14***

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Reinforced concrete culvert, storm drain, and sewer pipe.....ASTM-C-76
Perforated concrete pipe.....ASTM-C-444
Portland cement.....ASTM-C-150
Other
Styrene rubber plastic drain pipe and fittings.....ASTM-D-2852
Pipe, corrugated (iron or steel, zinc coated).....ASTM-A-760
Specifications can be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia, PA 19103

General
The installing contractor shall certify that the installation complies with the requirements of these specifications. The contractor shall also name the source of materials.

Conduit Perforations Special Requirements
Where perforated conduit is required, the water inlet area shall be at least 1 in^2/ft of conduit length. Round perforations shall not exceed 3/16 inch diameter except where filters, envelopes, or other protection is provided or for organic soils, where a maximum hole diameter of 1/2 inch may be used. Slotted perforations shall not exceed 1/8 inch in width.

Specifications-Flexible Conduit
1. General requirements
All conduits shall be laid to line and grade in such a way that the side walls are continuously and uniformly supported with suitable bedding material. Such material shall be properly placed and compacted to provide lateral restraint against deflection and to protect the conduit against collapse during backfilling.

II. Trenching
Trench widths must be adequate for proper installation of the conduit, allow proper joining of sections, and allow proper placement of filter, envelope, or blinding materials. The trench bottom shall be constructed to proper grade before placement of the conduit.
Where rock is encountered the trench will be over excavated a minimum of 6 inch and refilled to proper grade with a suitable bedding material.
Provisions for safety during trenching operations shall be in compliance with the applicable safety and health regulations for construction.

III. Plow Installation
Plow installation has been satisfactorily used in many situations. Special care needs to be exercised relative to grade control and bedding conditions.

IV. Bedding
The trench bottom shall be smooth and free of clods and loose or exposed rock. Where a gravel envelope is not specified, the bottom of the trench shall be shaped to conform to the pipe. The groove may be semi-circular, trapezoidal, or a 90 degree "V" shape (90 degree "V" suitable for 3-8 inch only) and shall be of such dimensions that the bottom quarter of the pipe is below the contact points of the groove. In unstable soils a firm foundation shall be provided by over excavation and backfilling with processed stone or gravel, suitably graded so as to act as a mat into which unstable soil will not penetrate.

V. Filters and envelopes
If a sand-gravel filter is specified, it shall be clean, hard, durable material and of the gradation specified. When sand-gravel envelopes are used they will be of clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 60 sieve, and with a maximum size of 1 1/2 inch.

VI. Placement
Conduit will be placed in such a way that maximum stretch does not exceed 5 percent. Fittings shall be installed in

accordance with instructions furnished by the manufacturers.
Couplers are recommended at all joints and fittings, at all changes in direction (where the centerline radius is less than three times tubing diameter), at changes in diameter, and at junction with another line.

Caps are needed at the ends of lines. All fittings shall be compatible with the tubing. Where certain fittings are not available, hand cut holes are acceptable provided care is taken when making the connection not to create a means of obstructing flow, catching debris, or allowing soil to enter the line.
Place selected bedding material, containing no hard object larger than 1 1/2 inch in diameter in the trench to a minimum depth of 6 inch over the conduit. The conduit will be held in place mechanically until secured by blinding.

VII. Backfilling

Place backfill material so that displacement or deflection of the conduit will not occur. This is preferably on an angle, so the material flows down the front slope. Avoid large stones, frozen material, and dry clods that cause concentrated point loads on the tubing. The trench should be backfilled as soon as practical. When installing the tubing on a hot day, backfilling should be delayed until tubing temperature cools to the soil temperature.

