

# BMP POLLUTION REDUCTION GUIDANCE DOCUMENT



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December 2001

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**CAUTION:** *This document is currently under review and is subject to change prior to its final release. Accordingly, care should be exercised in using any of the information presented.*

## INTRODUCTION

Broadly speaking, Best Management Practices (BMPs) are structural and non-structural approaches used to reduce pollutant loads in watersheds draining both urban and rural areas. Unfortunately, there is no universally accepted definition of BMPs. The Soil and Water Conservation Society (SWCS) defines a BMP as “a practice or combination of practices that are determined by a state or designated area-wide planning agency to be the most effective and practicable (including technological, economic, and institutional considerations) means of controlling point and nonpoint source pollutants at levels compatible with environmental quality goals.” Alternatively, Novotny and Olem (1994) state that “BMPs are methods and practices for preventing or reducing nonpoint source pollution to a level compatible with water quality goals.” When referring to rural areas (which is the focus of this document), such BMPs are often called *conservation practices* or *agricultural* and *silvicultural* BMPs.

When considering options for BMP implementation, it is often useful to know how effective such BMPs might be in terms of reducing various types of pollutants such as sediment, nitrogen, and phosphorus. There is a very wide range of BMPs that could potentially be employed, as well as a wide range of associated costs and inherent pollutant reduction efficiencies. At the farm scale, it is critical that the most cost-effective BMP be implemented to address the pollutant(s) of concern at specific geographic locations given the marginal economies of this industry. Conversely, when addressing general water quality concerns within a watershed, it is not as important to identify specific BMPs for implementation at exact locations (at least at the planning stage). However, it is very useful to have a good sense of whether or not general types of BMPs would be potentially beneficial in reducing pollutant loads within a watershed in which non-point source pollutants are of primary concern. The focus of this guidance document is to provide information on potential pollutant reduction efficiencies for generic types of BMPs in rural rather than urban areas.

The next section contains brief descriptions of general categories of BMPs that are primarily utilized in agricultural areas; although some (such as *vegetated stream buffers*) may be used in non-agricultural areas as well. The third section contains specific reduction coefficients for sediment, nitrogen and phosphorus that have been derived for different generic types of BMPs, along with some discussion as to how such coefficients were obtained. Included as an Appendix to this document is a detailed listing of BMPs as recognized and coded by the Natural Resources Conservation Service of the U.S. Department of Agriculture (1998). Although information contained in the Appendix may be too detailed for use in general watershed planning, it may be useful to some when trying to identify the most appropriate BMP for a specific field application.

## DESCRIPTIONS OF GENERIC BMP TYPES

For the purposes of this guidance document, rural BMPs have been aggregated into eight (8) generic types: 1) Crop Residue Management, 2) Vegetated Buffers, 3) Crop Rotation, 4) Cover Crops, 5) Terraces and Diversions, 6) Grazing Land Management, 7) Streambank Protection, and 8) Nutrient Management. Most of the more commonly used non-structural BMPs recognized by the USDA fall into one or more of these categories. Many structural BMPs (e.g., *sediment detention ponds* and *manure storage facilities*) and the more “esoteric” non-structural practices such as *integrated pest management* and *critical area planting* are not addressed since these BMPs are either generally less well-defined, are not discussed in the literature much with respect to pollution reduction efficiencies, and/or are difficult to describe in terms of their effectiveness in reducing pollutant loads at the watershed level. The generic types discussed, however, are useful in trying to answer questions such as “How might water quality in a watershed be affected if a given BMP is implemented on so many stream miles or so many acres?” It is in the context that this particular document has been prepared.

### Crop Residue Management

Crop residue management (also called *conservation tillage*) refers to the planned use of crop residue to protect the soil surface. This is one of the most commonly-used BMPs, and includes the use of residue from corn or soybean stalks, small grain straw, or the residue from vegetables and other crops. There are many forms of this management practice including no-till planting, mulch tillage, and other tillage techniques that leave crop residue on the soil surface as shown in Figure 1. In general, crop residue management or conservation tillage is defined as any production system that leaves at least 30% of the soil surface covered with crop residue after planting to reduce soil erosion by water (Ritter and Shirmohammadi, 2001). Figure 2 shows an example of no-till planting of vegetables into a cover crop.

Other examples of crop residue management include strip tillage, ridge tillage, slit tillage, and seasonal residue management (Ritter and Shirmohammadi, 2001). Strip, ridge, and slit tillage refer to various methods used to till the field along the rows while minimizing the disturbance of crop residue between the rows. With seasonal residue management, the residue is left on the field during the period between harvest and planting. Immediately before planting, most of the residue is then tilled over.



Figure 1. Crop residue left at the soil surface.



Figure 2. No-till planting of vegetables into a cover crop.

## Vegetated Buffer Strips

*Vegetated buffer strips* (also called *conservation buffers*, *buffer zones*, or *filter strips*) are examples of structural BMPs. Such strips are areas of land maintained in some type of permanent vegetation (i.e., grasses, shrubs, and/or trees) for the purpose of trapping pollutants contained in surface runoff from adjacent land areas. Buffer strips are commonly utilized to treat surface runoff from cropland or confined animal facilities. Vegetated buffer strips can take many forms including: 1) permanently vegetated strips located between larger crop strips on sloping land (see Figure 3), 2) bands or strips of permanent vegetation established at the edge of agricultural fields, and 3) areas of trees, shrubs, and/or grasses adjacent to streams, lakes, ponds or wetlands (see Figure 4). Pollutants are removed to varying degrees via the processes of filtration, infiltration, absorption, adsorption, uptake, volatilization, and deposition, with the predominant processes tending to be the infiltration of dissolved pollutants and deposition of sediment-attached pollutants.



Figure 3. Contour buffer strip.



Figure 4. Riparian buffer strip.

## Cover Crops

This BMP refers to the use of annual or perennial crops (see Figure 5) to protect the soil from erosion during the time period between the harvesting and planting of the primary crop. The use of such crops can also improve soil health and offer the opportunity for additional income (as with the planting of winter wheat). Additionally, cover crops can store needed nutrients over the winter, prevent their loss, and act as a type of “green” manure in the spring if the cover crop is left in the field or plowed under before planting the primary crop.



Figure 5. Use of red clover as a cover crop.

## Crop Rotations

This particular conservation practice (often called *conservation crop rotation*) is defined as the use of different crops in a specified sequence on the same farm field, and is a typical BMP used on cropland in Pennsylvania. Crop rotations may be as simple as a 2-year rotation of corn and soybeans or an 8-year rotation of 4 years of silage corn and 4 years of hay. It could also be a more complex scheme involving a mixture of crops such as corn, small grain, soybeans and forages spread over 6-8 years or more.

There are several reasons for using crop rotations; although the primary one is to reduce soil erosion, thereby reducing the quantities of sediment and sediment-bound pollutants such as nitrogen, phosphorus, and pesticides. When addressing excess nutrients on agricultural land, cover crops (as discussed in the previous section) are often included in the rotation sequence. Similarly, crop rotations are often combined with other BMPs. For example, plants that produce large amounts of residue may be selected for a crop rotation in an area where conservation tillage is to be used.

## Terraces and Diversions

*Terraces* and *diversions* are essentially earthen channels that intercept runoff on sloping land parcels. These structures act to transform long slopes into a series of shorter ones, thereby reducing runoff velocities and allowing soil particles to settle out. *Terraces* are cross-slope channels that control erosion on cropland, and are usually constructed to permit crops to be grown on the terrace (see Figure 6). They are designed to handle areas of concentrated flow where ephemeral gullies might otherwise form. *Diversions* are also cross-slope channels; however, unlike *terraces*, they are permanently vegetated. These structures are often used on slopes where a terrace would be too expensive or difficult to build, maintain, or grow crops on. *Diversions* may also be used on adjacent non-cultivated land to prevent unwanted surface runoff from flowing across a farmstead or barnyard.

Similar to many other BMPs, *terraces* and *diversions* are usually most effective when used in combination with other conservation practices such as *crop residue management*, *contour farming*, *crop rotation*, and the use of *field borders*.



Figure 6. Aerial view of terracing.

## Pasture Land Management

*Pasture land management* refers to the utilization of practices that ensure adequate vegetation cover in order to prevent excessive soil erosion due to overgrazing and other forms of overuse. It is becoming more common for farmers to reduce feeding costs by establishing *rotational grazing systems* on improved pastureland or by planting hay or legumes to use as feed for their livestock. In addition to providing feed for livestock, establishing grasses and legumes as part of crop rotations also protects land areas from excessive soil erosion and adds needed nitrogen to the soil base.

One form of *rotational grazing* used in dairy production systems is referred to as *intensive rotational grazing*. In this approach, cows are periodically moved among fenced pastures or paddocks (see Figure 7). This practice prevents the overuse of any feeding area and allows forages to recover between periods of intensive feeding.

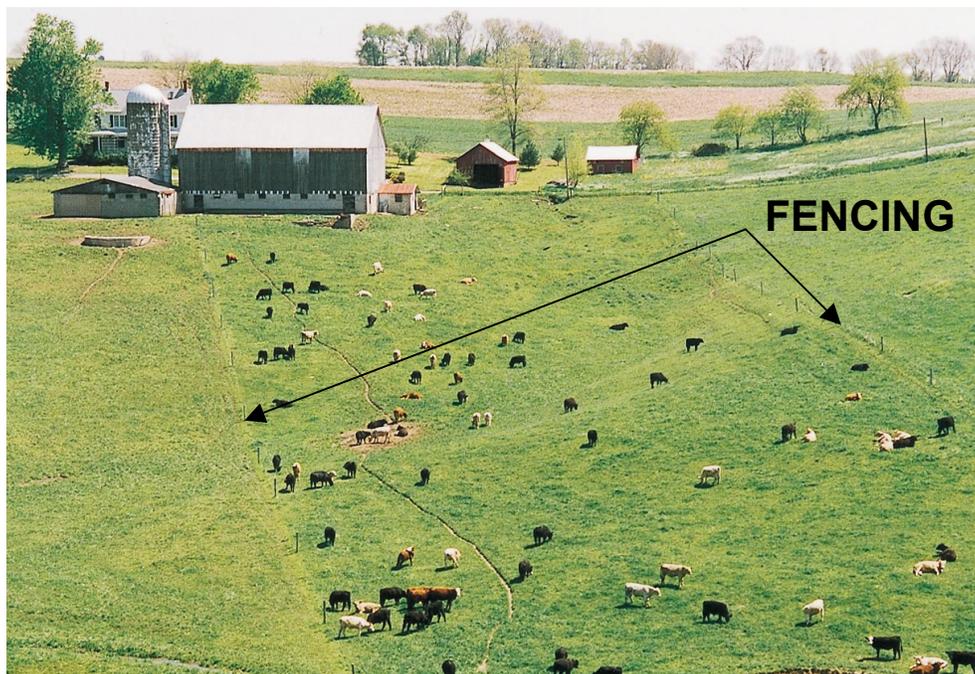


Figure 7. Use of paddocks in a rotational grazing system.

## Streambank Protection

*Streambank protection* collectively refers to several practices that can be employed for the purpose of mitigating the effects that grazing livestock have on adjacent streams. The most frequently used form of protection is fencing that prohibits cattle from trampling stream banks, destroying protective vegetation,

and stirring up sediment in the streambed. In addition to reducing direct soil loss caused by streambank degradation, fencing also reduces nutrient loads caused by defecation and urination of the animals in the stream. *Streambank protection* also often involves the use of *stable crossings* and/or *streambank stabilization* measures. *Stable crossings* (such as the one shown in Figure 8) allow for the movement of animals across streams while at the same time reducing impacts to stream banks. With *streambank stabilization*, rip-rap and/or gabion walls are installed along the edges of a stream to protect the banks during periods of heavy stream flow, thereby reducing direct streambank erosion. With this approach, the banks are often covered with rocks, grass, trees, shrubs, and other protective surfaces to reduce erosion as well.



Figure 8. Stabilized stream crossing.

As with other BMPs, *streambank protection* is often implemented in combination with other BMPs to reduce overall sediment and nutrient loads. For example, a *prescribed grazing system* that limits livestock access to streams for short periods of time (e.g., 24 hours or less) can provide similar benefits as fencing. Additionally, a buffer zone of vegetation adjacent to the stream can filter out excess sediment, nutrients and chemicals from overland runoff.

## **Nutrient Management**

This particular BMP refers to the planned use of organic and inorganic sources of nutrients to sustain optimum crop production while at the same time protecting the quality of nearby water resources. The implementation of this practice usually entails the development of a farm-wide *nutrient management plan* that is based on established DEP criteria. An important objective of such a

plan is to optimize forage and crop yields while minimizing nutrient loss to surface and ground water resources. This approach often involves using other BMPs such as providing adequate *cover crops* and devising appropriate *crop rotations* to reduce (or augment) overall nutrients loads on a farm.

As described by Beegle and Lanyon (1994), most farms can be described as having a nutrient deficit, an adequate nutrient balance, or an excess of nutrients. Similarly, farms can usually be categorized as being *crop systems farms*, *crop/livestock farms*, or *intensive livestock systems*. The basic problem in the case of *intensive livestock systems* is that there is not sufficient cropland on the farm to utilize the quantities of nutrients being generated by the livestock. Consequently, the major issue to be addressed in a *nutrient management plan* in this instance is how to reduce this surplus via on-site and/or off-site solutions.

An important point to remember when considering reductions that might be realized through implementation of a *nutrient management plan* is that the focus is usually placed on either nitrogen or phosphorus in developing the plan. This means that planned reductions or increases in one nutrient may well result in unwanted increases or decreases in loads of the other. For example, the amount of manure applied to cropland is typically based on the nitrogen needs of the crop, which may result in over-application of phosphorus. Conversely, a planned reduction in phosphorus loads may result in a less than adequate supply of nitrogen for the crops of concern. Load reduction efficiencies reported in this document are based on the assumption that a balanced approach is used to minimize nutrients loads at a given location. Practically speaking, this would probably require that phosphorus reductions be concomitant with an under-fertilization of crops with respect to nitrogen.

## BMP POLLUTANT REDUCTION EFFICIENCIES

While hundreds of studies have been completed over the last 25 years on the efficiencies of BMPs for reducing various pollutants (primarily sediment and nutrients), most of these studies have focused on the more frequently-used BMPs. Additionally, standard terminology and procedures in describing the BMPs and the reductions achieved have not been uniformly applied. For these reasons, it was necessary to lump many of the practices into the eight generic categories used above.

For the purposes of this document, information on pollutant reduction efficiencies has been drawn primarily from four different sources, including Dillaha, Yagow and Pease (2000), Ritter and Shirmohammadi (2001), Susquehanna River Basin Commission (1998), and U.S. EPA (1990). The first and fourth documents are exhaustive literature reviews of the results of hundreds of BMP efficiency studies conducted across the country over the last 25 years. In both documents, synopses of reduction efficiencies are reported for about two dozen BMPs, which sometimes overlap in terms of terminology and procedures, and sometimes do not. The third document is a report on a study to evaluate potential nutrient reduction using various pollutant mitigation strategies in the Susquehanna River Basin, and is based on the use of nonpoint source-related reduction efficiency values utilized in the EPA's Chesapeake Bay watershed model (U.S. EPA, 1995). Finally, the second document is a newly released textbook that, among other things, presents the results of a number of recent BMP studies completed by various researchers around the country.

Composite pollutant reduction values for the eight generic BMP types described earlier are presented in Table 1. As can be seen in the table, values are provided for nitrogen, phosphorus, and sediment. Due to the nature of the studies used in deriving these values (i.e., they were primarily "runoff plot" studies), the efficiency values shown should only realistically be used to estimate reductions in surface runoff loads. This limitation is very important with respect to evaluating reductions in nitrogen loads since at the watershed level, most of the nonpoint source load is typically contributed via the sub-surface movement of nitrates in agricultural areas. Exceptions to this "surface runoff" caveat are the values given for the *streambank protection* BMP. In this case, the reduction coefficients should only be used to estimate reductions to loads generated via streambank erosion.

Values given in the table for the *streambank protection* and *vegetated buffer strip* BMPs are meant to represent reductions on a "per mile" basis. That is, for each stream mile in which that particular BMP is implemented, the "streambank" or "surface runoff" load, respectively, is reduced by the percentage amount shown. The values for all other BMPs are meant to signify reductions on a "per acre" basis.

Table 1. Estimated BMP Reduction Efficiencies by Pollutant Type.

<b>BMP TYPE</b>	<b>Nitrogen</b>	<b>Phosphorus</b>	<b>Sediment</b>
Crop Residue Management	50	38	64
Vegetated Buffer Strips	54	52	58
Crop Rotations	7	40	55
Cover Crops	43	32	15
Terraces and Diversions	44	42	71
Pasture Land Management	43	34	13
Streambank Protection	65	78	76
Nutrient Management	19(75)	28(75)	*

Notes on Table Usage:

- Values represent estimated reductions in surface runoff-associated loads only, except the values for *streambank protection* that represent reductions to loads generated via streambank erosion.
- Values represent percent reductions. For example, 38% of the surface P load can be reduced by implementing *crop residue management*.
- No value is reported for sediment for *nutrient management* since this BMP is typically not used for sediment reduction.
- The reduction values given for *nutrient management* assume a “balanced” approach to reducing N and P loads as described in the text. Otherwise, a value of 75 should be used if the reduction of either pollutant is addressed at the expense of the other in the nutrient management plan. In no instance should a value of 75 be used to reduce both nutrients at the same time.

## **ACKNOWLEDGEMENTS**

This document was prepared with funding from the Pennsylvania Department of Environmental Protection under the open-ended Agreement No. ME359494. The authors also wish to express their deep appreciation to Fran Koch of the Pennsylvania Department of Environmental Protection for her efforts in providing needed assistance from various authoritative sources and to Stacey Mitchell from the Natural Resources Conservation Service for providing photographic materials used in this document.

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## **APPENDIX**

### **NATURAL RESOURCES CONSERVATION SERVICE CONSERVATION PRACTICE STANDARDS**

# NATURAL RESOURCES CONSERVATION SERVICE CONSERVATION PRACTICE STANDARD

**NOTE:** CONSERVATION PRACTICE STANDARDS ARE REVIEWED PERIODICALLY, AND UPDATED IF NEEDED. TO OBTAIN THE MOST CURRENT VERSION OF THIS STANDARD, CONTACT THE NATURAL RESOURCES CONSERVATION SERVICE.

[Access Road \(FT\) \(560\)](#)  
[Alley Cropping \(AC\) \(311\)](#)  
[Animal Trails and Walkways \(AC\) \(575\)](#)  
[Bedding \(AC\) \(310\)](#)  
[Brush Management \(AC\) \(314\)](#)  
[Channel Vegetation \(AC\) \(322\)](#)  
[Chiseling and Subsoiling \(AC\) \(324\)](#)  
[Clearing and Snagging \(FT\) \(326\)](#)  
[Closure of Waste Impoundments \(NO\) \(360\)](#)  
[Commercial Fishponds \(AC\) \(397\)](#)  
[Composting Facility \(NO.\) \(317\)](#)  
[Conservation Cover \(AC\) \(327\)](#)  
[Conservation Crop Rotation \(AC\) \(328\)](#)  
[Constructed Wetland \(AC\) \(656\)](#)  
[Contour Buffer Strips \(332\)](#)  
[Contour Farming \(AC\) \(330\)](#)  
[Contour Orchard and Other Fruit Area \(AC\) \(331\)](#)  
[Contour Stripcropping \(AC\) \(585\)](#)  
[Controlled Drainage \(AC\) \(335\)](#)  
[Cover Crop \(AC\) \(340\)](#)  
[Critical Area Planting \(AC\) \(342\)](#)  
[Cross Wind Ridges \(AC\) \(589A\)](#)  
[Cross Wind Stripcropping \(AC\) \(589B\)](#)  
[Cross Wind Trap Strips \(AC\) \(589C\)](#)  
[Dam, Diversion \(NO.\) \(348\)](#)  
[Dam, Floodwater Retarding \(NO. AND AC-FT\) \(402\)](#)  
[Dam, Multiple-Purpose \(NO. AND AC-FT\) \(349\)](#)  
[Dike \(FT\) \(356\)](#)  
[Diversion \(FT\)\(362\)](#)  
[Dry Hydrant \(Each\) \(432\)](#)  
[Early Successional Habitat Development/Management \(AC\) \(647\)](#)  
[Fence \(FT\) \(382\)](#)  
[Field Border \(FT\) \(386\)](#)  
[Filter Strip \(AC\) \(393\)](#)  
[Firebreak \(FT\) \(394\)](#)  
[Fish Raceway or Tank \(M, FT AND M3/S, FT3/S\) \(398\)](#)  
[Fish Stream Improvement \(FT\) \(395\)](#)  
[Fishpond Management \(NO.\) \(399\)](#)  
[Floodwater Diversion \(FT\) \(400\)](#)  
[Floodway \(FT\) \(404\)](#)  
[Forage Harvest Management \(AC\) \(511\)](#)  
[Forest Harvest Trails and Landings \(AC\) \(655\)](#)  
[Forest Site Preparation \(AC\) \(490\)](#)  
[Forest Stand Improvement \(AC\) \(666\)](#)  
[Grade Stabilization Structure \(NO.\) \(410\)](#)  
[Grassed Waterway \(AC\) \(412\)](#)  
[Grazing Land Mechanical Treatment \(AC\) \(548\)](#)

