NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

UNDERGROUND OUTLET

(Ft.)

CODE 620

DEFINITION

A conduit or system of conduits installed beneath the surface of the ground to convey surface water to a suitable outlet.

PURPOSE

To carry water to a suitable outlet from terraces, water and sediment control basins, diversions, waterways, surface drains, and other similar practices or flow concentrations without causing damage by erosion or flooding.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Disposal of surface water is necessary.
- An outlet is needed for a terrace, diversion, water and sediment control basin or similar practice and a surface outlet is impractical because of stability problems, topography, climatic conditions, land use or equipment traffic.

CRITERIA

General Criteria Applicable to All Purposes

Fire resistant materials shall be used for underground outlet components if fire is an expected hazard. All plastics must be UV resistant or protected from exposure to sunlight.

Components of underground outlets, including inlet collection boxes and conduit junction boxes, shall be designed with sufficient size to permit maintenance and cleaning operations.

Perforated components of underground outlets shall be designed to prevent soil particle movement into the underground outlet. Refer to Conservation Practice Standard 606, Subsurface Drain, for criteria for design of filters.

Capacity. The design capacity of the underground outlet will be based on the requirements of the structure or practice it serves. The underground outlet can be designed to function as the only outlet for a structure or in conjunction with other types of outlets. The capacity of the underground outlet shall be adequate for the intended purpose without causing inundation damage to crops, vegetation, or works of improvement.

The underground outlet shall remove the design volume of surface water from natural or constructed basins within 48 hours or less for row and other commodity type crops.

The underground outlet shall be designed to account for anticipated water surface conditions at the outlet during design flow.

Flood routing techniques may be used to determine the relationship between flooding duration, underground release rate, and basin storage volume.

Underground outlets may be designed for either pressure or gravity flow. If designed as a pressure system, all pipes and joints must be adequate to withstand the design pressure, including surge pressure and vacuum conditions.

For gravity flow systems, utilize a flow restricting device such as an orifice or weir to limit flow into the conduit or choose conduit sizes that are large enough to prevent pressure flow.

Orifice plates, when used, shall be made of metal or durable plastic, fit tight against the seat of connectors and have a smooth edge. Use NEH, Part 650 (EFH), Chapter 8, Terrace, or other appropriate design tools to determine the capacity of orifices or other types of devices

which restrict flow. Submergence of the orifice will reduce the orifice head pressure. Use the reduced head pressure to determine submerged orifice capacity.

An underground outlet shall not be designed to discharge into a structure unless the structure is designed to accommodate the additional inflow.

Pressure-relief Wells. Pressure-relief wells may be used to allow excess flow to escape the conduit and flow over the ground surface. Use pressure relief wells only where there is a stable outlet for the flow from the relief well. The relief well shall extend to the ground surface but no more than 6 inches above the surrounding natural ground. Cover pressure relief wells with a grate or other appropriate covering to prevent the entry of small animals and debris.

The design flow for the relief well shall be the difference between full pipe flow in the upstream conduit(s) and the flow in the downstream conduit. The flow velocity through the relief well shall not exceed 2 feet per second.

Inlet. An inlet can be a collection box, blind inlet (gravel), perforated riser, perforated conduit, or other appropriate device.

The capacity of the inlet shall be equal to or greater than the design discharge rate used to compute basin storage volume. The inlet capacity shall be calculated assuming that the water surface is at a maximum of 70 percent of the design ridge height.

Open inlets must have a trash guard. The inlet must also have an animal guard to prevent the entry of rodents or other animals.

Design the inlet to permit trash or debris entering the inlet to pass through the flow restricting device and conduit without plugging. The maximum screen opening dimension shall not exceed one-half the orifice diameter on inlets with orifices.

Inlet caps or screens shall be removable on inlets with orifice plates.

Pipe inlets shall have a minimum inside diameter of 4.0 inches.

Perforated riser inlets shall be durable, structurally sound, and resistant to damage by rodents or other animals. Perforations must be smooth, free of burrs, and have adequate capacity to prevent the riser from restricting flow in the underground outlet. The inlet capacity shall be calculated assuming that at least 50 percent of the openings on the side of the inlet are plugged.