Specifications-Clay and Concrete Tile

I. Clay and Concrete Drain Ttile Special Requirements

If clay tile will not be exposed to freezing and thawing before or during installation and if the average frost depth will be less than 18 inch the freezing and thawing and adsorption tests may be modified or waived.
The use of concrete tile in acid and sulfate soils shall be in accordance with the following limitations:

Acid soils:

Class of tile	Lower permissible limits of pH values: Organic and sandy soils	Lower permissible limits of pH values: Medium & heavy textured soils
ASTM-C-412		
Standard quality	6.5	6.0
Extra quality	6.0	5.5
Heavy duty extra Quality	6.0	5.5
Special quality	5.5	5.0
ASTM-C-14 C-118, C-444	5.5	5.0

NOTE: Figures represent the lowest reading of pH values for soil or soil water at subsurface drain depth.

Sulfate soils:

Type of tile & cement (minimum)	Permissible maximum limit of sulfates, singly or in combination
	p/m
Tile: ASTM-C-412 Special quality C-14, C-118, C-44 Cement: ASTM-C-150, Type V	7,000
Tile: ASTM-C-412 Extra quality Heavy-duty extra quality C-14, C-118, C-444 Cement: ASTM-C-150, Type II or V	3,000
Tile: ASTM-C-412 Standard quality C-14, C-118, C-444 Cement: ASTM-C-150, any type	1,000

NOTE: Figures represent the highest reading of sulfates for soil or soil water at subsurface drain depth.

Bell and spigot, tongue and groove, and other types of pipe that meet the strength, absorption, and other requirements of clay or concrete tile as specified in the preceding paragraphs, except for minor imperfections in the bell, the spigot tongue, or the groove, and ordinarily classed by the industry as "seconds," may be used for drainage conduits, provided that the pipe is otherwise adequate for the job.

II. Trenching

Trench widths must be adequate for proper installation of the conduit; must allow proper joining of sections; and must allow proper placement of filter, envelope, or blinding materials. The trench width will be a minimum of 3 to 6 inches on both sides of tubing. The trench bottom shall be constructed to proper grade and shape before placement of the conduit. Where rock is encountered the trench will be over excavated a minimum of 6 inch and refilled to proper grade with a suitable bedding material.

Provisions for safety during trenching operations shall be in compliance with the applicable safety and health regulations for construction.

III. Bedding

If unstable soil conditions are encountered, the trench bottom must be stabilized before placement of conduit. Where necessary the unstable material will be removed and replaced with sand-gravel or a similar suitable stabilizing material. Where an envelope is not specified, the bottom of the trench shall be shaped to ensure good alignment of the conduit.

Where the conduit is to be laid in a rock trench, or where rock is exposed at the bottom of the trench, the rock shall be removed below grade enough that the trench may be backfilled, compacted, and bedded; and when completed, the conduit shall be a minimum of 6 inch from rock.

IV. Filters and envelopes

If a sand-gravel filter is specified, it shall be of clean, hard, durable material and of the gradation specified.

When sand-gravel envelopes are used they will be of clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 60 sieve, and with a maximum size of 1 1/2 inch . ASTM-C-33 fine aggregate for concrete will meet these requirements.

V. Placement

All conduits shall be laid to line and grade and covered with the specified blinding, envelope, or filter material to a depth of not less than 3 inch around the drain. Blinding material shall contain no hard objects larger than 1 1/2 inch in diameter.

When a sand/gravel filter is specified, all openings in the conduit must be covered with at least 3 inch of filter material except that the top of the conduit and the side filter material may be covered with a sheet of plastic or similar impervious material. The impervious sheet will be covered with at least 3 inch of blinding material. Joints between drain tile shall not exceed 1/8 inch except in sandy soils, where the closest possible fit must be obtained, and in organic soils where some of the more fibrous types make it desirable to increase slightly the space between tile.

Vi. Backfill

Backfill will be placed in such a manner as to avoid displacement of the conduit. Backfill should be moved into the trench at an angle so that material flows down the front slope of previously placed material. Backfill shall not contain frozen material, stones, clods, or objects large enough to damage the conduit. The trench should be backfilled as soon as possible after blinding.