## [References](#)

[Heavy Use Area Protection \(AC\) \(561\)](#)  
[Hedgerow Planting \(FT\) \(422\)](#)  
[Herbaceous Wind Barriers \(FT\) \(422A\)](#)  
[Hillside Ditch \(FT\) \(423\)](#)  
[Irrigation Canal or Lateral \(FT\) \(320\)](#)  
[Irrigation Field Ditch \(FT\) \(388\)](#)  
[Irrigation Land Leveling \(AC\) \(464\)](#)  
[Irrigation Pit or Regulating Reservoir \(NO.\), Irrigation Pit \(552A\)](#)  
[Irrigation Pit or Regulating Reservoir \(NO.\), Regulating Reservoir \(552B\)](#)  
[Irrigation Storage Reservoir \(NO. AND AC-FT\) \(436\)](#)  
[Irrigation System \(NO. AND AC\), Microirrigation \(441\)](#)  
[Irrigation System \(NO. AND AC\), Sprinkler \(442\)](#)  
[Irrigation System \(NO. AND AC\), Surface and Subsurface \(443\)](#)  
[Irrigation System, Tailwater Recovery \(NO.\) \(447\)](#)  
[Irrigation Water Conveyance \(FT\), Ditch and Canal Lining, Flexible Membrane \(428B\)](#)  
[Irrigation Water Conveyance \(FT\), Ditch and Canal Lining, Galvanized Steel \(428C\)](#)  
[Irrigation Water Conveyance \(FT\), Ditch and Canal Lining, Nonreinforced Concrete \(428A\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, Aluminum Tubing \(430AA\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, Asbestos-Cement \(430BB\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, High-Pressure, Underground, Plastic \(430DD\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, Low-Pressure, Underground, Plastic \(430EE\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, Nonreinforced Concrete \(430CC\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, Reinforced Plastic Mortar \(430GG\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, Rigid Gated Pipeline \(430HH\)](#)  
[Irrigation Water Conveyance \(FT\), Pipeline, Steel \(430FF\)](#)  
[Irrigation Water Management \(AC\)\(449\)](#)  
[Land Clearing \(AC\) \(460\)](#)  
[Land Reclamation, Fire Control \(NO.\) \(451\)](#)  
[Land Reclamation, Highwall Treatment \(NO. AND M, FT\) \(456\)](#)  
[Land Reclamation, Landslide Treatment \(NO. AND HA, AC\) \(453\)](#)  
[Land Reclamation, Subsidence Treatment \(HA, AC\) \(454\)](#)  
[Land Reclamation, Toxic Discharge Control \(NO.\) \(455\)](#)  
[Land Reconstruction, Abandoned Mined Land \(AC\) \(543\)](#)  
[Land Reconstruction, Currently Mined Land \(AC\) \(544\)](#)  
[Land Smoothing \(AC\) \(466\)](#)  
[Lined Waterway or Outlet \(FT\) \(468\)](#)  
[Manure Transfer \(NO\) \(634\)](#)  
[Mine Shaft and Adit Closing \(NO\) \(457\)](#)  
[Mole Drain \(FT\) \(482\)](#)  
[Mulching \(AC\) \(484\)](#)  
[Nutrient Management \(AC\) \(590\)](#)  
[Obstruction Removal \(AC\) \(500\)](#)  
[Open Channel \(FT\) \(582\)](#)  
[Pasture and Hay Planting \(AC\) \(512\)](#)  
[Pest Management \(AC\) \(595A\)](#)  
[Pipeline \(FT\) \(516\)](#)  
[Pond \(NO.\) \(378\)](#)  
[Pond Sealing or Lining \(NO.\), Asphalt-Sealed Fabric Liner \(521E\)](#)  
[Pond Sealing or Lining \(NO.\), Bentonite Sealant \(521C\)](#)  
[Pond Sealing or Lining \(NO.\), Cationic Emulsion-Waterborne Sealant \(521D\)](#)  
[Pond Sealing or Lining \(NO.\), Flexible Membrane \(521A\)](#)  
[Pond Sealing or Lining \(NO.\), Soil Dispersant \(521B\)](#)  
[Precision Land Forming \(AC\) \(462\)](#)  
[Prescribed Burning \(AC\) \(338\)](#)  
[Prescribed Grazing \(AC\) \(528A\)](#)  
[Pumping Plant for Water Control \(NO.\) \(533\)](#)

[Pumped Well Drain \(NO.\) \(532\)](#)  
[Range Planting \(AC\) \(550\)](#)  
[Recreation Area Improvement \(AC\) \(562\)](#)  
[Recreation Land Grading and Shaping \(AC\) \(566\)](#)  
[Recreation Trail and Walkway \(FT\) \(568\)](#)  
[Regulating Water in Drainage Systems \(AC\) \(554\)](#)  
[Residue Management, Mulch Till \(AC\) \(329B\)](#)  
[Residue Management, No-Till and Strip Till \(AC\) \(329A\)](#)  
[Residue Management, Ridge Till \(AC\) \(329C\)](#)  
[Residue Management, Seasonal \(AC\) \(344\)](#)  
[Restoration and Management of Declining Habitats \(AC\) \(643\)](#)  
[Riparian Forest Buffer \(AC\) \(391A\)](#)  
[Riparian Herbaceous Cover \(AC\) \(390\)](#)  
[Rock Barrier \(FT\) \(555\)](#)  
[Roof Runoff Management \(NO.\) \(558\)](#)  
[Row Arrangement \(AC\) \(557\)](#)  
[Runoff Management System \(NO. AND AC\) \(570\)](#)  
[Sediment Basin \(NO.\) \(350\)](#)  
[Shallow Water Management for Wildlife \(AC\) \(646\)](#)  
[Soil Salinity Management-Nonirrigated \(AC\) \(571\)](#)  
[Spoil Spreading \(FT\) \(572\)](#)  
[Spring Development \(NO.\) \(574\)](#)  
[Stream Channel Stabilization \(FT\) \(584\)](#)  
[Streambank and Shoreline Protection \(FT\) \(580\)](#)  
[Stripcropping \(AC\), Field \(586\)](#)  
[Structure for Water Control \(NO.\) \(587\)](#)  
[Subsurface Drain \(FT\) \(606\)](#)  
[Surface Drainage \(FT\), Field Ditch \(607\)](#)  
[Surface Drainage \(FT\), Main or Lateral \(608\)](#)  
[Surface Roughening \(AC\) \(609\)](#)  
[Terrace \(FT\) \(600\)](#)  
[Toxic Salt Reduction \(AC\) \(610\)](#)  
[Tree/Shrub Establishment \(AC\) \(612\)](#)  
[Tree/Shrub Pruning \(AC\) \(660A\)](#)  
[Trough or Tank \(NO.\) \(614\)](#)  
[Underground Outlet \(FT\) \(620\)](#)  
[Upland Wildlife Habitat Management \(AC\) \(645\)](#)  
[Use Exclusion \(AC\) \(472\)](#)  
[Vertical Drain \(NO.\) \(630\)](#)  
[Waste Management System \(NO.\) \(312\)](#)  
[Waste Storage Facility \(NO.\) \(313\)](#)  
[Waste Treatment Lagoon \(NO.\) \(359\)](#)  
[Waste Utilization \(AC\) \(633\)](#)  
[Water and Sediment Control Basin \(NO.\) \(638\)](#)  
[Water Harvesting Catchment \(NO.\) \(636\)](#)  
[Water Table Control \(AC\) \(641\)](#)  
[Water Well \(NO.\) \(642\)](#)  
[Waterspreading \(AC\) \(640\)](#)  
[Well Decommissioning \(NO\) \(351\)](#)  
[Wetland Creation \(AC\) \(658\)](#)  
[Wetland Enhancement \(AC\) \(659\)](#)  
[Wetland Restoration \(AC\) \(657\)](#)  
[Wetland Wildlife Habitat Management \(AC\) \(644\)](#)  
[Wildlife Watering Facility \(NO.\) \(648\)](#)  
[Windbreak/Shelterbelt Establishment \(FT\) \(380\)](#)  
[Windbreak/Shelterbelt Renovation \(FT\) \(650\)](#)

# ACCESS ROAD

(ft)  
CODE 560

## DEFINITION

A travelway constructed as part of a conservation plan.

## SCOPE

This standard applies to vehicular and equipment roads constructed to provide access to farms, ranches, fields, conservation systems, structures, woodlands, and recreation areas.

## PURPOSE

To provide a fixed route for travel for moving livestock, produce, equipment, and supplies; and to provide access for proper operation, maintenance, and management of conservation enterprises while controlling runoff to prevent erosion and maintain or improve water quality.

## CONDITIONS WHERE PRACTICE APPLIES

Where access is needed from a private or public road or highway to a conservation enterprise or measure, or where travelways are needed in a planned land use area.

## DESIGN CRITERIA

Access roads shall be designed to serve the enterprise or planned use with the expected vehicular or equipment traffic. The type of vehicle or equipment, speed, loads, climatic, and other conditions under which vehicles and equipment are expected to operate need to be considered.

Visual resources and environmental values shall be considered in planning and designing the road system.

Access roads range from seldom used trails to all-weather roads heavily used by the public and built to very high standards. Some trails facilitate control of forest fires are used for logging, serve as access to remote areas for recreation, or are used for maintenance of facilities.

Where general public use is anticipated, roads should be designed to meet applicable federal, state, or local criteria.

Sound engineering practices shall be followed to insure that the road meets the requirements of its intended use and that maintenance requirements are in line with operating budgets.

**Location.** Roads shall be located to serve the purpose intended, to facilitate the control and disposal of water, to control or reduce erosion, to make the best use of topographic features, and to include scenic vistas where possible. The roads should generally follow natural contours and slopes to minimize disturbance of drainage patterns. Roads should be located where they can be maintained and so water management problems are not created. To reduce pollution, roads should not be located too near watercourses.

**Alinement.** The gradient and vertical and horizontal alinement shall be adapted to the intensity of use, mode of travel, and the level of development.

Grades normally should not exceed 10 percent except for short lengths, but maximum grades of 20 percent or more may be used if necessary for special uses.

**Width.** The minimum width of the roadbed is 14 ft for one-way traffic and 20 ft for two-way traffic. Single-land logging or special-purpose roads have a minimum width of 10 ft, with greater widths at curves and turnouts. The two-way traffic width shall be increased approximately 4 ft for trailer traffic.

The minimum tread width is 10 ft for one-way traffic and 15 ft for two-way traffic. The tread width for two-way traffic shall be increased approximately 4 ft for trailer traffic.

The minimum shoulder width is 2 ft on each side of the tread width.

Where turnouts are used, road width shall be increased to a minimum of 20 ft for a distance of 30 ft.

**Side slopes.** All cuts and fills shall have side slopes designed to be stable for the particular site conditions.

Areas with geological conditions and soils subject to slides shall be avoided or treated to prevent slides.

**Drainage.** The type of drainage structure used will depend on the type of enterprise and runoff conditions. Culverts, bridges, or grade dips for water management shall be provided at all natural drainageways. The capacity and design shall be consistent with sound engineering principles and shall be adequate for the class of vehicle, type of road, development, or use.

Roadside ditches shall be adequate to provide surface drainage for the roadway and deep enough, as needed to serve as outlets for subsurface drainage. Channels shall be designed to be on stable grades or protected with structures or linings for stability.

Water breaks or bars may be used to control surface runoff on low-intensity use forest or similar roads.

**Surfacing.** Access roads shall be given a wearing course or surface treatment if required by traffic needs, climate, erosion control, or dust control. The type of treatment depends on local conditions, available materials, and the existing road base. If these factors or the volume of traffic is not a problem, no special treatment of the surface is required.

Unsurfaced roads may require controlled access to prevent damage or hazardous conditions during adverse climatic conditions.

Toxic and acid-forming materials shall not be used on roads. This should not be construed to prohibit use of chemicals for dust control and snow and ice removal.

**Traffic safety.** Passing lanes, turnouts, guardrails, signs, and other facilities as needed for safe traffic flow shall be provided. Traffic safety shall be a prime factor in selecting the angle and grade of the intersection with public highways. Preferably, the angles shall be not less than 85 degrees. The public highway shall be entered either at the top of a hill or far enough from the top or a curve to provide visibility and a safe sight distance. The clear sight distance to each side shall not be less than 300 feet, if site conditions permit.

**Erosion control.** If soil and climatic conditions are favorable, roadbanks and disturbed areas shall be vegetated as soon as possible and skid trails, landings, logging, and similar roads shall be vegetated after harvesting or seasonal use is completed. If the use of vegetation is precluded and protection against erosion is needed, protection shall be provided by nonvegetative materials, such as gravel or other mulches.

Roadside channels, cross drains, and drainage structure inlets and outlets shall be designed to be stable without protection. If protection is needed, riprap or other similar materials shall be used.

## **GENERAL CRITERIA**

Watercourses and water quality shall be protected during and after construction by erosion-control facilities and maintenance. Filter strips, sediment and water control basins, and other conservation practices shall be used and maintained as needed.

Dead end roads shall be provided with a turnaround. In some areas turnarounds may also be desirable for stream, lake, recreation, or other access purposes.

Parking space as needed shall be provided to keep vehicles off the road or from being parked in undesirable locations.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing access roads shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **ACCESS ROAD SPECIFICATIONS**

Construction operations shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall present a workmanlike finish. Construction shall be according to the following requirements as specified for the job:

1. Trees, stumps, roots, brush, weeds, and other objectionable material shall be removed from the work area.
2. Unsuitable material shall be removed from the roadbed area.
3. Grading, subgrade preparation, and compaction shall be done as needed.
4. Surfacing shall be done as needed.
5. Roads shall be planned and laid out according to good landscape management principles.

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# **ALLEY CROPPING**

(Acre)  
CODE 311

## **DEFINITION**

Trees or shrubs planted in a set or series of single or multiple rows with agronomic, horticultural crops or forages cultivated in the alleys between the rows of woody plants.

## **PURPOSES**

Produce tree or shrub products (wood, nuts, berries, fodder, mulch, etc.) along with crops or forages to improve or optimize the economic viability of the operation. This purpose may be accomplished alone or concurrently with one or more of the following purposes:

- Improve crop or forage quality and quantity by enhancing microclimatic conditions.
- Reduce excess surface water runoff and erosion.
- Improve utilization and recycling of soil nutrients.
- Reduce excess subsurface water or control water table depths.
- Provide food and cover habitat for wildlife.

## **CONDITIONS WHERE PRACTICE APPLIES**

On all lands where crops or forages are grown and improvement of the economic or environmental conditions is desired.

## **CRITERIA**

### **GENERAL CRITERIA APPLICABLE TO ALL PURPOSES**

The location, layout, species and density of the trees and shrubs will accomplish the purpose and intended function for both the agronomic or horticultural crop or forage as well as the trees or shrubs. Plant species selection will be based on the following:

- Combinations of crops or forages and woody plants shall be compatible and complementary, and provide the products and crops that meet landowner objectives.
- Crops or forages shall be adapted to the climatic region and the soil resource, marketable and suited to the landowner's equipment and management capabilities.
- Crop or forage sequence and woody species selection shall be determined using an acceptable nutrient balance procedure. Select crops, forages and woody species to maximize the utilization and recycling of soil nutrients, animal wastes and plant residues and to maintain soil organic matter content.
- Crops or forages and woody plants shall be selected for rooting depths and water requirements not to exceed available soil water.
- Select pest resistant crop/forage and tree/shrub varieties.
- Avoid selecting tree or shrub species which provide habitat to animal, bird, or insect species considered to be pests of the accompanying crop or forage.

The distance between the sets of trees or shrubs will be determined by tree or shrub management objectives, light requirements and growth period of the crops or forages in the alleys, erosion control needs, and machinery widths.

Crops (woody and herbaceous) shall be grown in a planned conservation management system.

Tree or shrub rows will be oriented on the contour to control water erosion or perpendicular to troublesome winds to control wind erosion.

Soil erosion by wind or water will be controlled by vegetative or other means until the alley cropping design is fully functional.

Planting dates and care in handling and planting the seed or seedlings will assure acceptable plant survival.

Only viable and high quality planting stock or seed of adapted woody species will be used for establishing the tree or shrub rows.

Site preparation shall be sufficient for establishment and growth of selected species and appropriate for the site.

## **CONSIDERATIONS**

Crop, forage, tree and/or shrub varieties selected should be tolerant to herbicides that will be used in the management of either the crops, forages, trees or shrubs.

Spacing between the rows of trees or shrubs may be adjusted, within the limits listed above, to accommodate equipment widths and turn-arounds.

Species diversity including use of native species should be considered to avoid loss of function due to species-specific pests.

High value trees or shrubs should be selected to maximize economic returns.

Anticipate possible off-site effects and modify the practice design accordingly.

## **PLANS AND SPECIFICATIONS**

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

The trees, shrubs, crops, and/or forages will be inspected periodically and protected from adverse impacts including insects, diseases or competing vegetation. The trees or shrubs will also be protected from fire and livestock damage.

All other specified maintenance measures and techniques of tree/shrub establishment will be continued until plant survival and establishment are assured. This includes replacement of dead and dying trees or shrubs and control of undesirable competing vegetation.

Any removals of tree or shrub products and use of fertilizers, pesticides, and other chemicals shall be conducted in a manner that maintains the intended purpose.

The type, use and timing of maintenance equipment will be appropriate to accomplish operation and maintenance tasks while not damaging or degrading the site and soil conditions.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **QUANTITY**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects of snowcatch and melt on water budget components.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the volume of and timing of downstream flow to prohibit undesirable environmental, social, or economic effects.

### **QUALITY**

1. Short-term and construction-related effects of this practice on the quality of on site downstream water courses.
2. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.
3. Effects on the visual quality of water resources.
4. Effects on the movement of dissolved substances below the root zone toward the ground water.
5. Effects on wetlands and water-related wildlife habitats that would be associated with the practice.

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# **ANIMAL TRAILS AND WALKWAYS**

(Ft.)  
CODE 575

## **DEFINITION**

A travel facility for livestock and/or wildlife to provide movement through difficult or ecologically sensitive terrain.

## **PURPOSES**

This practice may be applied as part of a conservation management system to accomplish one or more of the following purposes:

- Provide or improve access to forage, water and/or shelter.
- Improve grazing efficiency and distribution.
- Divert travel away from ecologically sensitive and/or erosive sites.

## **CONDITIONS WHERE THIS PRACTICE APPLIES**

On grazing lands where animal movement is impeded or restricted such as, steep rough terrain, across rock outcrops, through dense timber or brush, over lava beds, on marsh rangelands, and grazing lands susceptible to overflow by water.

## **CRITERIA**

### **General Criteria Applicable For All The Purposes Stated Above**

Trails or walkways shall be constructed wide enough to accommodate movement of livestock and access by operator.

Trails or walkways shall be constructed in such a manner that accelerated erosion will not occur.

Where necessary diversions with a safe outlet will be provided.

Trails or walkways seeded or planted to vegetative cover will be protected from grazing until planting material is fully established and capable of withstanding grazing and/or trampling.

### **Criteria Applicable For Walkways**

Walkways will be constructed to meet minimum height requirements above normal high water.

During the construction process of walkways, borrow pits will be staggered so that access to grazing areas and back to walkway will be available from either side.

When necessary structures will be installed to prevent interference with natural water movement or to control salt water intrusion.

## **CONSIDERATIONS**

Other practices that facilitate grazing distribution and proper intensity such as prescribed grazing should be implemented along with this practice.

## **PLANS AND SPECIFICATIONS**

Each trail or walkway shall have a site specific design based on the criteria in this standard and as supplemented by additional criteria developed by each individual State using this practice.

## **OPERATION AND MAINTENANCE**

Operation will consist of periodic grading or shaping on trails and walkways to maintain designed dimensions. Maintenance will consist of repair that may be needed following major storm events such as high runoff events, high tides or other occurrences that cause damage and interfere in the normal operation of this practice.

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# **BEDDING**

(acre)  
CODE 310

## **DEFINITION**

Plowing, blading, or otherwise elevating the surface of flat land into a series of broad, low ridges separated by shallow, parallel channels.

## **SCOPE**

This standard applies to the practice of shaping the land surface into a series of broad, low ridges. It does not apply to the cultural practice of farming small planting beds a few feet apart.

## **PURPOSE**

To provide improved surface drainage at relatively low cost by establishing adjoining parallel beds or land running in the direction of the available natural slope. This is accomplished by mowing soil toward the center of beds to form a series of ridges and dead furrows (troughs) that will minimize water pondage, provide gradients for removing runoff, permit efficient operation of tillage and harvesting equipment, or eliminate sources for mosquito production.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to poorly drained areas of flat to nearly flat land usually having slowly permeable soils. It is generally applicable where land use does not warrant more intensive drainage. Soils must be of sufficient depth to provide a satisfactory root zone after bedding.

## **DESIGN CRITERIA**

Bedding shall run in the direction of the available land slope so that drainage can be provided without causing harmful erosion. Bedding is usually established without detailed engineering surveys. Beds shall be shaped and cross-row ditches provided where required to provide free movement of water from the crown to the dead furrow. Crowns shall provide a cross slope of not less than 0.3 percent.

Crown height, width, and maximum length of beds shall be determined on the basis of site conditions.

Parallel channels may be shallow and side slopes steep or flat, based on the depth of the soil, crops grown, and local construction and maintenance methods. Parallel channels shall be graded toward an outlet.

An outlet, natural or constructed, must have sufficient capacity and depth to provide for removal of water from the parallel channels.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for beddings shall be in keeping with this standard and shall describe the essential requirements for properly applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Potential for a change in rates of plant growth and transpiration because of changes in the volume of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the relation of the soil surface to the water table to ensure that a suitable rooting depth for crops.

### **Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects on the use and management of nutrients and pesticides and their effect on surface and ground water quality.
3. Effects on the movement of dissolved substances below the root zone and to ground water.
4. Effects of water levels on soil processes such as nutrient use by the plant.
5. Effects on wetlands or water-related wildlife habitats.
6. Effects on the visual quality of downstream water.

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# **BRUSH MANAGEMENT**

(Acre)  
CODE 314

## **DEFINITION**

Removal, reduction, or manipulation of non-herbaceous plants.

## **PURPOSES**

This practice may be applied as part of a conservation management system to accomplish one or more of the following purposes:

- Restore natural plant community balance.
- Create the desired plant community.
- Reduce competition for space, moisture, and sunlight between desired and unwanted plants.
- Manage noxious woody plants.
- Restore desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality and enhance stream flow.
- Maintain or enhance wildlife habitat including that associated with threatened and endangered species.
- Improve forage accessibility, quality and quantity for livestock.
- Protect life and property from wildfire hazards.
- Improve visibility and access for handling livestock.