Blind inlets may be used where the installation of an open or above ground structure is impractical. Design the blind inlet to prevent soil particle movement into the conduit. Design the blind inlet with a graded granular filter around the conduit. Design the filter based on the particle size of the surrounding soil and the desired flow rate. Refer to NEH Part 650, Engineering Field Handbook, Chapter 14 for the design of blind inlets.

Conduit. The minimum allowable diameter of conduits is 4 inches, except the offset pipe between the surface intake riser and underground outlet may be 3 inches. Conduit joints shall be hydraulically smooth and consistent with the manufacturer's recommendation for the conduit material and installation.

An offset pipe is required between the inlet and the underground outlet conduit, unless the outlet conduit does not extend upstream from the inlet. The minimum length of the offset pipe shall be 8 feet.

If the offset pipe is used to restrict flow, use pipe and joints rated to withstand the anticipated pressure.

The fittings used to connect the inlet pipe to the underground outlet conduit shall be water tight. Fittings shall comply with the underground outlet manufacturer's recommendations and be of equivalent strength and pressure rating. Fittings shall not reduce or impair the overall integrity or function of the underground outlet system.

Design the underground outlet to ensure that maximum allowable loads on the conduit are not exceeded for the type and size of conduit. Depth of cover requirements shall be assessed to prevent damage to the underground outlet from tillage operations and frost action.

Thrust blocking or anchoring shall be provided where needed to prevent undesired movement of the conduit. Placement and bedding requirements for the conduit are required to ensure integrity of the installation.

The flow velocity in the conduit must not exceed the maximum allowable design velocity for the conduit materials and installation condition according to the conduit manufacturer's recommendation or velocities shown in Table 1.

Gravity flow systems must maintain a positive grade throughout the conduit length towards the outlet.

If junction boxes and other structures are needed, design them to allow cleaning and other maintenance activities.

Refer to Conservation Practice 606, Subsurface Drain, for criteria for design loading, thrust blocking, placement and bedding requirements, and minimum and maximum design velocity in the conduit.

Table 1. MAXIMUM PERMISSIBLE VELOCITIES FOR CONDUIT LINES

Soil Texture	Perforated Corrugated Plastic Pipe* ft/sec	Dual Wall Polyethylene Pipe[$] ft/sec
Sand & Sandy Loam	3.5	12
Silt & Silt Loam	5.0	12
Silty Clay Loam	6.0	12
Clay & Clay Loam	7.0	12
Course Sand and Gravel	9.0	12

* National Engineering Handbook, Section 16, Drainage of Agricultural Land

[$] ADS Drainage Guide, Section 3, Hydraulics. http://www.ads-pipe.com/pdf/en/adh3-hydraulics_(id_2999).pdf. Accessed February 19, 2014.

MaterialsAll materials specified in Conservation Practice Standard 606, Subsurface Drain, may be used for underground outlets. Materials must meet applicable site specific design requirements for leakage, external loading, and internal pressure including vacuum conditions.

Underground outlets shall be conduits of continuous tubing, tile or pipe and may be perforated or non-perforated. Perforated outlets shall be designed to prevent soil particle movement into the conduit. Use an appropriately designed filter fabric wrap (sock) or granular filter if migration of soil particles into the conduit is anticipated. Design the filter based on the particle size of the surrounding soil to prevent rapid clogging of the filter. Refer to Subsurface Drain (606) for criteria for the design of filter media. Protect all exposed plastic materials from degradation due to exposure to sunlight.

The fill height over the underground outlet conduit or pipe shall not exceed the values shown in Table 2 or Table 3, depending on the type of conduit material. The use of different pipes and/or pipe cover parameters is acceptable if all of the following conditions are met:

- The pipe shall be of a type listed in NEH, Part 650, Chapter 14, Section 650.1425, Materials
- An engineering load analysis is completed in accordance with the parameters and procedures defined in NEH, Part 636, Chapter 52, Structural Design of Flexible Conduits
- Installation specifications have been developed for the specific site conditions and pipe material used

Table 2. ALLOWABLE COVER ON METAL PIPE (STEEL AND ALUMINUM)

Material Type	Diameter Inches	Minimum Pipe Cover Feet	Non - Trench Maximum Earth Fill Pipe Cover Feet	Maximum Pipe Cover for Pipes Installed in a Trench Condition Feet
Helical Corrugated Metal Pipe * (Steel)	6 - 18	1.0	20.0	20.0
Annular Corrugated or Helical Corrugated Metal Pipe # (Aluminum)	6 – 10	1.0	20.0	20.0
Annular Corrugated or Helical Corrugated Metal Pipe $ (Aluminum)	12 - 18	1.0	20.0	20.0
Smooth Steel Pipe &	4 - 16	1.0	20.0	20.0

* ASTM's A760, A762, and A929 with a minimum wall thickness of 16 gauge (either 1-½ inch by ¼ inch corrugations or 2-$^{2}/_{3}$ inch by ½ inch corrugation)

ASTM B745 with 1-½ inch by ¼ inch corrugations and a minimum wall thickness of 16 gauge

$ ASTM B745 with 2-$^{2}/_{3}$ inch by ½ inch corrugations and a minimum wall thickness of 16 gauge

& Minimum wall thickness is ¼ inch

Outlet. The outlet must be stable and protected against erosion and undermining for the range of design flow conditions.

The outlet must consist of a continuous section of pipe, 20 feet or longer, without open joints or perforations, and with stiffness necessary to withstand expected loads, including those caused by ice.

A shorter section of closed conduit may be used if a headwall is used at the outlet of the conduit.

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.

All outlets shall have animal guards to prevent the entry of rodents or other animals. Design animal guards to allow passage of debris while blocking the entry of animals large enough to restrict the flow in the conduit.

A vertical outlet may be used to discharge water to the ground surface where topography does not allow adequate conduit cover using a horizontal outlet, or where it is practical to discharge over a vegetated filter strip.

The vertical outlet shall be adequately perforated and placed in an envelope of coarsely graded aggregate to allow the system to drain during periods when not in use.

Stabilization. Reshape and regrade all disturbed areas so that they blend with the surrounding land features and conditions. For areas that will not be farmed, refer to Conservation Practice Standard 342, Critical Area Planting, for establishment of vegetation criteria. Permanent vegetation shall be established on all disturbed areas as soon as possible after construction.

Table 3. ALLOWABLE COVER ON PVC AND PE PIPE

Material Type	Diameter Inches	Minimum Pipe Cover Feet *	Non - Trench Maximum Earth Fill Pipe Cover Feet #	Maximum Pipe Cover for Pipes Installed in a Trench Condition Feet $
PVC SDR 41 **	4 – 12	2.7	5.8	12.2
PVC SDR 32.5 **	4 – 12	2.2	8.4	14.2
PVC SDR 26 **	4 – 12	2.1	12.4	17.9
PVC SDR 21 **	4 – 12	2.0	19.7	20.0
PVC Schedule 40 ##	4	2.0	20.0	20.0
PVC Schedule 40 ##	6	2.0	15.0	20.0
PVC Schedule 40 ##	8	2.1	11.7	19.1
PVC Schedule 40 ##	10	2.1	9.6	16.8
PVC Schedule 40 ##	12	2.1	8.9	15.5
PVC Schedule 80 ##	4 – 12	2.0	20.0	20.0
HD Corrugated Plastic PE $$	3 – 15	2.4	7.3	11.6
Dual Wall PE && (corrugated exterior w/ a smooth wall interior)	4 - 15	2.2	7.0	11.2

* PVC and PE pipes were analyzed with a modulus of soil reaction, E' = 400 psi and a H20 Live Load Classification (P_L = 16000 lbs)

PVC and PE pipes were analyzed with a modulus of soil reaction, E' = 200 psi

$ PVC and PE pipes were analyzed with a modulus of soil reaction, E' = 400 psi; however, the width of the pipe trench from the bottom to at least 6 inches above the pipe shall not exceed the pipe diameter plus 24 inches or else the "Non-Trench Maximum Earth Fill Pipe Cover" shall be used as the limiting control factor.