## **CONDITIONS WHERE THIS PRACTICE APPLIES**

On rangeland, native or naturalized pasture, pasture and hay lands where removal or reduction of excessive woody (non-herbaceous) plants is desired.

## **CRITERIA**

### **General Criteria Applicable For All The Purposes Stated Above**

Brush management will be designed to achieve the desired plant community in woody plant density, canopy cover, or height.

Brush Management will be applied in a manner to achieve the desired control of the target woody species and protection of desired species. This will be accomplished by mechanical, chemical, biological, prescribed burning or a combination of these methods.

Prescribed Grazing shall be applied to ensure desired response from treatments.

### **Additional Criteria For Improving Wildlife Habitat.**

Brush Management will be planned and applied in a manner to meet the habitat requirements of the wildlife of concern.

Brush management will be planned in a manner that it will not adversely affect threatened or endangered species or their habitats.

### **Additional Criteria For Reducing Wildfire Hazards.**

Control undesirable woody plants in a manner that creates the desired plant community which does not provide wildfire hazard conditions.

## **CONSIDERATIONS**

Timing and sequence of brush management in a pasture and/or the entire operating unit should be planned to ensure needed grazing management.

Consider soil erosion potential and difficulty of vegetation establishment when choosing a method of control that causes soil disturbance.

## **PLANS AND SPECIFICATIONS**

Plans and specifications will be prepared for each pasture, field, or management unit where Brush Management will be applied.

Plans and specifications will be based on the practice standard and may include narratives, maps, drawings, job sheets, or similar documents. These documents will contain the following data as a minimum:

Brush canopy and/or species count, transect line locations and percent canopy and/or species numbers per acre of the target plant(s).

As needed, maps or drawings showing areas to be treated and areas to be left undisturbed should be prepared.

For mechanical treatment methods, plans and specifications will include types of equipment and any modifications necessary to enable the equipment to adequately complete the job. Also included should be:

- Dates of treatment
- Operating instructions
- Techniques or procedures to be followed

For chemical treatment methods, plans and specifications will include:

- Herbicide name
- Rate of application or spray volumes
- Acceptable dates of application
- Mixing instructions (if applicable)
- Any special application techniques, timing considerations, or other factors that must be considered to ensure the safest, most effective application of the herbicide
- Reference to label instructions

For biological treatment methods, plans and specifications will include:

- Kind of biological agent or grazing animal to be used
- Timing, duration, and intensity of grazing or browsing
- Desired degree of grazing or browsing use for effective control of target species
- Maximum allowable degree of use on desirable non-target species
- Special precautions or requirements when using insects or plants as control agents

## **OPERATION AND MAINTENANCE**

**Operation:** Brush Management practices shall be applied using approved materials and procedures. Operations will comply with all local, state, and federal laws and ordinances. Success of the practice shall be determined by evaluating regrowth or reoccurrence of target species after sufficient time has passed to monitor the situation and gather reliable data. Evaluation periods will depend on the methods and materials used.

**Maintenance:** Following initial application, some regrowth, resprouting, or reoccurrence of brush should be expected. Spot treatment of individual plants or areas needing retreatment should be done as needed.

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# **CHANNEL VEGETATION**

(acre)  
**CODE 322**

## **DEFINITION**

Establishing and maintaining adequate plants on channel banks, berms, spoil, and associated areas.

## **PURPOSE**

To stabilize channel banks and adjacent areas and reduce erosion and sedimentation. To maintain or enhance the quality of the environment, including visual aspects and fish and wildlife habitat.

## **SCOPE**

This standard applies to the vegetation of open channels, streams, or ditches. It applies to Floodwater Diversions (400), Floodways (404), Open Channels (582), Stream Channel Stabilization (584), Streambank Protection (580), and Surface Drainage, Main Or Lateral (607-B). It does not apply to Diversions (362), Grassed Waterways Or Outlets (412), or Surface Drainage, Field Ditches (607-A).

## **CONDITIONS WHERE PRACTICE APPLIES**

On channel banks, berms, spoil, and associated areas; except grassed waterways, diversions and areas with protective linings, those covered with water for an extended period, or in areas where conditions will not support adequate vegetation.

## **PLANNING CONSIDERATIONS**

Evaluate slopes and soil material, time of year for proper establishment of vegetation, necessity for irrigation, visual aspects, fish and wildlife, fire hazards and special needs when construction is done from one side. Other considerations include:

1. Protection of channel vegetation from sediment deposits resulting from wind and water erosion;
2. Provisions for safety and protection of human life and property in all aspects of designs, application, and maintenance;
3. Methods by which endangered and threatened plants and nationally recognized natural vegetated areas will be identified and protected;
4. Requirements for overseeding or planting woody or herbaceous vegetation on the unexcavated side when construction is done from one side;
5. Identification of desirable trees and other vegetation and means for their preservation; and
6. Special techniques for establishing and maintaining vegetation near inlets, outlets, or other appurtenances.

## **SPECIFICATIONS GUIDE**

An adequate vegetative cover stabilizes the channel area and provides for temporary or permanent protection or both.

**Slides slopes.** Specify side slopes that permit establishing and maintaining desired vegetation and that have been effective in the past. In urban and recreation areas, flatter side slopes may be required to provide for public safety and enhancement of visual resources.

**Species selection.** Specify species that are suited to the soil, climate, and exposure. They must provide a lasting cover to protect the channel area and to maintain the channel design capacity. Use special purpose plantings outside the channel for wildlife, recreation, or visual resources.

**Seedbed preparation.** Specify seedbed preparation, fill rills and gullies, and remove stones and debris.

**Fertilizer and soil amendments.** Specify fertilizers and soil amendments, including analyses, rate, method of application, and requirements for top-dressing.

**Planting.** Specify dates, rates, and methods of seeding sprigging, sodding or planting.

**Mulching.** Specify types and rates of mulch materials and the methods of anchoring.

**Irrigation.** Specify irrigation if it is needed for establishing vegetation.

**Controlled access.** Control access to channels, as needed by fencing or by other means to protect slopes and vegetation from damage.

**Maintenance.** Provide for:

1. Periodic inspection and evaluation of channel vegetation to determine maintenance needs.
2. Management of vegetation growth, as applicable, by mowing controlled grazing, approved chemicals, or other means to maintain the desired cover.
3. Reseeding or replanting, along with the use of fertilizers and/or soil amendments and irrigation, as needed.
4. Repair of appurtenances and fences.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Potential runoff from bare soil during construction.
2. Effects on the water budget components, especially on volumes and rates of runoff.

### **Quality**

1. Effects of nutrients or pesticides in runoff during establishment of vegetation.
2. Effects of streambank erosion before vegetative establishment.

## **EFFICIENCIES**

Use of vegetative and mulching measures has shown a high reduction of sedimentary soil erosion. An average sediment reduction of about 80 to 90% in a review of over 20 field test plot studies of hydroseeding and various mulches on construction site soils in 1990 (Brown and Caraco, 1997). A 99% reduction in suspended solids load was reported with establishing a grass cover (Lee and Skogergboe, 1985). The grass cover increased the biomass of the test area from 0 to 2464 lb/ac (Lee and Skogergboe, 1985).

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# CHISELING AND SUBSOILING

(acre)  
CODE 324

## DEFINITION

Loosening the soil, without inverting and with a minimum of mixing of the surface soil, to shatter restrictive layers below normal plow depth that inhibit water movement or root development.

## PURPOSE

To improve water and root penetration and aeration.

## CONDITIONS WHERE PRACTICE APPLIES

On suitable soils, chiseling is applicable if restrictive soil layers are less than 16 in. deep. On suitable soils, subsoiling is applicable if restrictive soil layers are more than 16. in. deep.

## SPECIFICATION GUIDE

Specify soils to which each practice is adapted; time of operations, including time of optimum soil moisture; and spacing and direction of tillage if important. Write separate specifications for soils having restrictive layers at different depths.

## PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

### Quantity

1. Effects on the water budget components, especially on volumes and rates of runoff and infiltration.
2. Variability of the practices effects caused by seasonal weather variations.

### Quality

1. Effects of slope and direction of tillage on sediment delivery to surface water.
2. Effects of the erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
3. Potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive layers.

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# CLEARING AND SNAGGING

(ft)  
CODE 326

## DEFINITION

Removing snags, drifts, or other obstructions from a channel.

## SCOPE

This standard applies to the clearing of trees and brush and the removal of sediment bars, drifts, logs, snags, boulders, piling, piers, headwalls, debris, and other obstructions from the flow area of a natural or excavated channel. It also applies to selective snagging, which is the selective removal of obstructions from the channel and streambanks to increase its capacity to carry water.

## PURPOSE

To increase the flow capacity of a channel by improving its flow characteristics; to prevent bank erosion by eddies; to reduce the forming of bars; and to minimize blockages by debris and ice. Special attention shall be given to restoring, maintaining or improving landscape resources and habitat for fish and wildlife, where applicable.

## CONDITIONS WHERE PRACTICE APPLIES

Any channel or floodway where the removal of trees, brush, and other obstructions is needed to accomplish one or more of the listed purposes. If clearing and snagging are likely to result in channel erosion, impairment to the landscape resource quality, or impairment to habitat for fish and wildlife, either the clearing and snagging shall not be done or practices to minimize such damages shall be applied concurrently with the clearing and snagging.

## DESIGN CRITERIA

The capacity of the channel, both before and after improvement, shall be determined by use of Manning's Formula, using applicable values of the retardance factor "n," for both conditions. The value of "n" used to determine channel capacity after improvement shall reflect the degree of maintenance expected in future years.

The area to be cleared and snagged shall include the perimeter of the channel, the flow area of the floodway, or both. Adjacent trees or other objects that may fall into the channel shall also be included. Clearing and snagging may be specified for other areas, including berms, for use as temporary disposal areas or travelways, or for planned conservation uses.

Channel stability shall not be impaired by clearing and snagging. The criteria for determining channel stability in open channels (582) shall be complied with. The effect of removing obstructions on downstream reaches shall be considered.

## PLANS AND SPECIFICATIONS

Plans and specifications for clearing and snagging shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **CLEARING AND SNAGGING SPECIFICATIONS**

All trees, stumps, and brush to be removed within the perimeter of the channel shall be cut as close to the ground as the cutting tools permit. If other areas are to be cleared, the trees, brush, and other woody vegetation shall be cut within the maximum distance above the ground level specified.

Trees shall be felled in such a manner as to avoid damage to other trees, property, and objects outside the limits of clearing.

Down trees, logs, drifts, boulders, debris and other obstructions lying wholly or partly in the channel shall be removed. Piling, piers, headwalls, and sediment bars that obstruct the free flow of water shall be removed if so designated in the drawings.

If herbicide treatment is planned, the stumps and brush in the specified area shall be treated at the time of clearing according to the recommendations of the manufacturer of the herbicide specified or being used.

The use of explosives in all clearing and snagging operations shall be in strict compliance with applicable state statutes and regulations.

If channels are located in cultivated areas or in areas of high value land, trees, logs, and all combustible material resulting from the clearing and snagging operations shall be burned, buried, or piled in designated disposal areas as specified. All burning shall be performed outside the channel and shall conform to regulations in effect in the area. In other areas, such as woodland or rangeland, where burning is prohibited, material shall be disposed of in such a manner that it does not float away or reenter the channel. Residue from burning and noncombustible material shall be buried outside the channel or placed in designated disposal areas. All buried material shall have an adequate earth cover to permit proper land use.

Selective snagging, where possible, shall be performed primarily with hand-operated equipment, water-based equipment, or small equipment used in a manner that will minimize soil, water, and other resource disturbances.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical. Special attention shall be given to visual resources, protecting and maintaining key shade, food, and den trees and to stabilization of disturbed areas.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Possible downstream flooding.
2. Effect of changed drawdown on bank stability.
3. Effect of changed flow conditions on ground water recharge.

### **Quality**

1. Effects of discharge on the flood plain and channel relative to erosion and sediment production, both during construction and after establishment.
2. Effects sediment load, sediment-attached substances, organic loadings.
3. Relationships between stream quality and aquifer quality where ground water recharge occurs.
4. Temporary and long-term effects on visual quality of water and landscape.
5. Effects on onsite and downstream water temperatures.

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# CLOSURE OF WASTE IMPOUNDMENTS

(No.)  
CODE 360

## DEFINITION

The closure of waste impoundments (treatment lagoons and waste storage ponds), that are no longer used for their intended purpose, in an environmentally safe manner.

## PURPOSE

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

- To protect the quality of surface water and groundwater resources.
- To eliminate a safety hazard for humans and livestock
- To safeguard the public health.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to agricultural waste impoundments that are no longer needed as a part of a waste management system and are to be permanently closed or converted.

Where these impoundments are to be converted to fresh water storage and the original impoundment was not constructed to NRCS standards, this practice will only apply where the investigation, as called for in National Engineering Manual (NEM) 501.23, shows structural integrity.

## CRITERIA

### General Criteria Applicable to All Purposes

The closure shall comply with all Federal, State, and local laws, rules, and regulations. All structures used to convey waste to waste impoundments shall be removed and replaced with compacted earth material or otherwise rendered unable to convey waste.

Liquid and slurry wastes shall be agitated and pumped to the extent conventional pumping will allow. Clean water shall be added as necessary to facilitate the agitation and pumping. The wastewater shall be utilized in accordance with NRCS conservation practice standard, Waste Utilization, Code 633. The sludge remaining on the bottom and sides of the waste treatment lagoons or waste storage ponds may remain in place if it will not pose a threat to the environment. If leaving the sludge in place would pose a threat, it shall be removed to the fullest extent practical and utilized in accordance with NRCS conservation practice standard, Waste Utilization, Code 633.

**Land Reclamation.** Impoundments with embankments may be breached so that they will no longer impound water and excavated impoundments may be backfilled so that these areas may be reclaimed for other uses. Waste impoundments that have water impounded against the embankment are considered embankment structures if the depth of water is three feet or more above natural ground.

1. Embankment Impoundments. Waste shall be removed from the site before the embankment is breached. The slopes and bottom of the breach shall be stable for the soil material involved, however the side slopes shall be no steeper than three horizontal to one vertical (3:1).
2. Excavated Impoundments. The backfill height shall exceed the design finished grade by 5 percent to allow for settlement. The finished surface shall be constructed of the most clayey material available and mounded to shed rainfall runoff. Incorporate available topsoil where feasible to aid establishment of vegetation.

**Conversion to Fresh Water Storage.** The converted impoundment shall meet the requirements as set forth in the NRCS practice standard for the intended purpose.

**Safety.** When sludge is not removed from a waste impoundment that is converted to fresh water storage, it shall not be used for fish production. Precautions (fencing and warning signs) shall be used to ensure that the pond is not used for incompatible purposes such as swimming and livestock watering until water quality is adequate for these purposes.

**Protection.** All disturbed areas not returned to crop production shall be vegetated in accordance with seeding specifications in the Field Office Technical Guide, or other suitable measures used to control erosion and restore the esthetic value of the site.

Measures shall be taken during construction to minimize site erosion and pollution of downstream water resources. This may include such items as silt fences, hay bale barriers, temporary vegetation, and mulching.

## **CONSIDERATIONS**

Reduce pumping effort to empty waste impoundments where the surface is covered by a dense mat of floating vegetation by first applying herbicide to the vegetation and then burning the residue.

Appropriate permits must be obtained before burning.

Alternative methods of sludge removal may be required where the impoundments contain large amounts of oyster shells, soil, or other debris.

Minimize the impact of odors associated with emptying and land applying wastewater and sludge from a waste impoundment by using an incorporation application method at a time when the humidity is low, when winds are calm, and when wind direction is away from populated areas.

Keep sludge left in place flooded to prevent its aerobic decomposition with the potential release of nutrients to surface and ground water.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for closure of abandoned waste treatment lagoons and waste storage ponds shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall also be consistent with the requirements of that standard.

## **OPERATION AND MAINTENANCE**

The proper closure of a waste treatment lagoon or waste storage pond should require little or no operation and maintenance; however, if it is converted to another use, such as a fresh water pond, operation and maintenance shall be in accordance with the needs as set forth in NRCS conservation practice standard for the intended purpose.

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# COMMERCIAL FISHPONDS

(ha, acre)  
CODE 397

## DEFINITION

A water impoundment constructed and managed for commercial aquaculture production.

## SCOPE

This standard applies to impoundments that store water and are managed for commercial aquaculture purposes. It applies to all types of ponds installed or modified for commercial production of fish and other animals and plants, including those for fee harvesting on the site. It does not apply to ponds used for noncommercial aquaculture products grown for home use or recreational purposes. This standard applies to Class (a) dams having a product of storage times effective height of dam of less than  $1.13 \times 10^6 \text{ m}^4$  (3,000 acre ft<sup>2</sup>) and effective height of dam less than 10.7 m (35 ft).

## PURPOSE

To provide a favorable water environment for producing, growing, harvesting, and marketing commercial aquaculture crops to supplement natural food supplies, to control water quality, and for effective use of land, water, and related resources.

## CONDITIONS WHERE PRACTICE APPLIES

On land where soil conditions, climate, water resources, and topography are suitable for constructing a pond or reservoir for commercial aquaculture production that meets the following criteria and conditions:

1. Water quantity will be adequate considering evaporation, seepage, and need for water exchange.
2. Water quality will be suitable for use in aquaculture production or can be made satisfactory by suitable treatment.
3. Application of practical pond management techniques will achieve the desired level of production on a predictable basis.
4. Access to the site is available or can be constructed and maintained.
5. Provision will be made for any needed treatment of water released downstream from the pond.
6. Ponds will store the recommended depth and area of water needed for specific aquaculture products.
7. The location, design, and installation of ponds will comply with flood plain, wetland, and prime farmland regulations.

## PLANNING CONSIDERATIONS

The owner/operator's objectives will dictate the level of development and management to be planned. The plan must be based on the limitations and potentials of available natural resources. A thorough aquaculture resource assessment must be made to determine the feasibility of the project. The planning is complete when all practice components essential to reaching the cooperator's management objectives have been identified.

## DESIGN CRITERIA

The site must be protected from flooding, sedimentation, and contamination. The soils within the pond area, as well as those in the contributing drainage area, must be checked for residues of pesticides and other harmful chemicals if there is a possibility of contamination.

Commercial fishponds may be:

1. Embankment ponds that intercept and store surface runoff water, or
2. Excavated ponds that are completely enclosed by an embankment around the outer perimeter and are filled by pumping.

**Embankment ponds.** Earthfill dams and embankments around excavated ponds shall meet or exceed the requirements specified for Pond - 378 with the following additional requirements:

1. The minimum elevation of the top of the settled embankment shall be increased to allow for wave action. This increased allowance shall be as specified in table 1.

Table 1.-Wave height

Max. fetch* length		Wave height	
<i>m</i>	<i>ft</i>	<i>m</i>	<i>ft</i>
< 100	< 330	0.15	0.5
100 - 200	330 - 660	0.31	1.0
200 - 400	660 - 1,320	0.46	1.5
400 - 1,600	1,320 - 5,280	0.61	2.0

\*Fetch is defined as the longest uninterrupted distance traveled by wind or wave.

2. The minimum top width of the embankment shall be 4.3 m (14 ft) and 6.1 m (20 ft), respectively, where it is to be used as a one-lane or two-lane road for management purposes and is nonpublic.
3. Interior embankments constructed for division of water or to direct water flow for circulation shall have adequate cross section to provide for stability and function for its intended purpose.

**Excavated ponds.** Ponds established by excavating and constructing an embankment around their outer perimeter that excludes outside runoff shall have either an emergency spillway with a bottom width of at least 3.0 m (10 ft) or have an overflow pipe installed with sufficient capacity to remove a 10-yr/24-hr direct rainfall amount or be at least 200 mm (8 in) in diameter, whichever is larger.

The pond bottom should be sloped to the outlet at a gradient of at least 0.06 m per 30 m (0.2 ft per 100 ft).

**Orientation.** Rectangular ponds shall be positioned as nearly as possible as follows: 4.0 ha (10 acres) or less — long axis in the direction of prevailing wind. More than 4.0 ha (10 acres) — long axis perpendicular to the direction of prevailing wind.

**Water supply.** Wells are the most desirable source of water, but any available source may be used if the quality and quantity are adequate. If water is pumped from rivers and streams or other sources where undesirable fish may be introduced, filters must be installed on the intake.

The minimum incoming water supply for adequate maintenance is considered to be 0.4 to 0.6 L/s/ha (15 to 25 gal/min/acre). However, evaporation rates, fish-loading densities, and species requirements will be used in establishing specific rates. Flow shall be measured during periods of lowest flow. The pumping and pipeline facilities shall be located to best serve the pond, taking into account accessibility for maintenance and repair; protection from overflow and flood hazards; connections to power lines or fuel sources; and future expansion. Water entering the pond shall

be aerated to increase dissolved oxygen and dissipate harmful gases if needed. This can be accomplished by falling, splashing, spraying, etc. Also, incoming water shall be as far away from outlet drain as possible so that "short circuits" will be avoided.

**Pipes and conduits.** Pump discharge through levees shall be installed above expected high water, and provisions shall be made to prevent pump and motor vibrations being transmitted to discharge conduits.

**Depth.** The water depths for various species are as shown in table 2. These values are applicable to warm climates. Additional depth is required in cold climates to prevent or minimize winterkill.

Table 2.-Water depth for various species

Species	Most desirable <i>m(ft)</i>	Minimum <i>m(ft)</i>
Channel catfish	1.2 (4) to 1.8 (6)	<sup>1</sup> 0.76 (2.5)
Crawfish	0.4 (1.5) to 0.6 (2)	0.3 (1)
Minnnows, other baitfish	1.2 (4) to 1.8 (6)	0.9 (3)
Trout	<sup>2</sup> 0.9 (3) to 1.5 (5)	0.9 (3)

<sup>1</sup>Ponds used for cage culture shall have a minimum depth of 1.5 m (5 ft) where cages are located. (Minimum clearance below the cage is 0.3 m (1 ft) but as much as 0.9 m (3 ft) is preferred.)

<sup>2</sup>Ponds are supplied by a constant flow of water. If pond is filled only during rainy seasons, a depth of 3 to 3.7 m (10 to 12 ft) over one-fourth or more of the pond area is recommended.

**Drains.** The pond must have facilities for complete as well as partial drainage. Turn-down pipes, quick-release valves, bottom-water release sleeves, or other devices for water level control and pond management are to be included in the construction of the drain facility as appropriate. Pond-(378) shall be followed for conduit design and installation of anti-seep collars.

**Pond bottom.** Where fish are harvested by seining, the pond bottom shall be smoothed and free of all stumps, trees, roots, and other debris. Existing channels and depressions in the pond area shall be filled and smoothed

For ponds where crawfish are harvested by trapping, complete clearing and removal of trees, stumps, and other vegetation are not necessary unless required by state or local ordinances.

**Access and safety.** Provisions shall be made for access to the site as well as access for operation and maintenance. Ramps shall be located as necessary to accommodate aeration and harvesting equipment. The maximum grade for equipment access shall be 20 percent (5:1 slope). Generally, level areas or restraining barriers shall be provided to protect pumps, motors, fuel tanks, and utility poles from vehicular traffic. Appropriate safety features and devices shall be installed or made available close by to aid people who fall into the pond and to prevent such accidents.

**Protection.** A protective cover of vegetation shall be established on all exposed soil surfaces that have been disturbed. If soil or climatic conditions preclude the use of vegetation, other protection methods may be used. Adequate provisions must be made to protect earth surfaces from wave erosion and turbulent water at pipe inlets and outlets. Fences shall be installed as necessary to exclude livestock and unwanted traffic. Road surfaces shall be treated if necessary to prevent vehicles from cutting deep ruts or sliding into the pond. Dams and levees shall be crowned to provide positive drainage.

**Operation and maintenance.** A plan for operation and maintenance shall be prepared for use by those responsible for the system. This plan shall provide for inspection, operation, and maintenance of vegetation, pipes, valves, spillways, roads, and other parts of the system.

**Plans and specifications.** Plans and specifications for constructing commercial fishponds shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, with emphasis on effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on the volume of downstream flow or aquifers that might cause undesirable environmental, social, or economic effects.

### **Quality**

1. Effects on erosion and the movement of sediment, organics, and soluble and sediment-attached substances.
2. Effects on the visual quality of water resources.
3. Short-term and construction-related effects on the water resources.
4. Effects on the temperature of water discharged.
5. Effects on the movement of dissolved substances below the root zone and toward ground water.
6. Potential for redistributing toxic materials during earth moving.

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# COMPOSTING FACILITY

(No.)  
CODE 317

## DEFINITION

A facility for the biological stabilization of waste organic material.

## SCOPE

This standard establishes the minimum acceptable requirements for design, construction, and operation of composting facilities. Waste organic material for composting may include livestock and poultry manure, dead animal carcasses, and food processing wastes where food is processed as part of normal farming operation. Municipal sludge, solid waste, and other non-farm type wastes are not included in this standard.

## PURPOSE

To treat waste organic material biologically by producing a humus-like material that can be recycled as a soil amendment and fertilizer substitute or otherwise utilized in compliance with all laws, rules, and regulations.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

1. Waste organic material is generated by agricultural production or processing;
2. Composting is needed to manage the waste organic material properly;
3. An overall waste management system has been planned that accounts for the end use of the composted material.

## PLANNING CONSIDERATIONS

**Types.** Three types of composting operations are covered in this standard— aerated windrows, static piles, and in-vessel. Aerated windrows are more suited to large volumes of organic material that are managed by power equipment used to turn the composting material periodically. Periodic turning re-aerates the windrows, promoting the composting process.

Organic material in static piles is initially mixed to a homogeneous condition and not turned again throughout the composting process. Static pile material must have the proper moisture content and bulk density to facilitate air movement throughout the pile. Forced air might be necessary to facilitate the composting process.

In-vessel composting in a totally enclosed structure is carried out on a blended organic material under conditions where temperature and air flow are strictly controlled. In-vessel composting also includes naturally aerated processes where organic materials are layered in the vessel in a specified sequence. Layered, in-vessel materials are usually turned once to facilitate the process. Vessel dimensions must be consistent with equipment to be used for management of compost.

**Process.** Composting is accomplished by mixing an energy source (carbonaceous material) with a nutrient source (nitrogenous material) in a prescribed manner to meet aerobic microbial

metabolic requirements. The process is carried out under specific moisture and temperature conditions for a specified period of time. Correct proportions of the various compost ingredients are essential to minimize odors and to avoid attracting flies, rodents, and other small animals.

**Carbon Source.** A dependable source of carbonaceous material must be available. The material should have a high carbon content and high carbon to nitrogen ratio (C:N). Wood chips, sawdust, peanut hulls, straw, corn cobs, bark peat moss, and well bedded horse manure are good sources of carbon.

**Moisture Control.** Large amounts of water evaporate during the composting process because operating temperatures drive off water. A source of water must be available for compost pile moisture control from start-up through completion. Proper moisture facilitates the composting process and helps control odors.

**Equipment Needs.** Appropriate equipment must be available for initial mixing, turning, and hauling composted material and carbonaceous material. Appropriate long stem thermometers should be available for managing the composting material.

**Bulking Materials.** Bulking materials may be added to enhance air flow within the composting material. Piles that are too compact will inhibit the composting process. The carbonaceous material can be considered as a bulking agent. Where it is desirable to salvage carbonaceous material, provisions for removing the material, such as screening, must be made.

**Management.** Composting operations require close management. Management capabilities of the operator and availability of labor should be assessed as part of the planning and implementing process.

**Economics.** Benefits associated with the ultimate use of the composed material should be compared to the capital expenditure and operating costs of the composting operations. In addition to cost return, benefits can include environmental protection, improved handling, disposal of dead poultry and other farm animal carcass, odor control, and reduced need for storage volume.

## DESIGN CRITERIA

**Soils.** Locate composting facilities on soils having slow to moderate permeability to minimize seepage of dissolved substances into the soil profile and movement toward groundwater.

Evaluate site paving needs in terms of effects of equipment operation on trafficability, soil compaction, and potential for contamination from compost and petrol products.

**Runoff.** Divert surface runoff from outside drainage areas around the compost facility. Collect runoff from the compost facility and utilize or dispose of it properly. Evaluate the effects of changed infiltration conditions on groundwater recharge, and evaluate changes in volumes and rates of runoff caused by the location of the operation. Properly manage movement of organic material, soluble substances, and substances attached to solids carried by runoff.

**Carbon-Nitrogen Ratio.** Calculate the amounts of the various ingredients to establish the desired carbon-nitrogen ratio (C:N) of the mix to be composed. The C:N should be between 25:1 and 40:1. Use the higher range of C:N for organic materials that decompose at a high rate (or are highly unstable) with associated high odor production.

Where more than two ingredients are to be blended, the two main ingredients are to be used in the analysis for the desired C:N and mixed accordingly. Adding up to 50 percent by weight of other ingredients to improve workability and air movement is permissible as long as the C:N of the added ingredient does not exceed the target C:N of the compost.

**Odor.** Select carbonaceous material that, when blended with the nitrogenous material, will result in the desired pH. The blended material should have a pH at or slightly below neutral for best odor control. Where odors do not present a problem, pH of 8 to 9 is acceptable, but strong ammonia and amine related odors will be present for up to the first 2 weeks.

Locate composting operations where movement of any odors toward neighbors will be minimized. Buffer areas, vegetative screens, and natural landscape features can help minimize the effects of odors.

**Facility Size.** Where dead poultry and other small farm animals are composted, establish the size of the composter units on the basis of locally determined animal loss rates. Composting facilities for the purpose of processing animal carcasses are to include a primary composting unit into which alternate layers of low moisture content manure (unusual poultry manure), carbon source material (straw is common), and dead animal carcasses are placed. A secondary composting unit is often necessary to complete the composting process.

**Moisture.** The moisture content of the blended material at start-up of the composting process should be approximately 60 percent (wet weight basis) and maintained between 40 and 60 percent during the composting process. The composting process may become inhibited when moisture falls below approximately 40 percent. Water used for moisture control must be free of deleterious substances.

**Pile Configuration.** Compost piles for windrows and static piles should be triangular to parabolic in cross-sectional form with a base width to height ratio of about 2 to 1. Increased surface area favorably affects evaporation and natural aeration and increases the area exposed to infiltration from precipitation in uncovered stacks. Aligning piles north to south and maintaining moderate side slopes maximizes solar warming. Windrows should be aligned to avoid accumulation of precipitation.

**Composting Period.** The time needed for completion of the process varies with the material and must continue until the material reaches a stability level at which it can be safely stored without creating undesirable odors and poor handling features. Acceptable stability occurs when microbial activity diminishes to a low level. Stability can be obtained in about 21-28 days but can require up to 60 days to produce the desired quality. Visual inspection and temperature measurements will provide needed evaluation of compost status.

**Storage.** Provide properly designed storage facilities sized for the appropriate storage period. Protect composted material from the weather by roofs or other suitable covers. Structures must meet the requirements of conservation practice standard, "Waste Storage Structure," Code 313.

## **OPERATION CRITERIA**

**Temperature.** For best results, operating temperature of the composting material should be 130 °F to 170 °F once the process has begun. It should reach operating temperature within about 7 days and remain elevated for up to 14 days to facilitate efficient composting. The material should remain at or above 110 °F for the remainder of the designated composting period.

If temperature falls significantly during the composting period and odors develop, or if material does not reach operating temperature, investigate piles for moisture content, porosity, and thoroughness of mixing. Compost managed at the required temperatures will favor destruction of any pathogens and weed seeds.

**Aeration.** Heat generated by the process causes piles to dehydrate. As the process proceeds, material consolidates, and the volume of voids through which air flows decreases. Materials selected for the composting mix should provide for adequate air movement throughout the composting process. Periodically turning the pile and maintaining proper moisture levels for windrows and static piles will normally provide adequate aeration.

**Nutrients.** Keep compost well aerated to minimize nitrogen loss by denitrification. Keep pH at neutral or slightly lower to avoid nitrogen loss by ammonification. High amounts of available carbon will aid nitrogen immobilization. Phosphorus losses will be minimized when the composting process is managed according to the requirements of this standard. Include compost nutrients in nutrient management plans, determine the effects of use and management of nutrients on the quality of surface water and ground water as related to human and livestock consumption.

**Testing Needs.** Test compost material for carbon, nitrogen, moisture, and pH if compost fails to reach desired temperature or if odor problems develop. The finished compost material should be periodically tested for constituents that could cause plant phytotoxicity as the result of application to crops. Composted materials that are prepared for the retail market will require testing for labeling purposes.

## **PLANS, SPECIFICATIONS, AND OPERATION AND MAINTENANCE.**

Plans and specifications for organic composting facility shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. A written operation and maintenance plan shall be developed with full knowledge and input of the owner-operator and included with the documents provided to the owner-operator.

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# CONSERVATION COVER

(Acre)  
CODE 327

## DEFINITION

Establishing and maintaining permanent vegetative cover to protect soil and water resources.

## PURPOSES

- Reduce soil erosion and sedimentation.
- Improve water quality.
- Enhance wildlife habitat.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies on land to be retired from agricultural production requiring permanent protective cover, and on other lands needing permanent protective cover. This practice does not apply to plantings for forage production or to critical area plantings.

## CRITERIA

### General Criteria Applicable to All Purposes

Species shall be adapted to soil, range site, and climate conditions.

Species planted shall be suitable for the planned purpose and site conditions. Use of invasive species shall be avoided.

Seeding rates and methods shall be adequate to accomplish the planned purpose.

Planting dates, planting methods and care in handling and planting of the seed or planting stock shall ensure that planted materials have an acceptable rate of survival.

Only viable, high quality and adapted seed or planting stock shall be used.

Legume seed shall be inoculated with the proper Rhizobia bacteria before planting.

Site preparation shall be sufficient for establishment and growth of selected species.

Timing and use of equipment shall be appropriate for the site and soil conditions.

Vegetative manipulation will be accomplished by mechanical, biological or chemical methods, by prescribed burning, or a combination of the four. If burning is used alone or in combination with the other methods, Prescribed Burning, practice code 338, must be included as a planned practice.

All nutrients shall be applied following the nutrient management requirements in the Field Office Technical Guide (FOTG).

### **Additional Criteria for Enhancing Wildlife Habitat Planting/Establishment**

Grasses, forbs, and legumes shall be planted in mixes to encourage maximum plant diversity.

### **Management/Maintenance**

Methods used shall be designed to protect the soil resource from erosion.

Maintenance practices and activities shall not disturb cover during the reproductive period for grassland wildlife species.

Maintenance measures must be adequate to control noxious weeds and other invasive species.

To benefit insect food sources for grassland nesting birds, spraying or other control of noxious weeds shall be done on a "spot" basis to protect forbs and legumes that benefit native pollinators and other wildlife.

### **CONSIDERATIONS**

This practice may be used to promote the conservation of wildlife species in general, including threatened and endangered species.

Where applicable this practice may be used to conserve and stabilize archeological and historic sites.

Consider rotating management and maintenance activities (e.g. mow only one-fourth or one-third of the area each year) throughout the managed area to maximize spatial and temporal diversity.

Where wildlife management is an objective, the food and cover value of the planting can be enhanced by using a habitat evaluation procedure to aid in selecting plant species and providing or managing for other habitat requirements necessary to achieve the objective.

Use native species when available. Consider trying to re-establish the native plant community for the site

If a native cover (other than what was planted) establishes, and this cover meets the intended purpose and the landowner's objectives, the cover should be considered adequate.

### **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. They shall include, but are not limited to, recommended species, seeding rates and dates, establishment procedures, and other management actions needed to insure an adequate stand. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

### **OPERATION AND MAINTENANCE**

Maintenance practices and activities should not disturb cover during the primary nesting period for grassland species in each state. Exceptions should be considered for periodic burning or mowing when necessary to maintain the health of the plant community. Mowing may be needed during the establishment period to reduce competition from annual weeds. Noxious weeds will be controlled to prevent proliferation and spreading to adjacent fields.

Annual mowing of the conservation cover stand for general weed control is not recommended. Any use of fertilizers, pesticides and other chemicals shall not compromise the intended purpose.

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# CONSERVATION CROP ROTATION

(Acre)  
CODE 328

## DEFINITION

Growing crops in a recurring sequence on the same field.

## PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following:

- Reduce sheet and rill erosion.
- Reduce soil erosion from wind.
- Maintain or improve soil organic matter content.
- Manage the balance of plant nutrients.
- Improve water use efficiency.
- Manage saline seeps.
- Manage plant pests (weeds, insects, and diseases).
- Provide food for domestic livestock.
- Provide food and cover for wildlife.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land where crops are grown, except:

This standard does not apply to pastureland, hayland, or other land uses where crops are grown occasionally only to facilitate renovation or re-establishment of perennial vegetation.

## CRITERIA

### General Criteria Applicable To All Purposes

Crops shall be grown in a planned, recurring sequence as outlined in Plans and Specifications.

Crops shall be adapted to the climatic region, the soil resource, and the goals of the producer.

Adapted crops and varieties, listed in appropriate university publications or other approved sources, shall be selected.

A conservation crop rotation may include crops planted for cover or nutrient enhancement.

Crops shall be selected that produce sufficient quantities of biomass at the appropriate time to reduce erosion by water or wind to within acceptable soil loss levels. In those instances where crops selected do not produce sufficient biomass to meet this criteria, a cover crop (see Cover Crop, 340) or other appropriate practices shall be used. The amount of biomass needed shall be determined using current approved erosion prediction technology. Soil loss estimates shall account for the effects of other practices in the conservation management system.

### **Additional Criteria To Maintain Or Improve Soil Organic Matter Content**

Crops shall be selected that produce the amount of plant biomass needed to maintain or improve soil organic matter content, as determined using the current approved Soil Conditioning Index Procedure or determined by approved research.

If partial removal of residue by means such as baling or grazing occurs, enough residue shall be maintained to achieve the desired soil organic matter content goal.

Cover and green manure crops planted specifically for soil improvement may be grazed, as long as grazing is managed to retain adequate biomass.

### **Additional Criteria To Manage the Balance of Plant Nutrients**

Crop selection and sequence shall be determined using an approved nutrient balance procedure.

When crop rotations are designed to add nitrogen to the system, nitrogen-fixing crops shall be grown immediately prior to or interplanted with nitrogen-depleting crops.

To reduce excess nutrients, crops or cover crops having rooting depths and nutrient requirements that utilize the excess nutrients shall be grown.

### **Additional Criteria To Improve Water Use Efficiency**

Selection of crops and varieties, sequence of crops, or the annual decision to plant a crop or to fallow, shall be determined using an approved water balance procedure.

### **Additional Criteria To Manage Saline Seeps**

Crops grown in the recharge area of saline seeps shall be selected for rooting depths and water requirements adequate to fully utilize all plant available soil water. Summer fallow will not be used. Crop selection and sequence shall be determined using an approved water balance procedure.

If excess subsoil moisture exists below the rooting depth of crops commonly grown in the recharge area, deep-rooted perennial crops shall be established for the number of years needed to dry the soil profile.

Crops grown in the discharge area of saline seeps shall be selected for their tolerance to salinity levels in the discharge area.

### **Additional Criteria To Manage Plant Pests (Weeds, Insects, Diseases)**

Crops shall be alternated to break the pest cycle and/or allow for the use of a variety of control methods. Affected crops and alternate host crops shall be removed from the rotation for the period of time needed to break the life cycle of the targeted pest.

Resistant varieties, listed in appropriate university publications or other approved sources, shall be selected where there is a history of a pest problem.

### **Additional Criteria To Provide Food For Domestic Livestock**

Crops shall be selected to balance the feed supply with livestock numbers. The needed amount of selected crops shall be determined using an approved forage-livestock balance procedure.

## **Additional Criteria To Provide Food And Cover For Wildlife**

Crop selection to provide either food or cover for the targeted wildlife species will be grown, managed, or left unharvested as per the needs of the targeted wildlife as determined by an approved habitat evaluation procedure.

## **CONSIDERATIONS**

When used in combination with CROSS WIND STRIPCROPPING (589B) or STRIPCROPPING CONTOUR (585), the crop sequence should be consistent with the stripcropping design.

When used in combination with RESIDUE MANAGEMENT practices, selection of high residue producing crops and varieties, use of cover crops and adjustment of plant population and row spacing can enhance production of the kind, amount, and distribution of residue needed.

Where maintaining or improving soil organic matter content is an objective, the effects of this practice can be enhanced by managing crop residues, tillage practices, utilizing animal wastes, or applying mulches to supplement the biomass produced by crops in the rotation.

Where excess plant nutrients or soil contaminants are a concern, utilizing deep rooted crops or cover crops in the rotation can help recover or remove the nutrient or contaminant from the soil profile.

Where precipitation is limited, seasonal or erratic moisture can be conserved for crop use by maintaining crop residues on the soil surface to increase infiltration and to reduce runoff and evaporation. Where winter precipitation occurs as snow, additional moisture can be obtained for crop use by trapping snow with standing residue, windbreaks, or other barriers.

Where improving water use efficiency on deep soils is a concern, rotating or combining deep-rooted crops with shallow rooted crops can help utilize all available water in the soil profile.

Crop damage by wind erosion can be reduced with this practice by selecting crops that are tolerant to abrasion from wind blown soil or tolerant to high wind velocity. If crops sensitive to wind erosion damage are grown, the potential for plant damage can be reduced by crop residue management, field windbreaks, herbaceous wind barriers, intercropping, or other methods of wind erosion control.

Where pesticides are used, consider application methods and the crop rotation to avoid negative impacts on the following crop due to residual herbicides in the soil or adverse affects on aquatic wildlife or habitat through runoff.

Soil compaction can be reduced by adjusting crop rotations to include deep rooted crops that are able to extend to and penetrate the compacted soil layers, as well as avoiding crops that require field operations when the soils are wet.

Leaving several rows unharvested around the edges of the field will provide protection and/or food for overwintering wildlife.

Crop plantings may be developed to benefit particular communities, species or life stages of wildlife. Food plots or crops for wildlife could be provided as part of a habitat restoration project as an initial food and cover source for wildlife until food and cover producing vegetation becomes established.

Crop residues may be a valuable food source for wintering wildlife where winter browse is sparse. Careful consideration should be given to pesticide use if applied to crops raised for wildlife.

This practice has the potential to have either a positive or negative affect National Register listed or eligible (significant) cultural resources (archeological, historic or traditional cultural properties).

Care should be taken, especially during site preparation and maintenance, to avoid adverse effects to these resources. Follow NRCS state policy for considering cultural resources during planning and maintenance.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and operation of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation and Maintenance described in this standard. Specifications should include the sequence of crops to be grown, length of time each crop will be grown and total length of rotation.

Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Rotations shall provide for acceptable substitute crops in case of crop failure or shift in planting intentions for weather related or economic reasons. Acceptable substitutes are crops having similar properties that meet the criteria for all the resource concerns identified for the field or treatment unit.

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# CONSTRUCTED WETLAND

(acre)  
CODE 656

## DEFINITION

A wetland that has been constructed for the primary purpose of water quality improvement.

## PURPOSE

This practice is applied to treat waste waters from confined animal operations, sewage, surface runoff, milkhouse wastewater, silage leachate, mine drainage by the biological, chemical and physical activities of a constructed wetland.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies where runoff is contaminated by metals, pesticides, nutrients, fertilizers, or animal wastes to levels unacceptable for downstream receiving waters.

This practice applies to the treatment of a wastewater discharge stream (confined animal facilities, food processing, mine drainage, and other constant inputs) or nonpoint source runoff discharges (agricultural, urban stormwater).

This practice is applicable only if the constructed wetland can provide the intended water quality treatment.

This practice does not apply to: wetland restoration (657) intended to rehabilitate a degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to original conditions; wetland enhancement (659) intended to rehabilitate a degraded wetland where specific functions and/or values are enhanced beyond original conditions; or wetland creation (658) for creating a wetland on a site location which historically was not a wetland, or was a wetland with a different hydrology, vegetation type, or functions that occurred naturally on site.