** ASTM D2241 Designation 1120 (12454-B), 1220 (12454-C), and 2120 (12454-D)

ASTM D1785 Designation 1120 (12454-B), 1220 (12454-C), and 2120 (12454-D)

$$ ASTM F405 or F667 depending on pipe diameter; AASHTO M252 and M294

&& ASTM F 2648 or D3350; AASHTO M252 and M29

CONSIDERATIONS

Pressure relief wells and vertical outlets, if not properly covered, can present a safety hazard for people or animals and may be damaged by field equipment. Pressure relief wells and vertical outlet locations should be identified with a high visibility marker.

Additional subsurface drain pipe may be installed as an extension to the inlet to improve farmability along the channel. This subsurface drain shall meet the requirements of Subsurface Drain (606) and be a minimum of 10 feet in length. Manufacturer approved end caps or concrete shall be used to cap the open end of the subsurface drain.

Consideration should be given to the effects that the underground outlet may have on water quantity downstream. Consider these long term environmental, social, and economic effects when making design decisions for the underground outlet and the structure or practice it serves. Refer to Conservation Practice Standard 554, Drainage Water Management, for criteria on flow restriction from natural basins.

Where wetlands may be affected, the cooperator will be advised and current NRCS wetland policy will apply.

Seasonal water sources can be beneficial for migratory waterfowl and other wildlife. Consider the use of a water control structure, on the inlet of an underground outlet, during non-cropping periods to provide water for wildlife. Refer to Conservation Practice Standard 646, Shallow Water Development and Management, for information on managing seasonal water sources for wildlife.

Underground outlets can provide a direct conduit to receiving waters for contaminated runoff from crop land. Underground outlets and the accompanying structure or practice should be installed as part of a conservation system that addresses issues such as nutrient and pest management, residue management and filter areas.

The construction of an underground outlet in a riparian corridor can have an adverse effect on the visual resources of the corridor. Consider the visual quality of the riparian area when designing the underground outlet.

Consider potential effects of soil physical and soil chemical properties influence on area where a conduit or system of conduits are installed to convey surface water. Refer to soil survey data as a preliminary planning tool for assessment of areas. Consult the Web Soil Survey to obtain soil properties and qualities information.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for underground outlets that describe the requirements for applying this practice according to this standard. The plans and specifications for an underground outlet may be incorporated into the plans and specifications for the structure or practice it serves. As a minimum the plans and specifications shall include:

- A plan view of the layout of the underground outlet.
- Typical cross sections and bedding requirements for the underground outlet.
- Profile of the underground outlet.
- Details of the inlet and outlet.
- Seeding requirements if needed.
- Use Iowa Construction Specification IA-620 and other construction specifications as needed to describe in writing the site specific installation requirements of the underground outlet.
- Include Iowa Standard Drawing Number IA-1501 (Underground Outlet) or equivalent drawing(s) with the plans used to construct this practice.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. The minimum requirements to be addressed in a written operation and maintenance plan are:

- Periodic inspections, especially immediately following significant runoff events, to keep inlets, trash guards, and collection boxes and structures clean and free of materials that can reduce flow.
- Prompt repair or replacement of damaged components.
- Repair or replacement of inlets damaged by farm equipment.
- Repair of leaks and broken or crushed lines to insure proper functioning of the conduit.
- Periodic Inspection of the outlet and animal guards to ensure proper functioning.
- Repair of eroded areas at the pipe outlet.
- Maintenance of adequate backfill over the conduit.
- To maintain the permeability of surface materials on blind inlets, periodic scouring or removal and replacement of the surface soil layer may be necessary.

REFERENCES

USDA, NRCS. National Engineering Handbook, Part 650 Engineering Field Handbook, Chapters 6, 8 & 14.

Iowa Drainage Guide. 2008. Iowa State University Special Report 13.

Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/app