## CRITERIA

### General Criteria

- The landowner shall obtain necessary local, state, and federal permits that apply before wetland construction, including water rights if required.
- The design will comply with local, state, and federal permit requirements.
- The soil, hydrology and vegetative characteristics of the site and its contributing watershed before construction shall be documented.

### Criteria for Wetland Hydrology

- The constructed wetland area must have sufficient detention volume to store the design wastewater stream and/or storm runoff volume of the "first flush" of runoff which contains the majority of pollutants. When less than the full runoff is stored, bypass of the excess storm flow must be provided.
- Release of the treated water must be provided in preparation for receiving the next storm runoff and/or wastewater stream. The storage volume, detention time, and release rate

must be compatible with the space available for the constructed wetland and bypass waterway.

- Where significant sediment and organic debris are expected in the waste water to be treated, provisions for its entrapment before entry into the wetland must be provided.
- A soil or synthetic liner and subsurface drainage shall be installed where there is a potential for exchange or mixing of waste water and ground water.
- The standards and specifications for Dike (356) and Structure for Water Control (587) will be used as appropriate. Refer to the Engineering Field Handbook, Chapters 13, "Wetland Restoration, Enhancement, and Creation," and 6, "Structures," for additional design information. Existing drainage systems will be utilized, removed, or modified as needed to achieve the intended purpose.
- Design Storm: The constructed wetland system shall be designed to contain a 2-year storm runoff. Limited area sites handling only the "first flush" volume shall have a minimum capacity to store 0.5 inch of runoff volume from the entire drainage area.
- Wetland Cells: Shape - length to width ratios are to be 4:1 to 10:1. Other dimensions and shapes that provide a more natural landscape appearance that meet treatment requirements can be used.
- Depth- maximum water depth shall be 24 inches.
- Outlet - a water control structure to automatically regulate storage release in accordance with the design detention time shall be installed.
- Detention time and surface area- the detention time and surface area shall be calculated on the time required to achieve the required level of treatment based on the limiting contaminant present.

#### **Criteria for Hydrophytic Vegetation**

- Vegetation selected for the constructed wetland shall be hydrophytic plants suitable for local climatic conditions and tolerant of the concentrations of nutrients, pesticides, and other constituents in the stormwater or wastewater stream and selected for their treatment potential.
- Preference shall be given to native wetland plants with localized genetic material. Plant materials collected or grown from material collected within a 200 mile radius from the site is considered local.
- Adequate substrate material and site preparation necessary for proper establishment of the selected plant species shall be included in the design.

#### **Criteria for Wetland Functions**

- A functional assessment (Hydrogeomorphic or similar method) shall be performed on the site prior to construction.

### **CONSIDERATIONS**

Consider effect of volumes and rates of runoff, infiltration, evaporation, and transpiration on the water budget.

Consider the potential for a change in rates of plant growth and transpiration because of changes in the volume of available soil water.

Consider effects on downstream flows or aquifers that would affect other water uses or users.

Consider effects on movement of sediment and soluble and sediment-attached substance carried by runoff.

Consider effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

Consider the effects of the constructed wetland on potential human or wildlife use and/or wildlife use of the constructed wetland (e.g. additional nutrient inputs from waterfowl use, toxic effects on wildlife); de-emphasize the incorporation of additional functions beyond the treatment function where necessary.

Consider the effects on wetlands or water-related resources and fish and wildlife habitats that would be affected by the practice.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other documentation.

## **OPERATION AND MAINTENANCE**

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

- The use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals to assure the constructed wetland function shall not compromise the intended purpose. Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible;
- Timing and level setting of water control structures required for the establishment of desired hydrologic conditions or for management of vegetation shall be outlined in the operation and maintenance plan.
- Inspection schedule for embankments and structures for damage assessment.
- Depth of sediment accumulation to be allowed before removal is required.
- Management needed to maintain vegetation, including control of unwanted vegetation.

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# CONTOUR BUFFER STRIPS

(Acre)  
CODE 332

## DEFINITION

Narrow strips of permanent, herbaceous vegetative cover established across the slope and alternated down the slope with parallel, wider cropped strips.

## PURPOSES

- To reduce sheet and rill erosion.
- To reduce transport of sediment and other water-borne contaminants downslope, on-site or off-site.
- To enhance wildlife habitat
- 

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to cropland. It is most suitable on uniform slopes ranging from 4 to 8 percent with slope lengths less than the Critical Slope Length (Critical Slope Length = length of slope above which contouring loses its effectiveness). It is also most suitable in regions where rainfall intensities are low to moderate (10 year EI less than 140). EI = storm energy \* intensity.

This practice is not suited to fields with extremely long slopes whose length exceeds the critical slope length for contouring by more than 1.5 times, unless the field slope length is shortened by the installation of other practices (e.g. terraces).

The practice is more difficult to establish on undulating to rolling topography because of the difficulty of maintaining parallel strip boundaries across the hill slope or staying within row grade limits.

The narrow strips of permanent vegetative cover are not a part of the normal crop rotation.

This standard does not apply to situations where the width of the buffer strips will be equal to or exceed the width of the adjoining crop strips.

## CRITERIA

### **Criteria Applicable to Both Reducing Sheet and Rill Erosion and Reducing Transport of Sediment and Water-Borne Contaminants.**

#### **a. Row Grade, Strip Boundaries, and Baselines**

The grade of the cropped strip shall be aligned as closely as possible to the contour to achieve the greatest erosion reduction possible. The maximum grade of rows within the crop strips shall not exceed one half of the up and down hill field slope or 2 percent, whichever is less.

For crops sensitive to ponded water for periods less than 48 hours, design a positive row grade of not less than 0.5 percent from the nose of a hill or ridge toward a stable outlet. Up to 3 percent row grade is allowed for a maximum of 150 feet as crop rows approach a stable outlet.

The grade along the up slope side of the vegetated buffer shall be the same as for the cropped strip directly above it.

When the grade of any crop strip reaches the maximum allowable design grade, a new baseline shall be established up or down slope from the last buffer strip and used for the layout of the next crop strip.

#### **b. Arrangement of Strips**

Cropped strips shall be alternated with buffer strips down the hill slope. Normally, a crop strip will occupy the area at the top of the hill.

When used in combination with terraces with underground outlets, diversions, or water and sediment control basins, the layout of buffer strips shall be coordinated with the grade and spacing of the terraces so that strip boundaries will parallel terraces wherever possible. The buffer strip shall occupy the terrace or diversion berm, a channel leading to a water and sediment control basin, or lie immediately up slope of the terrace or diversion channel.

#### **c. Stable Outlets**

Surface flow from contoured crop rows must go to a stable outlet. Stable outlets include grassed waterways, underground outlets for terraces or diversions, water and sediment control basins, field borders, headlands or end rows, or similarly stabilized areas.

### **Additional Criteria to Reduce Sheet and Rill Erosion**

#### **a. Width of Strips**

The buffer strips shall be of equal width, except when a varying width buffer strip is needed to keep either a cropped strip adjacent to it of uniform width or to maintain the strip boundary grades within the criteria set above. Width of buffer strips at their narrowest point shall be no less than 15 feet for grasses or grass legume mixtures and no less than 30 feet when legumes are used alone.

Cropped strips shall be of uniform width between buffer strips and not exceed the lesser of:

1. 50 percent of the slope length (L), used for the erosion calculation, or
2. 50 percent of the critical slope length for contour buffer strips. (The critical slope length for contour buffer strips is calculated by multiplying 1.5 times the critical slope length for contour farming as determined by using approved erosion prediction technology).

Cropped strip width shall be designed to account for some multiple of full equipment width.

#### **b. Vegetation**

Vegetation grown on buffer strips designed to reduce sheet and rill erosion shall be established to permanent vegetation consisting of grasses, legumes, or grass-legume mixtures, adapted to the site, and tolerant of the anticipated depth of sediment deposition. No plants listed on the noxious weed list of the state will be established in a buffer strip cropping system.

The buffer strips shall have a Vegetative Cover-Management Condition of 1 (established meadow - very dense cover) or 2 (1st year meadow or grass legume hay just before cutting) that provides protective cover and induces sediment deposition during periods when erosion is expected to occur on the cropped strips. Cropped strips will normally be expected to have a Cover-Management Condition within the range from 3 (heavy dense cover or very rough) through 7 (Clean tilled, smooth or fallow). (Cover Management Conditions are described in Chapter 6, Predicting Soil Erosion by Water, A Guide to Conservation Planning with the Revised Universal soil Loss Equation "RUSLE")

The stem density for grass species shall be greater than 50, and for legumes, greater than 30 stems per square foot.

**c. Level of Erosion control**

The level of erosion control achieved by the buffer strip cropping practice shall meet or exceed the soil erosion level specified by the conservation plan objective. It shall be determined using the approved erosion prediction technology, accounting for the impact of other conservation practices in the system.

**e. Headlands or End Rows**

On fields where row crops are a part of the rotation, keep headlands or end rows in permanent sod if their row grade would be steeper than the designed grade of the crop strip.

**Additional Criteria to Reduce the Transport of Sediment and Other Water-Borne Contaminants Downslope**

**a. Vegetation**

Buffer strips designed to reduce the transport of sediment and other water-borne contaminants shall be established to permanent sod forming vegetation with stiff, upright stems only. No plants listed on the noxious weed list of the state will be established in a buffer strip cropping system.

**b. Width of Strips**

On cropland having slopes exceeding 3 percent, the buffer strip width shall be based on the minimum criteria given above to reduce sheet and rill erosion. On slopes 3 percent or flatter, the width of the buffer strip shall be 15 feet or wider.

The maximum width of cropped strips between buffer strips shall be one half of the field slope length not to exceed 150 feet. Cropped strip width shall be designed to account for some multiple of full equipment width.

**c. Arrangement of Strips**

Buffer strips and crop strips will be alternated down the hill slope. A buffer strip will be established at the bottom of the slope. This width of this buffer strip will be two times the width of the other buffer strips in the system.

**d. Headlands or End Rows**

Headlands or end rows shall be vegetated and have a minimum width of 15 feet between the end of the tilled strip and the field's edge.

**Additional Criteria to Enhance Wildlife Habitat**

To enhance wildlife habitat, native, warm season grass specie mixture, recommended for wildlife purposes, will be used where adapted.

Delay mowing the buffer strips to every other year or every third year depending upon geographical location.

Mow only after the desired species of ground nesting birds have hatched. Allow for regrowth before the growing season ends.

To enhance wildlife cover, the width of buffer strips will be increased to 30 feet or wider as determined based on the requirements for nesting and escape cover of the target wildlife species.

The maximum width between buffer strips should not exceed 300 feet.

## **CONSIDERATIONS**

Protect areas of existing or potential concentrated flow erosion by any one or more suitable conservation practices, such as grassed waterways, water and sediment control basins, or diversion terraces.

When the slope length exceeds the critical slope length for the cover-management condition that best characterizes the field to be contour buffer stripped, establish structures, such as terraces, to reduce the slope length below critical if the soil loss objective is not reached. (Design Guidance: Critical slope lengths can be increased by retaining crop residue on the soil surface of the cultivated strips using crop residue management practices. Certain tillage practices can also be used on the cultivated strips to increase random roughness to cause deposition to occur in depressions between soil clods. However, if the cropped strips are kept very rough, in high ridges, or under heavy residue cover, the need for contour buffer strips as an erosion and sediment reduction practice will be reduced since less sediment will be delivered to them.)

On fields where row crops are a part of the rotation, consider establishing field borders on headlands or end rows, which are steeper than the designed grade of rows in the cropped strip. Where contour row curvature becomes too sharp to keep equipment aligned with rows during field operations, consider increasing the buffer strip width to avoid sharp ridge points. In drainageways, consider establishing grassed waterways at least to the point of sharp curvature. These strips should be wide enough to allow the equipment to be lifted and/or turned to meet the same rows across the turn strip.

Prior to design and layout, consider removing any obstructions or making changes in field boundaries or shape, where feasible, to improve the effectiveness of the practice and the ease of performing farming operations.

Prior to layout, inspect the field's position on the landscape to find key points for commencing layout or getting the width of one set of strips (one cultivated and one buffer) to pass by an obstruction or ridge saddle. Considering grade limits, whenever possible, run strip boundaries parallel with fence lines or other barriers. Account for uncropped access road widths when they must traverse the field by adjusting strip boundaries on either side accordingly.

Some non-noxious weedy growth may be allowed in the strips as they provide an insect source for young birds. Also, consider adding native forbs to the seeding mixture when they are available.

The standing residual cover provides early and late season nesting and escape cover for many species of wildlife displaced from other mowed areas.

## **PLANS AND SPECIFICATIONS**

Specifications for installation, operation, and maintenance of Contour Buffer Strips shall be prepared for each field according to the Criteria, Considerations, and Operations and Maintenance described in this standard, and shall be recorded on specification sheets, job sheets, narrative statements in conservation plans, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Conduct all farming operations parallel to the strip boundaries except on headlands or end rows with gradients less than the criteria set forth in this standard.

Time mowing of buffer strips to maintain appropriate vegetative density and height for optimum trapping of sediment from the upslope cropped strip during the critical erosion period(s). If wildlife enhancement is desired, delay mowing until after the desired species of ground nesting birds have hatched.

Fertilize buffer strips as needed to maintain stand density.

Mow sod turn strips and waterways at least annually.

Spot seed or totally renovate buffer strip systems damaged by herbicide application after residual action of the herbicide is complete.

Redistribute sediment accumulations along the upslope edge of the buffer-crop strip interface upslope over the cultivated strip when needed to maintain uniform sheet flow along the buffer/cropped strip boundary. If sediment accumulates just below the upslope edge of the buffer strip to a depth of 6 inches or stem density falls below specified amounts in the buffer strip, relocate the buffer/cropped strip interface location. Cultivated strips and buffer strips shall be rotated so that a mature stand of protective cover is achieved in a newly established buffer strip immediately below or above the old buffer strip before removing the old buffer to plant an erosion-prone crop. Alternate repositioning of buffer strips to maintain their relative position on the hill slope.

Renovate vegetated headlands or end row area as needed to keep ground cover above 65 percent.

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# CONTOUR FARMING

(Acre)  
CODE 330

## DEFINITION

Tillage, planting, and other farming operations performed on or near the contour of the field slope.

## PURPOSES

- To reduce sheet and rill erosion.
- To reduce transport of sediment and other water-borne contaminants.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies on sloping land where crops are grown.

Contour farming is most effective on slopes between 2 and 10 percent. This practice will be less effective in achieving the stated purpose(s) on slopes exceeding 10 percent and in areas with 10-year-frequency, single storm EI values greater than 140. The practice is not well suited to rolling topography having a high degree of slope irregularity because of the difficulty meeting row grade criteria. (EI = total storm energy times the maximum 30-minute intensity).

## CRITERIA

### General Criteria Applicable to All Purposes

#### Minimum Row Grade

Row grades for soils with slow to very slow infiltration rates (soil hydrologic groups C or D), or for crops sensitive to ponded water conditions for periods of less than 48 hours, shall be designed with positive row drainage of not less than 0.2 percent on slopes where ponding is a concern.

#### Maximum Row Grade

The row grade shall be aligned as closely as possible to the contour to achieve the greatest erosion reduction. The maximum grade of rows shall not exceed 2 percent or one half of the up and down hill slope percent used for erosion prediction, whichever is less. Up to 3 percent row grade may be permitted within 150 feet of the approach to a *grassed waterway*, *field border* or other stable outlet.

Headlands or end rows that are steeper than the maximum row grade criteria stated above shall have a cover-management condition no greater than 3 or established to permanent field borders. [Cover-Management Conditions are described in Chapter 6, *Predicting Soil Erosion by Water, A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)*. 1997. USDA Agricultural Research Service, Agricultural Handbook No. 703].

When the row grade reaches the maximum allowable design grade, a new baseline shall be established up or down slope from the last contour line and used for layout of the next contour pattern. All tillage and planting operations will follow the contour line established.

### **Minimum Ridge Height**

The ridge height shall be designed to reduce soil erosion compared to that of rows oriented up and down the slope. As a minimum, this practice shall be designed to achieve a 0.5-2 inch ridge height during the period of the rotation that is most vulnerable to soil erosion. Ridge height design will be determined using on site conditions and current erosion prediction technology approved for use.

The minimum ridge height criteria is not required for close-grown crops, such as small grains, when runoff is reduced compared to that of rows planted up and down the slope. As a minimum, plant height shall be at least 6 inches high and the spacing between plants within the row shall not be greater than 2 inches.

The minimum ridge height criteria is not required where the practice *residue management, no-till/strip-till* is used on the contour if at least 50 percent surface residue is present between the rows after planting.

### **Critical Slope Length**

A contour farming layout shall not occur on a hill slope that is longer than the critical slope length, unless supported by other practices (e.g., *terraces, diversions*) that either reduce slope length below the critical length or reduce overland flow velocities. Increasing residue cover and roughness will change the vegetative cover-management conditions and decrease overland flow velocities. Increasing roughness alone is not sufficient to reduce the critical slope length.

The computation of critical slope length shall be determined using approved erosion prediction technology.

### **Stable Outlets**

All runoff from contouring shall be delivered to stable outlets, such as *grassed waterways, field borders, water and sediment control basins, or underground outlets for terraces and diversions*.

## **CONSIDERATIONS**

Prior to design and layout, obstruction removal and changes in field boundaries or shape should be considered, where feasible, to improve the effectiveness of the practice and the ease of performing farming operations.

If using *residue management, ridge-till* on the contour, avoid crossing over ridged rows at correction areas. Consider sod turn strips if correction areas are unavoidable.

Ridge height may vary throughout the year as a result of tillage, planting, some harvest operations, hilling, row cultivation, and weathering. Use of the variable ridge height may be needed in some areas.

The width of correction areas, and the distance between baselines, should be adjusted for equipment operation widths.

*Grassed waterways, water and sediment control basins, underground outlets*, or other suitable practices should be used to protect areas of existing or potential concentrated flow erosion.

There are several factors that impact the effectiveness of contour farming to reduce soil erosion. These factors include: 10-year storm  $EI_{10}$  value, ridge height, furrow grade, slope steepness, soil hydrologic group, cover and roughness, and the critical slope length. Cover and roughness, row

grade, and ridge height can be influenced by management and provide more or less benefit depending on design.

*Contour farming* may need to be used in combination with other conservation practices to meet the goals of the conservation management system.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and operation of this practice shall be prepared for each field according to the Criteria, Considerations, and Operation and Maintenance described in this standard. Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Perform all tillage and planting operations parallel to contour baselines or *terraces, diversions, or contour buffer strip* boundaries where these practices are used, provided the applicable row grade criteria are met.

Where *terraces, diversions, or contour buffer strips* are not present, maintain contour markers on grades that, when followed during establishment of each crop, will maintain crop rows at designed grades. Contour markers may be field boundaries, a crop row left untilled near or on an original contour baseline, or other readily identifiable, continuous, lasting marker. All tillage and planting operations shall be parallel to the established marker. If a marker is lost, re-establish a contour baseline within the applicable criteria set forth by this standard prior to seedbed preparation for the next crop.

Farming operations should begin on the contour baselines and proceed both up and down the slope in a parallel pattern until patterns meet. Where field operations begin to converge between two non-parallel contour baselines, establish a correction area that is either permanently in sod, established to an annual close-grown crop, or is in cover-management condition 3.

Where contour row curvature becomes too sharp to keep machinery aligned with rows during field operations, establish sod turn strips on sharp ridge points or other odd areas as needed.

Renovate *field borders* as needed to maintain at least 65 percent ground cover. Maintain adequate field border width to allow farm implements room to turn.

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# CONTOUR ORCHARD AND OTHER FRUIT AREA

(acre)  
CODE 331

## DEFINITION

Planting orchards, vineyards, or small fruits so that all cultural operations are done on the contour.

## PURPOSE

To reduce soil and water loss, to better control and use water, and to operate farm equipment more easily.

## CONDITIONS WHERE PRACTICE APPLIES

On sloping land where soil and water losses need to be controlled, especially if a permanent cover is not established.

## SPECIFICATIONS GUIDE

Allowable deviation from the true contour.

## PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY

### Quantity

1. Effects the water budget, especially effects on volume and rates of runoff and infiltration.
2. Decreases in surface runoff and increases in infiltration with any benches or terraces constructed to provide access to growing plants. Consider the type of bench or terrace (inward sloping versus outward sloping), width, degree of slope, and vegetative cover at the time of runoff.

### Quality

1. Effects on erosion and the movement of sediment, and soluble and sediment-attached substances carried by runoff.
2. Effects of increased volumes of soluble nutrients, pesticides, and salts contained in infiltrating water. Comparison should be made to noncontoured orchards on sloping ground or to the present land use if not now in orchard.

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# CONTOUR STRIPCROPPING

(Acre)  
CODE 585

## DEFINITION

Growing row crops, forages, small grains, or fallow in a systematic arrangement of equal width strips on or near the contour of the field slope.

## PURPOSE

- To reduce sheet and rill erosion
- To reduce transport of sediment and other water-borne contaminants

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies on sloping land where crops are grown.

Although this practice may be applicable on steeper slopes and/or in areas with higher 10-year-frequency, single storm EI values, it will be less effective in achieving the purpose(s) of the practice on slopes exceeding 15 percent and in areas with 10-year storm EI values greater than 140. (EI = total storm energy times the maximum 30-minute intensity).

The practice has the greatest impact where cropped or fallow strips having less than 10 percent cover are alternated with close grown and/or grass/legume strips (Cover-Management Condition 1-2), or strips of *residue management, no/till/strip-till* with 75 percent or greater surface cover (Cover-Management Condition 3). [Cover-Management conditions are described in Chapter 6, *Predicting Soil Erosion by Water, A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)*. 1997. USDA Agricultural Research Service, Agricultural Handbook No. 703].

The practice is not well suited to rolling topography having a high degree of slope irregularity.

## CRITERIA

### General Criteria Applicable to All Purposes

#### Alignment of Strips

Where more than one strip boundary will be placed on the hill slope, strip boundaries shall run parallel to each other as long as their grades meet the row grade criteria. If unachievable, establish a new baseline at a distance up or down the slope equal to some multiple of strip widths that will limit the number of correction strips (non-uniform width strips) to the minimum needed to keep all strip boundaries within row grade limits.

All tillage and planting operations will follow the contour line established.

Where contour row curvature becomes too sharp to keep machinery aligned with rows during field operations, establish sod turn strips on sharp ridge points. On ridge tops, where grades are within row grade limits, row crops may be planted in these turn strip areas. Plant these areas last and harvest these areas first. When establishing *grassed waterways* in drainage ways, establish vegetation at least up to that point of sharp curvature. These strips shall be wide enough to allow

the equipment to be lifted and/or turned and meet the same rows across the turn strip. Mow sod turn strips and *grassed waterways* at least once yearly after ground-nesting birds have hatched. Harvesting is optional.

### **Strip Width**

Base strip widths on the slope length used for erosion prediction. Erosion-prone strip widths shall not exceed 50 percent of this slope length or 150 feet whichever is less. The erosion-resistant and erosion-prone strips shall be of equal width, except for any correction strip needed to keep strip boundaries within prescribed row grade limits. The correction strip may vary in width but shall be no narrower than the widest working farm implement used to traverse the strip.

### **Minimum Row Grade**

Row grades for soils with slow to very slow infiltration rates (soil hydrologic groups C or D), or for crops sensitive to ponded water conditions for periods of less than 48 hours, shall be designed with positive row drainage of not less than 0.2 percent on slopes where ponding is a concern.

### **Maximum Row Grade**

The row grade shall be aligned as closely as possible to the contour to achieve the greatest erosion reduction. The maximum grade of rows shall not exceed 2 percent or one half of the up and down hill slope percent used for erosion prediction, whichever is less. Up to 3 percent row grade may be permitted within 150 feet of the approach to a grassed waterway, field border or other stable outlet.

### **Minimum Ridge Height**

The ridge height shall be designed to reduce soil erosion compared to that of rows oriented up and down the slope. As a minimum, this practice shall be designed to achieve a 0.5-2 inch ridge height during the period of the rotation that is most vulnerable to soil erosion. Ridge height design will be determined using on site conditions and current erosion prediction technology approved for use.

The minimum ridge height criteria is not required for close-grown crops, such as small grains, when runoff is reduced compared to that of rows planted up and down the slope. As a minimum, plant height shall be at least 6 inches high and the spacing between plants within the row shall not be greater than 2 inches.

The minimum ridge height criteria is not required where the practice *residue management, no-till/strip-till* is used on the contour if at least 50 percent surface residue is present between the rows after planting.

### **Critical Slope Length**

The critical slope length for contour stripcropping is 1.5 times the critical slope length determined for contour farming. A contour stripcropping layout shall not occur on a slope longer than the critical slope length unless supported by other practices that reduce slope length below critical (e.g., diversions, terraces). The computation of critical slope length shall be determined using approved erosion prediction technology.

## **Stable Outlets**

All runoff from *contour stripcropping* shall be delivered to stable outlets, such as *grassed waterways, field borders, water and sediment control basins, or underground outlets for terraces and diversions.*

## **Headlands/End Rows**

On fields where row crops and tillage are a part of the rotation, keep headlands/end rows in permanent sod where their grades would be steeper than the criteria set forth for strip boundaries.

## **Additional Criteria to Reduce Sheet and Rill Erosion**

### **Arrangement and Vegetative Condition of Strips**

Alternate strips of erosion-prone crops or fallow (Cropland Cover-Management Conditions 4-7) down the slope with strips of erosion-resistant cover (Cropland Cover-Management Conditions 1-3). If condition 3 is utilized as one of the erosion resistant strips, at least 75 percent surface residue cover shall be present. The erosion resistant cover shall be present during periods when erosion is expected to occur.

No two adjacent strips shall be in an erosion-prone condition at the same time during the year. However, two adjacent strips may be in erosion-resistant cover at the same time.

A vegetative cover shall be selected that is tolerant of the anticipated depth of sediment deposition and potential pesticide damage.

## **Additional Criteria to Reduce Transport of Sediment and Other Water-borne Contaminants**

### **Arrangement and Vegetative Condition of Strips**

Erosion-prone crop or fallow strips shall be managed as Cropland Cover-Management Conditions 3-5. Erosion-prone strips shall be alternated down the slope with strips of erosion-resistant cover that meet Cropland Cover-Management Conditions 1-2. The erosion resistant cover shall be present during periods when erosion is expected to occur.

No two adjacent strips shall be in an erosion-prone condition at the same time during the year. However, two adjacent strips may be in erosion-resistant cover at the same time.

A vegetative cover shall be selected that is tolerant of the anticipated depth of sediment deposition and potential pesticide damage.

## **CONSIDERATIONS**

The *conservation crop rotation* on stripcropped fields should be consistent with the farm enterprise crop mix and/or associated livestock operation. These will influence the proportion of row crops, close growing crops, and meadow crops.

To avoid wide fluctuations in acreage of different crops from year to year, fields having identical crop rotations can be set up that are nearly equal in size and have offset years of rotation commencement. The number of fields needed to produce a nearly constant acreage of each crop for each year in the rotation is equal to one half of the years in the rotation. Even-year rotation lengths are preferable to odd-year rotation lengths for ease of design.

Protect areas of existing or potential concentrated flow erosion by any one or more suitable conservation practices, such as *grassed waterways*, *water and sediment control basins*, *diversions*, *terraces*, or *underground outlets*.

Design and install the strip layout to best facilitate operation of all machinery used on the strips. To avoid point rows and partial machine passes, lay out strip widths to have some multiple of full width passes by all farm implements, even at unavoidable constrictions.

Prior to design and layout, *obstruction removal* or changes in field boundaries or shape should be considered, where possible and feasible, to improve the effectiveness of the practice and the ease of performing field operations across the slope.

Prior to layout, inspect the field to find key points for commencing layout or getting a full strip width to pass by an obstruction or ridge saddle. Whenever possible, run the strip boundary parallel with fence lines or other barriers, as long as row gradient criteria are met. Account for access road widths when they must cross the field, and adjust the strip boundary on either side accordingly.

When the slope length used in erosion prediction exceeds the critical slope length for the cover-management condition that best characterizes the field to be contour stripcropped, establish structures, such as *diversions* or *terraces*, to reduce slope length below the critical slope length.

When this practice is used in combination with *diversions* or *terraces*, coordinate the strip layout with the diversion or terrace grade and spacing so that strip boundaries will parallel terraces wherever possible within the criteria for row grade. Where grass-back or narrow-base terraces are used, allow for the uncropped width along the terrace so that the same strip width is maintained for all strips in the field.

Retaining as much crop residue as possible on the soil surface by using residue management practices can maximize critical slope lengths. Certain tillage practices, such as uphill plowing and deep tillage with heavy implements, can also be used to increase random roughness, allowing deposition to occur in depressions between soil clods and increase critical slope length. However, if the most erosion-prone strips of the field are kept very rough, in high ridges, or under heavy residue most of the year, there is little need for stripcropping as an erosion and sediment control practice. Little sediment will be delivered to the protective cover strips.

Contour stripcropping may need to be used in combination with other conservation practices to meet the goals of the conservation management system.

## **PLANS AND SPECIFICATIONS**

Specifications for installation and maintenance of Contour Stripcropping shall be prepared according to the Criteria, Considerations, and Operations and Maintenance described in this standard, and shall be recorded on specification sheets, job sheets, narrative statements in conservation plans, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Conduct all farming operations parallel to the strip boundaries except on end rows that have gradients flatter than the criteria set forth in this standard unless the end rows are in cover-management condition 3.

Plant odd areas and short rows to maximize adherence to the contour and protect sensitive areas. Using no-till in the odd areas and short rows or seeding close-grown crops rather than row crops increase options.

Substituting a crop different from one called for in the planned crop rotation, or adjusting the crop rotation due to failed crops or loss of stand, is acceptable, provided neither situation allows two adjacent erosion-prone strips.

Sediment accumulations along the upslope edge of protected strips may need to be smoothed or redistributed to maintain uniform sheet flow along the strip boundary.

When headlands/end rows are in permanent cover, renovate as needed to keep ground cover above 65 percent. No-till renovation of headlands/end rows is recommended but in any case should only include the immediate seedbed preparation and reseeding to a sod-forming crop with or without a nurse crop. Maintain full headland/end row width to allow turning of farm implements at the end of a tilled strip to double back on the same strip.

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# **CONTROLLED DRAINAGE**

(Acre)  
CODE 335

## **DEFINITION**

Control of surface and subsurface water through use of drainage facilities and water control structures.

## **SCOPE**

This standard applies to management of surface or subsurface outflow from drainage facilities. This standard does not apply to water management systems that are planned to provide subirrigation water supply which is covered by Water Table Control (641).

## **PURPOSE**

To conserve water and maintain optimum soil moisture to:

1. Store and manage infiltrated rainfall for more efficient crop production.
2. Improve surface water quality by increasing infiltration thereby reducing runoff which may carry sediment and undesirable chemicals.
3. Reduce nitrates in the drainage water by enhancing conditions for denitrification.
4. Reduce subsidence and wind erosion of organic soils.
5. Hold water in channels in forest areas to act as ground fire breaks.
6. Provide water for wildlife and a resting and feeding place for waterfowl.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies primarily to cropland where:

1. The topography is relatively uniform, and flat to gently sloping.
2. Subsurface conditions are such that a water table can be maintained without excessive water loss. The presence of a slowly permeable underlying soil layer is needed to prevent excessive deep seepage losses during periods when a raised water table is desired.
3. Soil aeration is needed in addition to controlling ground water and surface runoff.
4. Saline or sodic soil conditions can be maintained at an acceptable level for efficient production of crops.
5. Improvement of onsite or offsite water quality is desired and may be provided by controlling drainage outflow.
6. Improvement of water quality can be achieved through management of water for maximum denitrification.

## **PLANNING CONSIDERATIONS**

1. Consider the effects on wetlands.
2. Evaluate the effects of variations in the water budget either above or below the point of control.
3. Consider effects of change in the flow of downstream water courses.
4. Consider the effects of change in the water table.
5. Consider effects of outflow on erosion in downstream water courses.

6. Evaluate the effects of possible change in the delivery of sediment and sediment-attached substances.
7. Consider the potential for changes in dissolved chemical loading from nitrates and other salts including managing denitrification.
8. Consider changes in salinity and other dissolved chemicals in soils and in ground water and surface waters.
9. Consider effects on downstream water temperatures.
10. Consider the effects of the planned drainage outflow on the visual quality of discharge or downstream water.

## DESIGN CRITERIA

**General.** Designs are to be in accordance with other pertinent Practice Standards such as Structure for Water Control (587); Subsurface Drain (606); Surface Drainage, Field Ditch (607); Surface Drainage, Main or Lateral (608); and the following additional criteria:

**Capacity.** Facilities are to be designed so that all component parts shall have the capacity to remove the flow of water required for designed drainage. The combined capacity of the surface and subsurface facilities shall satisfy the appropriate drainage coefficient for the crops to be grown.

**Structure for Water Control.** Structures for water control shall be installed wherever necessary and field surfaces graded and smoothed to ensure that moisture from the controlled water table is available to the crop. Structures shall be sized such that design flows over the flashboard or through the control structure can be maintained with a maximum head of 0.5 feet during normal operation. Structures shall be designed so that the control can be removed to return to the drainage mode when desired. Water tables should be dropped slowly to prevent high exit gradients which may draw sediment or other pollutants into the drains. Ease of management and operation of the control structures shall be considered. Automatic devices should be considered to lower the flashboard or control the position of the outlet structure during sudden or high peak flows following infrequent storms. Pumping may be needed to achieve the objective in some sites. Refer to Pumping Plant for Water Control (533).

## OPERATION

A plan of operation shall be prepared for the system to ensure that the system objectives are met. The plan of operation should address the following objectives as applicable:

1. During rainfall, if the water table rises significantly, the outlet controls should be lowered or the system put into a drainage mode.
2. Prior to tillage and planting operations, the water table should be at a depth to provide trafficability with capillary water available when needed.
3. Immediately after planting, the water table control device should be set to allow infiltration from rainfall to bring the water table up to the desired water level to provide capillary water in the root zone.
4. Water table management during wet periods is important because crops may be damaged if the water table is held too near the surface and if drainage is not provided when needed.
5. The system should be operated so that the water table is at a depth sufficient to ensure trafficability prior to harvest.

## PLAN AND SPECIFICATION

Plans and specifications for controlled drainage shall be in keeping with this standard and shall describe the requirements for properly installing and operating the practice. [Return to Top](#)

# **COVER CROP**

(acre)  
CODE 340

## **DEFINITION**

Grasses, legumes, forbs, or other herbaceous plants established for seasonal cover and conservation purposes.

## **PURPOSES**

- Reduce erosion from wind and water
- Increase soil organic matter
- Manage excess nutrients in the soil profile
- Promote biological nitrogen fixation
- Increase biodiversity
- Weed suppression
- Provide supplemental forage
- Soil moisture management

## **CONDITIONS WHERE PRACTICE APPLIES**

On all lands requiring vegetative cover for natural resource protection

## **CRITERIA**

### **General Criteria Applicable To All Purposes**

Plant species, seedbed preparation, seeding rates, seeding dates, seeding depths, and planting methods will be consistent with approved local criteria and site conditions.

The species selected will be compatible with the nutrient management and pest management provisions of the plan.

Cover crops will be terminated by harvest, frost, mowing, tillage, and/or herbicides in preparation for the following crop.

Herbicides used with cover crops will be compatible with the following crop

Cover crop residue will not be burned

### **Additional Criteria to Reduce Erosion From Wind and Water**

Cover crop establishment, in conjunction with other practices, will be timed so that the soil will be adequately protected during the critical erosion period(s).

Plants selected for cover crops will have the physical characteristics necessary to provide adequate protection.

The amount of surface and/or canopy cover needed from the cover crop shall be determined using current erosion prediction technology.

### **Additional Criteria to Promote Biological Nitrogen Fixation**

The specific Rhizobia bacteria will either be present in the soil or the seed will be inoculated at the time of planting legumes.

Nitrogen credits from legume cover crops will be accounted for in the nutrient management plan.

### **Additional Criteria to Manage Excess Nutrients in the Soil Profile**

Cover crops will be established and actively growing before expected periods of high precipitation that can cause leaching.

Cover crop species will be selected for their ability to absorb large amounts of nutrients from the rooting profile of the soil.

The aboveground biomass will be removed from the field for maximum nutrient removal efficiency.

### **Additional Criteria to Increase Soil Organic Matter**

Cover crop species will be selected on the basis of producing high volumes of organic material to maintain or improve soil organic matter.

The NRCS Soil Conditioning Index (SCI) procedure will be used to determine the amount of biomass required.

The cover crop will be terminated as late as feasible to maximize plant biomass and still prepare the seedbed for the subsequent crop.

### **Additional Criteria to Increase Biodiversity**

Cover crop species shall be selected that, have different maturity dates, attract beneficial insects, serve as a trap crop for damaging insects, and/or provide food and cover for wildlife habitat management.

### **Additional Criteria for Weed Suppression**

Species for the cover crop will be selected for their chemical or physical competition with weeds.

Cover crops residues will be left on the soil surface to maximize allelopathic (chemical) and mulching (physical) effects.

For long-term weed suppression, perennials and/or biennial species can be used.

### **Additional Criteria to Provide Supplemental Forage**

Species selected will have desired forage traits, be palatable to livestock, and not interfere with the production of the subsequent crop.

Forage provided by the cover crop may be hayed or grazed as long as sufficient biomass is left for resource protection.

### **Additional Criteria for Soil Moisture Management**

Terminate growth of the cover crop sufficiently early to conserve soil moisture for the subsequent crop.

Cover crops established for moisture conservation shall be left on the soil surface until the subsequent crop is planted.

In areas of potential excess soil moisture, allow the cover crop to grow as long as possible to optimize soil moisture removal.

### **CONSIDERATIONS**

The cover crop should be terminated as late as feasible to maximize plant growth and still prepare the seedbed for the subsequent crop.

Deep-rooted species provide maximum nutrient recovery.

Consider that grasses utilize more soil nitrogen, and legumes utilize both nitrogen and phosphorus.

Avoid cover crop species that attract potentially damaging insects.

Acceptable benefits, for most purposes, are usually accomplished when the plant density is at least 25 stems per foot, the combined canopy and surface cover is at least 60 percent, and the above ground (dry weight) biomass production is at least 2700 lb/acre.

Cover crops may be used to improve site conditions for establishment of perennial species.

### **PLANS AND SPECIFICATIONS**

Plans and specifications will be prepared for the practice site. The State standard will specify practice requirements for site specifications. Specifications will include, but are not limited to, recommended species, seeding rates and dates, establishment methods, nutrients needed, and other establishment information. Specifications can be recorded in narrative format, on job sheets, or forms designed to provide specific requirements for the practice.

### **OPERATION AND MAINTENANCE**

Control growth of the cover crop to reduce competition from volunteer plants and shading.

Control weeds in the cover crop by mowing or herbicide application.

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# **CRITICAL AREA PLANTING**

(acre)  
**CODE 342**

## **DEFINITION**

Planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas (does not include tree planting mainly for wood products).

## **PURPOSE**

To stabilize the soil, reduce damage from sediment and runoff to downstream areas, and improve wildlife habitat and visual resources.

## **CONDITIONS WHERE PRACTICE APPLIES**

On highly erodible or critically eroding areas. These areas usually cannot be stabilized by ordinary conservation treatment and management and if left untreated can cause severe erosion or sediment damage. Examples of applicable areas are dams, dikes, mine spoil, levees, cuts, fills, surface-mined areas, and denuded or gullied areas where vegetation is difficult to establish by usual planting methods.

## **SPECIFICATIONS GUIDE**

Species of grasses, legumes, shrubs, and trees; methods and rates of planting; fertilizer and lime requirements; planting site preparation; time of planting; mulching; and irrigation.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects of vegetation management on soil moisture.
3. Effects of snow catch and melt on the water budget.
4. Effects of increased organic matter on water holding capacity of the soil.
5. Potential for a change in plant growth and transpiration because of changes in soil water volume.

### **Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Filtering effect of vegetation on movement of sediment and dissolved and sediment-attached substance.
3. Short-term and construction-related effects on downstream water courses.
4. Potential for earth moving to uncover or redistribute toxic materials and effect on water or vegetation.
5. Effects on the use and management of nutrients and pesticides and resulting effects on surface and ground-water quality.
6. Effects on the visual quality of downstream water resources.

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# **CROSS WIND RIDGES**

(acre)  
CODE 589A

## **DEFINITION**

Ridges formed by tillage or planting and aligned across the prevailing wind erosion direction.

## **PURPOSE**

This practice may be applied as part of a conservation management system to reduce soil erosion from wind.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to cropland, or other land where crops are grown.

It is best adapted on soils which are stable enough to sustain effective ridges, such as clayey, silty, and sandy loam soils.

It is not well adapted on unstable soils such as sands, loamy sands, and certain organic soils.

## **CRITERIA**

Ridge height, spacing, and direction:

Acceptable combinations of ridge height, spacing, and direction are those having Ridge Roughness K values equal to 0.8 or less during those periods when wind erosion is expected to occur. K values are displayed in the National Agronomy Manual, Exhibit 502.62(a).

## **CONSIDERATIONS**

Transport of wind-borne sediment and sediment-borne contaminants offsite can be reduced by this practice when used in a conservation management system.

Where water erosion along the furrows formed by ridges is a concern, the hazard can be reduced by farming across the slope according to the standards for CONTOUR FARMING.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and maintenance of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation & Maintenance described in this standard.

Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Ridges shall be established or reestablished by normal tillage and planting equipment such as chisel plows, drills with hoe openers, or other similar implements which form effective ridges.

After establishment, ridges shall be maintained through those periods when wind erosion is expected to occur, or until growing crops provide enough cover to protect the soil from wind erosion.

If ridges deteriorate and become ineffective due to weathering or erosion, they shall be reestablished unless doing so would damage a growing crop.

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# CROSS WIND STRIPCROPPING

(acre)  
CODE 589B

## DEFINITION

Growing crops in strips established across the prevailing wind erosion direction, and arranged so that strips susceptible to wind erosion are alternated with strips having a protective cover that is resistant to wind erosion.

## PURPOSES

This practice may be applied as part of a conservation management system to support one or both of the following:

- Reduce soil erosion from wind.
- Protect growing crops from damage by wind-borne soil particles.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to cropland, or other land where crops are grown.

## CRITERIA

### General Criteria Applicable To All Purposes Named Above

#### a. Number of Strips:

A cross wind stripcropping system shall consist of at least two strips.

#### b. Width and Direction of Strips:

Strips having protective cover and managed as part of a crop rotation may be the same width as the erosion-susceptible strips or may be narrower, but in any case shall not be less than 25 feet.

The maximum width of strips, measured perpendicular to strip direction, shall not exceed 660 feet.

When the direction of erosion-susceptible strips deviates from perpendicular to the prevailing wind erosion direction, the width of these strips shall be correspondingly reduced.

#### c. Arrangement of Strips:

Strips susceptible to wind erosion shall be alternated with strips that provide protective cover.

Crops shall be rotated so that protective cover is maintained in alternate strips during those periods when wind erosion is expected to occur.

Two or more strips having protective cover may be next to each other, but strips susceptible to erosion must be separated by a strip providing protective cover.

#### **d. Vegetative Cover:**

Vegetation in a stripcropping arrangement consists of crops grown in a planned rotation.

Alternate strips shall be crops or crop residues which provide protective cover during those periods when wind erosion is expected to occur.

Acceptable protective cover includes a growing crop, including grasses, legumes, or grass-legume mixtures, standing stubble, or tilled residue with enough surface cover to provide protection.

#### **Additional Criteria To Reduce Soil Erosion From Wind**

The effective width of strips shall be measured along the prevailing wind erosion direction for those periods when wind erosion is expected to occur and for which the system is designed.

Strip width shall not exceed that permitted by the soil loss tolerance (T), other planned soil loss objective, or the maximum permissible width specified in this standard.

The width of strips shall be determined using current approved wind erosion prediction technology. Calculations shall account for the effects of other practices in the conservation management system.

#### **Additional Criteria To Protect Growing Crops From Damage By Wind-borne Soil Particles**

The effective width shall be measured along the prevailing wind erosion direction during those periods when sensitive crops are susceptible to damage by wind-borne soil particles.

The width of strips shall not exceed the width permitted by the crop tolerance to wind erosion\*, as specified in applicable Field Office Technical Guides, other accepted technical references, or other planned crop protection objective.

- **Crop tolerance to wind erosion is the maximum rate of soil blowing that the plants can tolerate without significant plant damage due to abrasion, burial, or desiccation.**

The width of strips shall be determined using current approved wind erosion prediction technology to estimate wind erosion during specific crop stage periods. Calculations shall account for the effects of other practices in the conservation management system.

## **CONSIDERATIONS**

The effectiveness of Cross Wind Stripcropping is maximized when the strips are oriented as close to perpendicular as possible to the prevailing wind erosion direction for the period for which the system is designed.

Transport of wind-borne sediment and sediment-borne contaminants offsite is reduced by this practice when used in a conservation management system.

Where this practice is used in combination with the practice, CONSERVATION CROP ROTATION (328), the stripcropping design must be consistent with the crop sequence. Strip widths may be adjusted, within the limits of the criteria above, to accommodate widths of farm equipment to minimize partial or incomplete passes. Alternative practices which may be used to separate erosion-susceptible strips include CROSS WIND TRAP STRIPS (589C), HERBACEOUS WIND BARRIERS (422A), or WINDBREAK/SHELTERBELT ESTABLISHMENT (380).

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and maintenance of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation and Maintenance described in this standard.

Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Erosion-resistant strips in rotation shall be managed to maintain the planned vegetative cover and surface roughness during periods when wind erosion is expected to occur. The protective cover must be adequate to inhibit the initiation of wind erosion and to trap saltating soil particles originating upwind.

Wind-borne sediment accumulated along strip edges shall be removed and distributed over the surface of the field as determined appropriate.

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# CROSS WIND TRAP STRIPS

(Acre)  
CODE 589C

## DEFINITION

Herbaceous cover resistant to wind erosion established in one or more strips across the prevailing wind erosion direction.

## PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following:

- Reduce soil erosion from wind.
- Induce deposition and reduce transport of wind-borne sediment and sediment-borne contaminants downwind.
- Protect growing crops from damage by wind-borne soil particles.
- Provide food and cover for wildlife.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to cropland, or other land where crops are grown.

This standard includes the location of cross wind trap strips and their management for identified uses. Criteria for the establishment of perennial herbaceous vegetation are in practice standards for establishing permanent vegetation, or in other places in the Field Office Technical Guide. Refer to locally accepted university or extension agronomy guides, or other accepted technical references for criteria to establish annual herbaceous vegetation.

## CRITERIA

### General Criteria Applicable To All Purposes Named Above

#### a. Number of Strips:

A cross wind trap strip system shall consist of one or more strips across the prevailing wind erosion direction.

#### b. Width of Trap Strips:

Trap strips shall be wide enough to trap saltating soil particles and store wind-borne sediments originating upwind.

The width of the trap strip shall be at least 15 feet, when vegetation or stubble in the strip will normally be one foot or more in height during periods when wind erosion is expected to occur.

The minimum width of the trap strip shall be at least 25 feet when the effective height of the vegetation or stubble in the strip will normally be less than one foot during periods when wind erosion is expected to occur.

### **c. Vegetative Cover:**

Trap strips may consist of perennial or annual plants, growing or dead. Plant materials shall be selected for the following characteristics:

- Adaptation to the site.
- Erect during wind erosion periods.
- Tolerant to sediment deposition.

### **Additional Criteria To Reduce Soil Erosion From Wind**

#### **a. Location of Trap Strips:**

Trap strips established for this purpose shall be located as follows:

- At the windward edge of fields; or
- Immediately upwind from areas within fields to be protected from erosion or deposition; or
- In recurring patterns interspersed between erosion-susceptible strips.

#### **b. Direction and Width of Erosion-Susceptible Strips:**

When trap strips are installed in patterns alternated with erosion-susceptible crop strips, and the direction of strips deviates from perpendicular to the prevailing wind erosion direction, the width of the erosion-susceptible strips shall be correspondingly reduced.

The effective width of strips shall be measured along the prevailing wind erosion direction during those periods when wind erosion is expected to occur. It shall not exceed the width permitted by the soil loss tolerance (T), or other planned soil loss objective.

The width of strips shall be determined using current approved wind erosion prediction technology. Calculations shall account for the effects of other practices in the conservation management system.

### **Additional Criteria To Induce Deposition And Reduce Transport Of Wind-borne Sediment And Sediment-borne Contaminants Downwind**

#### **Location of Trap Strips:**

Trap strips shall be established immediately upwind from areas to be protected from sediment deposition. There shall be no erosion-exposed area located between the trap strip and the area to be protected from sediment deposition.

### **Additional Criteria To Protect Growing Crops From Damage By Wind-borne Soil Particles**

#### **a. Placement of Trap Strips:**

Trap strips shall be established immediately upwind from areas used for sensitive crops. There shall be no erosion-exposed area located between the trap strip and the crop to be protected.

#### **b. Direction and Width of Strips of Sensitive Crops:**

Where trap strips are installed in patterns alternated with strips of crops susceptible to damage by wind-borne soil particles, and the direction of strips deviates from perpendicular to the prevailing wind erosion direction, the width of strips planted to sensitive crops shall be correspondingly reduced.

The effective width shall be measured along the prevailing wind erosion direction during those periods when sensitive crops are susceptible to damage by wind-borne soil particles. It shall not exceed the width permitted by the crop tolerance to wind erosion\*, as specified in Field Office Technical Guides, other accepted technical references, or other planned crop protection objective.

\* Crop tolerance to wind erosion is the maximum rate of soil blowing that crop plants can tolerate without significant damage due to abrasion, burial, or desiccation.

The width of the crop strips shall be determined using current approved wind erosion prediction technology to estimate wind erosion during specific cropstage periods. Calculations shall account for the effects of other practices in the conservation management system.

### **Additional Criteria to Provide Food and Cover for Wildlife**

#### **a. Vegetative Cover:**

Trap strips shall consist of vegetation that provides food and/or cover for the targeted wildlife species.

#### **b. Trap Strip Height:**

The minimum height of trap strips designed for this purpose shall have a minimum expected height that provides adequate cover for the targeted wildlife species.

## **CONSIDERATIONS**

The effectiveness of Cross Wind Trap Strips is maximized when strips are oriented as close to perpendicular as possible to the prevailing wind erosion direction for the period for which the system is designed.

Selection of plants for use in trap strips should favor species or varieties tolerant to herbicides used on adjacent crops or other land uses. When trap strips are designed to enhance wildlife habitat, plant species diversity within the strip should be encouraged. Trap strips that result in multiple structural levels of vegetation within the strip will maximize wildlife use.

Some plants are damaged by blowing wind as well as by wind-borne sediment. In such cases, the spacing between trap strips may have to be reduced from that obtained using wind erosion prediction technology.

Drifting snow or grazing by wildlife may reduce the trapping capability of trap strips. In such cases, other conservation practices, including the residue management practices (329A, 329B, or 329C, herbaceous wind barriers (422A), etc., may be used with, or as alternatives to, trap strips to achieve the conservation objective.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and maintenance of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation and & Maintenance described in this standard.

Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

After establishment, perennial trap strips shall be fertilized as needed to maintain plant vigor. Noxious weeds shall be controlled with mowing or chemicals.

Mowing or grazing of trap strips shall be managed to allow regrowth to the planned height before periods when wind erosion or crop damage is expected to occur.

Wind-borne sediment accumulated in trap strips shall be removed and distributed over the surface of the field as determined appropriate.

Trap strips shall be re-established or relocated as needed to maintain plant density and height.

When barriers are designed to enhance wildlife habitat, they shall not be mowed or pruned unless their height and width exceeds that required to obtain the wildlife objective and they become competitive with the adjoining land use. When mowing or pruning is necessary, it shall be done only during non-nesting season.

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# DAM, DIVERSION

(No.)  
CODE 348

## DEFINITION

A structure built to divert part or all the water from a waterway or a stream into a different watercourse, and irrigation canal or ditch, or a water-spreading system.

## SCOPE

This standard applies to structures of a permanent nature, constructed of materials having an expected life span consistent with the purpose for which the structure is designed. It does not apply to diversions (362), floodwater diversions (400), floodwater retarding dams (402), or grade stabilization structures (410).

## PURPOSE

1. To divert part or all the water from a waterway in such a manner that it can be controlled and used beneficially, or
2. To divert periodic damaging flows from one watercourse to another watercourse having characteristics that reduce the damage potential of the flows.

## CONDITIONS WHERE PRACTICE APPLIES

Where a diversion dam is needed as an integral part of an irrigation system or a water-spreading system designed to facilitate the conservation use of soil and water resources.

Where it is desirable to divert water from an unstable watercourse to a stable watercourse.

Where the water supply available is adequate for the purpose for which it is to be diverted.

Where the impact of a proposed dam on water quality, fish and wildlife habitat, forest, and visual resources are evaluated and the techniques and measures necessary to overcome the undesirable effects are made part of the work.

## DESIGN CRITERIA

**Materials.** All materials to be used in constructing the diversion dam and appurtenances shall have the strength, durability, and workability required to meet the installation and service conditions of the site.

**Outlet works.** If part of the flow is to be diverted, the outlet works must provide for positive control of both maximum and minimum diversions consistent with the purpose for which the diversion is made. If all the flow is to be diverted, the outlet works must provide for safe diversion of all expected flows, depending on site conditions.

**Bypass works.** The bypass works must be capable of passing all flows needed to satisfy downstream priorities and all flows in excess of diversion requirements, including expected flood flows. This may require a combination of orifices, weirs, and gates designed to meet the requirements of the site.

**Special-purpose works.** If debris, bedload materials, or sediments are present under flow conditions subject to diversion, provision shall be made to bypass or remove materials that may be detrimental to the functioning of the outlet works, to other parts of the works, or to areas to which diversion is made. This may require the use of setting basins, debris traps, trash guards, or sluiceways, depending on site conditions.

**Vegetation.** Distributed areas not otherwise covered or protected shall be established to grass as soon as practicable after construction. If soil or climatic conditions preclude the use of vegetation and protection is needed, nonvegetative materials, such as mulches or gravel, may be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with instructions in local technical guides. The vegetation shall be maintained and undesirable species controlled by chemical or mechanical means.

## **OPERATION AND MAINTENANCE.**

Provisions shall be made as necessary for operation and maintenance requirements and may include a formal plan for larger more complex dams.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing diversion dams shall be keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **DAM, DIVERSION, SPECIFICATIONS**

Specified materials shall be of adequate quality to provide the stability and durability required to achieve the planned objective. Consideration shall be given to appropriate factors of safety.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and as practical.

Construction operations shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.

The completed job shall present a workmanlike finish.

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge. Compare the original water course with the diverted water course.
2. Effects of the use of diverted waters for irrigation.

### **Quality**

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
2. Potential temperature changes in downstream waters resulting from differences in bank shading in different water courses.
3. Potential changes in the amount of soluble substances infiltrating and available for ground water recharge as well as the potential for salt pick-up.

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# **DAM, FLOODWATER RETARDING**

(No. and acre-ft)  
**CODE 402**

## **DEFINITION**

A single-purpose dam designed for temporary storage of floodwater and for its controlled release.

## **SCOPE**

This standard covers dams constructed to retard floodwater.

## **PURPOSE**

To reduce flood damages downstream by controlling the release rate from flood flows of predetermined frequencies. They may also permit the use of more economical channel modifications or stabilizing structures in the channel downstream and reduce environmental hazards and pollution.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies only to sites meeting all the following conditions:

1. Topographic, geologic, and soils conditions at the proposed site are satisfactory for the development of a feasible dam and reservoir.
2. The sediment yield at the site is not excessive.

Special attention shall be given to maintaining habitat for fish and wildlife if applicable.

## **DESIGN CRITERIA**

All dams designed under this standard shall meet or exceed the criteria as called for in the standard for ponds (378) or in TR-60, as appropriate, except as specifically modified by this standard.

The capacity of the principal spillway shall be adequate to discharge, in 10 days or less, the floodwater storage needed to provide the desired level of protection to the downstream benefited area. Storage provided primarily for the purpose of reducing the frequency of use of the emergency spillway need not be included in this 10-day drawdown limitation. The determination of capacity must be based on consideration of the benefits that accrue to the reduction in the discharge rate, damages that may result from prolonged storage in the retarding pool, damages that may result from prolonged outflow, and limitations in water rights or other legal requirements. Longer release times may be used if warranted by downstream conditions. This discharge through gated outlets shall not be considered in determining the emptying time of the retarding pool.

The elevation of the crest of the lowest stage of the principal spillway shall be set at the elevation of the sediments pool. For dry dams, the riser shall be designed to permit design discharge at the sediment pool elevation with provisions for discharging water at lower elevations to satisfy the functional requirements of the structure.

All parts of the principal spillway, except attached gates and trash racks, shall have an expected service life equal to or greater than the design life of the structure or provisions made for replacement. Principal spillways shall meet the requirements with respect to materials established in the standard for ponds (378) or in TR-60, as appropriate.

The minimum diameter of the conduit used as a principal spillway shall be 10 in.

The storage volume shall not be less than the expected sediment accumulation during a period equal to the design life.

The retarding storage requirements shall be of such as to contain the runoff expected to occur at a frequency consistent with the level of protection to be provided to the downstream benefited area, with proper allowance for discharge through the principal spillway. The retarding storage capacity shall be sufficient to limit the use of the emergency spillway to a permissible frequency and duration based upon consideration of the erosion resistance of the spillway material and vegetative protection to be provided.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing floodwater retarding dams shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

### **DAM, FLOODWATER, RETARDING SPECIFICATIONS 402**

Specifications for construction of floodwater retarding dams within the scope of the standard for ponds (378) shall, as a minimum, be commensurate with those for ponds (378). Those within the scope of the criteria in TR-60 shall be in accord with the guide specifications contained in the National Engineering Handbook, Section 20.

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Reductions in downstream flow during runoff periods.
2. Potential total runoff or decrease of evaporation from the reservoir surface and seepage from the pool bottom.
3. Potential increases in surface water volume during normal low flow periods caused by prolonged duration of reservoir releases.
4. Increase in deep percolation to the ground water resulting from seepage from the reservoir sides and bottom. The amount of seepage will depend on soils, area covered by the reservoir, and length of time inundated, and measures for reservoir sealing.

### **Quality**

1. Potential for improving downstream surface water quality resulting from trapping of suspended sediments, bedload material, and associated nutrients and pesticides in the pool area.
2. Instability of downstream banks and channel and their potential to deepen and widen.
3. Potential for degradation of surface water quality by sediments, fuels, oils, and other chemicals during construction.
4. Increase in temperature, decrease in dissolved oxygen, and the amount of absorbed nutrients and pesticides in deposited sediments in sediment pools.
5. Potential changes in downstream water temperatures and dissolved oxygen content that could result from the design of the outlet structure. Where dissolved oxygen may be

- reduced by outlet placement, plan some means of causing rapid dissolved oxygen recovery.
6. Increases in soluble nutrients and pesticides in deep percolating waters caused by seepage in reservoir sides and bottom. Chemicals may originate from those used in the structure and reservoir area, or may be dissolved in waters from the watershed area.

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# DAM, MULTIPLE-PURPOSE

(No. and acre-ft.)

CODE 349

## DEFINITION

A dam constructed across a stream or a natural watercourse that has a designed reservoir storage capacity for two or more purposes, such as floodwater retardation and irrigation water supply, municipal water supply, and recreation.

## SCOPE

This standard applies to dams that have separate storage allocation for two or more purposes. Sediment storage is not considered a separate purpose except as indicated under Sediment Basins (350).

## PURPOSE

A multiple-purpose dam must provide distinct and specific storage allocations for two or more of the following purposes: (1) floodwater retardation, (2) irrigation, (3) fishing, hunting, boating, swimming, or other recreational uses, (4) improve environment or habitat for fish and wildlife, (5) municipal, (6) industrial, and (7) other uses. (A reservoir for which multiple use is made of the same storage allocation is not a multiple-purpose dam; however, a dam designed for joint-use storage is a multiple-purpose dam.)

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies only to sites meeting all the following criteria:

1. Topographic, geologic, hydrologic, and soil conditions at the proposed site are satisfactory for constructing a feasible dam and reservoir.
2. The watershed is protected from erosion to the extent that the sediment yield will not shorten the planned effective life of the reservoir.
3. Water is available from a single or combined source of surface runoff base flow or from subsurface storage in sufficient quantity and adequate quality to satisfy the intended purposes.

## DESIGN CRITERIA

**Foundation, embankment, and spillway.** All dams designed under this standard shall meet or exceed the foundation, embankment, and spillway criteria called for in SCS standard for Ponds (378) or in TR-60, as appropriate.

**Floodwater retarding pool and spillway.** Dams having a floodwater retarding purpose shall meet or exceed the requirements of SCS standard for Floodwater Retarding Dams (402).

**Outlet works.** Outlet works discharging releases for several purposes shall have adequate capacity to carry the peak flow resulting from the combined demands at any time. Outlet conduits and appurtenances shall be designed according to criteria that are equal to or better than called for in SCS standard for Ponds (378) or in TR-60, as appropriate.

**Storage.** The usable storage capacity shall be adequate for all purposes. Seasonal variations in demand and the expected losses from seepage and evaporation must be considered.

**Sediment storage.** The capacity, in addition to that required for all other purposes, must offset depletion by sediment accumulation for a period equal to the design life.

**Type of structures.** All dams and appurtenances shall be designed to meet applicable SCS standards for the specific type and class of structure.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing multiple-purpose dams shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

### **DAM, MULTIPLE-PURPOSE, SPECIFICATIONS 349**

Specifications for dams to which the standard for Ponds (378) apply shall, as a minimum, be commensurate with those for Ponds (378).

Specifications for dams to which the criteria in TR-60 apply shall be in accord with the guide specifications contained in the National Engineering Handbook, Section 20.

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially of longer downstream flow duration, evaporation from the water surface, and infiltration in the bottom and sides of the pool area.
2. Effects of water taken from the reservoir for agricultural, industrial, or municipal use.

### **Quality**

1. Effects on the movement of sediments, pathogens, and soluble and sediment-attached substances carried by runoff.
2. Effects of increased downstream bank saturation resulting from longer flow duration on erosion and sediment yield.
3. Potential use of the reservoir for recreation. Factors include increased use of pesticides, human waste, and other pollutants.
4. Effects of sediments pool on temperature and dissolved oxygen on downstream waters.
5. Effects of location of the outlet structure on downstream water temperatures and dissolved oxygen.
6. Changes in ground water quality caused by increased infiltration of soluble substances.

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**DIKE**  
(ft)  
**CODE 356**

**DEFINITION**

An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

**SCOPE**

This standard applies to dikes or levees used to prevent or reduce flood damage to land and property, for flow control in conjunction with floodways or to impound or regulate water for fish and wildlife management.

Dikes are divided into classes determined by the value of the land, crops, and other improvements and the hazard to life within the area to be protected.

**PURPOSE**

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features and archeological sites from damage.

**CONDITIONS WHERE PRACTICE APPLIES**

Class I dikes are those constructed on sites where:

1. Failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways or railroads, and high value land, crops, or other improvements.
2. Unusual or complex site conditions require special construction procedures to ensure satisfactory installations.
3. Protection is needed to withstand more than 12 ft (3.7 m) of water above normal ground surface, exclusive of crossing of sloughs, old channels, or low areas.

Class II dikes are those constructed in highly developed and productive agricultural areas where:

1. Failure may damage isolated homes, highways or minor railroads, or cause interruption in service of relatively important public utilities.
2. The maximum design water stage against the dike is 12 ft (3.7 m).

Class III dikes are those constructed in rural or agricultural areas where:

1. Damage likely to occur from dike failure is minimal.
2. The maximum design water stage against the dike is 6 ft (1.8 m) for mineral soils and 4 ft (1.2 m) for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

## DESIGN CRITERIA - ALL DIKES

In locating dikes, careful considerations shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. If dike construction will adversely affect such values, concerned public agencies and private organizations shall be consulted about the project.

**Protection.** A protective cover of grasses shall be established on all exposed surfaces of the dike and other disturbed areas. Seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with recommendations in local technical guides.

If vegetation will not control erosion, riprap or other protective measures shall be installed.

**Maintenance.** All dikes must be adequately maintained to the required shape and height. The maintenance of dikes must include periodic removal of woody vegetation that may become established on the embankment. Provisions for maintenance access must be provided.

## DESIGN CRITERIA - CLASS I DIKES

**Location.** Conditions to be considered in designing Class I dikes are foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available.

**Height.** The design height of a dike shall be the design high water depth plus 2 ft (0.6 m) of freeboard or 1 ft (0.3 m) of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

1. If dike failure is likely to cause loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the stage of the 100-year-frequency flood or of the maximum flood of record, whichever is greater.
2. If dike failure is unlikely to result in loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will insure the desired level of protection or the 50-year-frequency flood whichever is greater.
3. If the dike will be subject to stages from more than one stream or source, the criteria indicated shall be met for the combination that causes the highest stage.
4. If the dike will be subject to tidal influence as well as streamflow, the streamflow peak shall be assumed to occur in conjunction with the mean high tide to determine the design high water depth.

The design height of the dike shall be increased by the amount needed to insure that the design top elevation is maintained after settlement. This increase shall be not less than 5 percent.

**Interior drainage.** If inflow from the area to be protected by the dike may result in loss of life or extensive high-value crop property damage, provisions shall be included in the plans to provide interior protection against a 100-year-frequency hydrograph, plus base flow, and an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value crop or property damage, storage areas, gravity outlets, or a pumping plant, alone or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will insure the desired level of protection, whichever is greater.

In sizing outlet works in combination with available storage, the minimum design storm duration for interior drainage shall be 10 days. If outlet works are designed using peak flood frequency flows without considering storage, the minimum design storm duration shall be 24 hours.

**Embankment and foundation.** The embankment shall be constructed of mineral soils, which when placed and compacted will result in a stable earth fill. No organic soil shall be used in the dike. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 ft (3 m) for embankment heights of 15 ft (4.6 m) or less and 12 ft (3.6 m) for heights more than 15 ft (4.6 m). If maintenance roads are to be established on the dike top, "turnarounds" or passing areas shall be provided, as needed.

Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the water side shall not be steeper than 4 horizontal to 1 vertical if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the landside toe shall be protected by a banquette or constructed berm. Banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall not be less than 1 ft (0.3 m) above mean ground and shall be sloped away from the dike.

A cutoff shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slopes adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If previous foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to insure stability of the dike shall be used.

**Ditches and borrow pits.** Landside ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 ft (4.6 m) in width, shall be left in the ditches at intervals not greater than 400 ft (121.9 m) to form a series of unconnected basins.

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill height	Minimum berm width
Less than 6 ft (1.8 m)	12 ft (3.7 m)
More than 6 ft (1.8 m)	18 ft (5.5 m)

A drainage system shall be used if necessary to insure the safety of a dike. Toe drains, if used, shall be located on the landside and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the landside toe of a dike than a distance three times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

**Pipes and conduits.** Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with antiseep collars.

All conduits through a dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed water line shall be equipped with a Dayton or a similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

## DESIGN CRITERIA - CLASS II DIKES

**Design water stage.** The maximum design water stage permitted is 12 ft (3.7 m) above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes, based on the required level of protection, exceeds 4 ft (1.2 m) the design shall be based on at least a 25-year-frequency flood. If this degree of protection is not feasible, the design shall approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

**Height.** The design height of an earth dike shall be the design water depth plus a free-board of at least 2 ft (0.6 m) or freeboard of 1 ft (0.1 m) plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus allowance for settlement necessary to insure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

**Interior drainage.** Provisions must be made for adequate drainage for the area to be protected by the dike.

**Cross section.** The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Design water height		Minimum top width		Steepest side slope
<i>ft</i>	<i>m</i>	<i>ft</i>	<i>m</i>	
0-6	(0-1.8)	6	(1.8)	1-1/2:1
6-12	(1.8-3.7)	8	(2.4)	2:1

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated in the fill as follows:

Design water height		Minimum top width		Steepest side slope
<i>ft</i>	<i>m</i>	<i>ft</i>	<i>m</i>	
0-6	(0-1.8)	6	(1.8)	1-1/2:1
6-12	(1.8-3.7)	10	(3)	2:1

Side slopes of 3 horizontal to 1 vertical on waterside and 2:1 on landside may be used instead of 2-1/2:1 for both slopes.

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall be less than 10 ft (3 m) if a maintenance road is planned on top the dike. "Turnarounds" or passing areas shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML, are used in construction.

A banquette (or constructed berm) shall reinforce the landside toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analyses show a different design is adequate.

**Foundation cutoff.** A cutoff shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

**Ditches and borrow pits.** Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill height	Minimum berm width
Less than 6 ft (1.8 m)	10 ft (3 m)
More than 6 ft (1.8 m)	15 ft (4.6 m)

A landside ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having a design water depth of more than 5 ft, (1.5 m), the landside ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design waterline with the waterside of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

**Pipes and conduits.** The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water, if feasible, or else equipped with antiseep collars.

All conduits through the dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibrations of the pumping plant being transmitted to the discharge conduits.

**Drains.** Drains shall be used where necessary to insure safety of dikes and shall be located on the land side, have a graded sandgravel filter, and be designed and installed in accordance with Soil Conservation Service standards for such drains.

Field subsurface drains shall not be installed or permitted to remain without protection closer to the landside toe of a dike than a distance three times the design water height for the dike. If such

drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sandgravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

## **DESIGN CRITERIA - CLASS III DIKES**

The design criteria shall be based on site conditions for mineral or organic soils as applicable.

**Top width.** Minimum top width is 4 ft (1.2 m).

**Side slopes.** Minimum side slope is 1:1.

**Freeboard.** The minimum freeboard is 1 ft (0.3 m) plus wave height. The constructed height shall be increased by the amount necessary to insure that the settled top is at design elevation but not less than 5 percent.

**Foundation cutoff.** A cutoff shall be installed if necessary to insure dike stability.

**Ditches and borrow pits.** Minimum berm widths between the toe and the dike and the edge of the excavated channel or borrow shall be two times the depth of the ditch but not less than 8 ft (2.4 m).

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects upon components of the water budget, especially on volumes and rates of runoff, infiltration, evaporation, and transpiration.
2. Potential for changes in rates of plant growth and transpiration because of changes in the volume of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the rate or volume of downstream flow to prohibit environmental, social, or economic effects.

### **Quality**

1. Effect on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substances to ground water.
3. Short-term, construction, and maintenance related effects on the quality of water resources.
4. Effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.
5. Effects on wetlands or water-related wildlife habitats that would be associated with the practice.
6. Effects on the visual quality of water resources.

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# DIVERSION

(Ft)  
CODE 362

## DEFINITION

A channel constructed across the slope with a supporting ridge on the lower side.

## SCOPE

This standard applies to the installation of all diversions except floodwater diversions (400) and diversion dams (348).

## PURPOSE

To divert excess water from one area for use or safe disposal in other areas.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to sites where:

1. Runoff damages cropland, pastureland, farmsteads, feedlots, or conservation practices such as terraces or stripcropping.
2. Surface flow and shallow subsurface flow caused by seepage are damaging sloping upland.
3. Runoff is in excess and available for use on nearby sites.
4. A diversion is required as part of a pollution abatement system.
5. A diversion is required to control erosion and runoff on urban or developing areas and construction or mining sites.

## DESIGN CRITERIA

**Capacity.** Diversions as temporary measures, with a life span of less than 2 years, shall carry as a minimum the 2-year, 24 hour-duration storm. Diversions that protect agricultural land and those that are part of a pollution abatement system must have the capacity to carry the peak runoff from a 10-year-frequency, 24-hour-duration storm as a minimum.

Diversions designed to protect areas such as urban areas, buildings, and roads, shall have enough capacity to carry the peak runoff expected from a storm frequency consistent with the hazard involved but not less than a 25-year-frequency, 24-hour-duration storm with a freeboard not less than 0.3 ft.

**Cross section.** The channel may be parabolic, V-shaped, or trapezoidal. The diversion shall be designed to have stable side slopes. The ridge height shall include an adequate settlement factor. The ridge shall have a minimum top width of 4 ft at the design elevation. The minimum cross section shall meet the specified dimensions. The top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement.

**Grade and velocity.** Channel grades may be uniform or variable. Channel velocity shall not exceed that considered nonerosive for the soil and planned vegetation or lining.

**Location.** The location of the diversion shall be determined by outlet conditions, topography, land use, cultural operations, and soil type. A diversion in a cultivated field must be aligned to permit use of modern farming equipment.

**Protection against sedimentation.** Diversions should not be used below high-sediment-producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with or before the diversions. If movement of sediment into the channel is a significant problem, a vegetated filter strip shall be used where soil or climate does not preclude its use. Then, the design shall include extra capacity for sediment and be supported by supplemental structures, cultural or tillage practices, or special maintenance measures.

**Outlets.** Each diversion must have a safe and stable outlet with adequate capacity. The outlet may be a grassed waterway, a vegetated or paved area, a grade stabilization structure, an underground outlet, a stable watercourse, or a combination of these practices. The outlet must convey runoff to a point where outflow will not cause damage. Vegetative outlets shall be installed before diversion construction to insure establishment of vegetative cover in the outlet channel. Underground outlets consist of an inlet and underground conduit. The release rate when combined with storage is to be such that the design storm will not overtop the diversion ridge. On large watersheds, runoff flows are usually too large to outlet entirely through underground outlets.

The design elevation of the water surface in the diversion shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

**Vegetation.** Disturbed areas that are not to be cultivated shall be established to grass as soon as practicable after construction. If the soils or climatic conditions preclude the use of vegetation for erosion protection, nonvegetative linings such as gravel, rock rip-rap, or cellular block may be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with standards in local technical guides. The vegetation shall be maintained and trees and shrubs controlled by hand, machine, or chemicals.

## **OPERATION AND MAINTENANCE**

A maintenance program shall be established to maintain diversion capacity, storage, ridge height, and the outlets. Maintenance needs are to be discussed with the landowner or operator who is responsible for maintaining the practices installed with SCS assistance. Diversion ridges can be hazardous for farming operations or mowing. Any hazards must be brought to the attention of the responsible person.

## **PLANS AND SPECIFICATIONS**

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

### **DIVERSION SPECIFICATIONS 362**

All ditches or gullies not filled, and undesirable trees and other obstructions not removed before construction begins shall be part of the diversion construction. The diversion shall be constructed to planned alignment, grade, and cross section.

If underground conduits are located under diversion ridges, mechanical compaction or water packing should be required. Installation and backfill of conduit trenches shall be made in advance to allow adequate settlement. The materials used for the inlet and conduit shall be

suitable for the purpose intended and shall meet the requirements for subsurface drains (606). Diversion ridges constructed across gullies or depressions shall be compacted sufficiently to keep settlement within tolerable limits.

The surface of the finished diversion shall be reasonably smooth and present a workmanlike appearance.

Topsoil should be stockpiled and spread over excavations and other areas to facilitate revegetation. If vegetation is needed, seedbed preparation, seeding, fertilizing, and mulching shall comply with standards in local technical guides.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge.
2. The type of outlet, time of water detention, geology, and topography of the site.

### **Quality**

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Filtering effects of vegetation on movement of sediment and dissolved and sediment-attached substances.
4. Short-term and construction-related effects on the quality of downstream water.
5. Effects on the movement of dissolved substances below the root zone and toward the ground water
6. Potential for uncovering or redistributing toxic materials and low productive soils that might cause undesirable effects on the water or plants.

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# DRY HYDRANT

(Each)  
CODE 432

## DEFINITION

A non-pressurized permanent pipe assembly system installed into water source that permits the withdrawal of water by suction.

## PURPOSE

To provide all weather access to an available water source for fire suppression.

## CONDITIONS WHERE PRACTICE APPLIES

Where a dependable source of water is available, where transport vehicles can access the site, and where a source of water is needed for fire suppression.

## CRITERIA

**Site Conditions.** Site conditions shall be such that an all weather vehicle access is available to the dry hydrant or can be developed. The dry hydrant shall be reasonably close to the water source to minimize the length of suction line. This should be determined in conjunction with local fire officials. Special care and maintenance will be required when debris and fine soil particles are part of the stream bed.

**Water Requirement.** The quantity to be considered available to a dry hydrant is the minimum available (at not over 15 feet total static lift) during a drought. A minimum of 30,000 gallons (1.1 acre-inches) of pumpable impoundment water or a minimum pump flow rate of 250 gpm without interruption for 2 hours is considered a dependable water supply.

**Location.** A location map showing the exact site of the hydrant and vehicle access shall be furnished local fire department with a copy to the landowner. A letter of approval to use the site shall be obtained from the landowner prior to construction. Access, topography, and location should be reviewed by fire department personnel prior to installation.

The fire truck connection shall be within 10 feet of the edge of an all weather access road. The all weather access road and fire truck pumper connection shall be higher than the auxiliary spillway elevation if installed in a constructed impoundment.

**Water supply.** The adequacy of the water supply from impoundments shall be determined in accordance to appropriate local criteria. The RESOP or similar computer program can be used to determine the water supply contained by earthen construction or water impounding embankments. The adequacy of stream flow source can be determined from regional analysis of stream gage data.

**Pipe.** The pipe material may be iron, steel or plastic. Plastic pipe shall be schedule 40, SDR-26 or otherwise protected from ultraviolet rays. No more than two 90-degree elbows shall be used in the entire pipe system. Pipe shall be 6 inches nominal diameter or larger. The pipe shall be fitted with intake screen or strainer and standard fire truck hose adapters for quick connect/release operations acceptable to the local fire department.

The depth at which the pipe is installed shall be below the frost-free depth for the area.

**Pipe Intake.** The pipe intake depth shall be calculated from the design water elevation plus pipe diameter plus 2 feet. The intake screen should have a minimum opening of 4 times the pipe cross sectional area. Where the intake is more than 3 feet off the bottom, a trash rack may be used in lieu of a screen.

A dry hydrant installation shall provide for a positive slope toward the water source. In pits or impoundment's, the intake screen or strainer shall be supported and secured at least two feet above the pool bottom. The intake shall be at least 4 feet beyond the earth slope.

To avoid a vortex or whirlpool during pumping, the top of the inlet pipe shall be at least 2.0 feet below the design water level unless a special design is prepared to prevent vortex.

**Pump Lift.** The top of the fire truck pumping connection or centerline of pump (whichever is higher) shall be no more than 15 feet in elevation above the bottom of the fire protection pool or stream surface during drought conditions.

The fire truck connection shall be approximately 24 inches above the ground surface, but never higher than the intake of the using fire truck.

The total lift (pumping head) shall not exceed 20 feet when all losses are totaled. Pumping head for each site shall include head loss from screen or strainer, elbows, line friction, elevation (static head), and hard rubber or flexible suction hose to the fire truck.

**Dry Hydrant.** Dry barrel (conventional) hydrants may not be used due to excess suction loss and the necessity that they be absolutely airtight.

A recessed hydrant (below ground-level connection) may be specified for use in areas with special needs, such as in a high vandalism area or for low profile and esthetic needs. It is also referred to as a flush mount hydrant and does not require the 24 inch riser. It may be used with the 45° or straight dry hydrant head assembly.

**Dry Hydrant Head.** The hydrant sleeve shall be made of bronze, brass, aluminum alloy or other durable, non-corrosive metal. Sleeve must be permanently affixed inside a PVC head using epoxy adhesive and stainless steel bolts.

The hydrant head shall be able to accept a 6 inch NHT (American National Fire Hose Thread) connection to provide maximum supply. Hydrant (6 inch) head shall conform to ASTM 2466.

All hydrants shall contain a removable head strainer and stainless steel snap ring that can be removed without special tools. The strainer shall be conical in shape to maximize straining area. All hydrants shall use a rubber "O" ring between the threaded sleeve and PVC head.

**Dry Hydrant Cap.** The cap shall be of snap-on/snap-off design and removable without special tools. It shall be joined with a steel cable or chain and be permanently attached to the dry hydrant head. The cap shall be hard plastic or of same metal as NHT connection for maximum corrosion resistance.

**Strainer.** The strainer shall be fabricated from PVC material compatible with the pipe. Individual inlet holes shall not exceed 3/8-inch diameter. All components, including pins, shall be non-corrosive. Manufactured well screens shall be corrosion resistant. Screens and strainers shall have a minimum open area of 4 times the pipe cross sectional area.

A strainer may be formed by drilling 1/4 inch to 3/8 inch diameter holes with a minimum of one hole diameter between the holes in PVC pipe. Drill holes shall be deburred and the pipe cleaned before putting the strainer into service. The screens or strainers shall be capped with a removable end cap.

**End Cap.** The end cap must be easily removed without special tools. Perforations are recommended in the end cap, also, to improve flow conditions into the strainer and for jetting action for silt cleanout.

**Materials.** All materials shall meet or exceed the minimum requirements for materials described in the various sections of this standard."

**Access.** Vehicle access to and from the dry hydrant shall be provided for fire truck and pumper units. Access shall have an all-weather surface, be well drained and be at least 12 feet wide for ease of movement by personnel and equipment during an emergency. When local road traffic may be involved, an all-weather road surface adjacent to the dry hydrant and completely off the public road is recommended for safety of the emergency personnel and the public.

**Protection.** After the dry hydrant installation, the site shall be graded for surface drainage and vegetated or otherwise protected from erosion. Vegetation shall be in accordance with Critical Area Planting Standard and Specification (342).

## **CONSIDERATIONS**

1. Effect of the use of the dry hydrant on upstream and downstream water quantity.
2. Sediment production caused by erosion during construction.
3. Possible effects on surface and ground water of spilled fuels and lubricants by fire trucks using the dry hydrant.
4. This practice has the potential to negatively affect National Register listed or eligible (significant) cultural resources (archaeological, historical or traditional cultural properties); it also has the potential to protect listed or eligible historic structures. Consider these factors during planning and also follow the NRCS State policy during construction and maintenance.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing dry hydrants shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. Required permits shall be obtained prior to initiating any work.

## **OPERATION AND MAINTENANCE**

Keeping the site clear of obstruction and regular mowing of the dry hydrant access area will be required to keep the area readily available for emergency use.

Pumper testing of the dry hydrant shall be done at least annually to verify site usability. This test shall include back flushing, followed by a pumper test at the maximum designed flow rate. Careful attention should be given to silt, debris, aquatic growth, or other interference that may limit the full operation of the dry hydrant.

Checks of the intake screen should be made once every five years to identify any sediment build up and to provide information for a clean-out operation or for aquatic growth control needs. The hydrant should be back-flushed each spring and fall to remove any silt or debris that may have accumulated on the screen.

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# EARLY SUCCESSIONAL HABITAT DEVELOPMENT/MANAGEMENT

(acre)  
CODE 647

## DEFINITION

Manage early plant succession to benefit desired wildlife or natural communities.

## PURPOSE

- Increase plant community diversity.
- Provide wildlife or aquatic habitat for early successional species.
- Provide habitat for declining species.

## CONDITIONS WHERE PRACTICE APPLIES

On all lands that are suitable for the kinds of wildlife and plant species that are desired.

## CRITERIA

- Early successional management will be designed to achieve the desired plant community in density, vertical and horizontal structure, and plant species diversity.
- Methods used will be designed to maintain soil erosion quality criteria.
- Vegetative manipulation to maximize plant and animal diversity can be accomplished by disturbance practices including; prescribed burning, light disking, mowing, grazing, or a combination of the above.
- This practice should be applied periodically to maintain the desired early successional plant community.
- Native adapted plant materials will be used whenever possible, but introduced species may be appropriate depending upon objectives.
- Management practices and activities are not to disturb cover during the primary nesting period for grassland species. Exceptions will be allowed for periodic burning or mowing when necessary to maintain the health of the plant community. Mowing may be needed during the plant establishment period to control weeds.
- Measures must be provided to control severe outbreaks of noxious weeds and other invasive species in order to comply with state noxious weed laws.
- To benefit insect food sources for grassland nesting birds, spraying or other control of noxious weeds will be done on a "spot" basis to protect forbs and legumes that benefit native pollinators and other wildlife.

## CONSIDERATIONS

All habitat manipulations will be planned and managed according to soil capabilities and recommendations for management will avoid excessive soil loss.

Early successional treatments should be rotated throughout the managed area.

Treatment shall be accomplished whenever succession has gone past the desired stages.

Managing for early successional plant communities is beneficial if not essential for less mobile animal species. The less mobile the species, the more important to provide all the habitat requirements in a small area.

Design and install the treatment layout to best facilitate operation of all machinery used on the strips or to make easily controlled burning boundaries. Whenever possible, lay out strips to have some multiple or full width passes by all farm implements.

Grazing may be used as a management tool to achieve the intended purpose of this practice. A grazing plan is required.

This practice may be used to promote the conservation of declining species, including threatened and endangered (plant, wildlife or aquatic) species.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance).

Any use of fertilizers, pesticides and other chemicals to assure early successional management shall not compromise the intended purpose.

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**FENCE**  
**(Feet)**  
**CODE 382**

**DEFINITION**

A constructed barrier to livestock, wildlife or people.

**PURPOSES**

This practice may be applied as part of a conservation management system to facilitate the application of conservation practices that treat the soil, water, air, plant animal and human resource concerns.

**CONDITIONS WHERE THIS PRACTICE APPLIES**

This practice may be applied on any area where livestock and/or wildlife control is needed, or where access to people is to be regulated. Fences are not needed where natural barriers will serve the purpose.

**CRITERIA**

Fencing materials shall be of a high quality and durability, and the construction performed to meet the intended management objectives.

Fences shall be positioned to facilitate management requirements.

Standard or conventional (barbed or smooth wire), suspension, woven wire, or electric fences shall consist of acceptable fencing designs to control the animal(s) or people of concern and meet the intended life of the practice.

Height, number, and spacing of wires will be installed to facilitate control and management of the animal(s) and people of concern.

Height, size, spacing and type of posts will be used that best provides the needs for the style of fence required and is best suited for the topography of the landscape.

**CONSIDERATIONS**

Consider installing fences in locations that will facilitate maintenance avoiding irregular terrain and/or water crossings.

Consider wildlife movement needs when locating fences.

Consider livestock management, handling, watering and feeding when locating fences.

Boundary fences shall comply with state laws and standards for construction.

Where applicable, clear right-of-ways will be established which will facilitate fence construction and maintenance.

Consider soil erosion potential when planning and constructing a fence on steep slopes.

## **PLANS AND SPECIFICATIONS**

Plans and specifications are to be prepared for specific field sites based on the NRCS National and State Fence Standards and appropriate state or local statutes or laws.

## **OPERATION AND MAINTENANCE**

Regular inspection of fences should be part of an on-going management program. Inspection of fences after storm events is needed to facilitate the function of the intended use of the fence.

Maintenance and repairs will be performed as needed to facilitate the intended operation of the installed fence.

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**FIELD BORDER**  
(Feet)  
CODE 386

**DEFINITION**

A strip of permanent vegetation established at the edge or around the perimeter of a field.

**PURPOSES**

- Reduce erosion from wind and water
- Soil and water quality protection
- Management of harmful insect populations
- Provide wildlife food and cover

**CONDITIONS WHERE PRACTICE APPLIES**

At the edges of cropland fields and to connect other buffer practices within the field. May also apply to recreation land or other land uses where agronomic crops are grown.

**CRITERIA**

**General Criteria Applicable To All Purposes**

Minimum field border widths shall be based on local design criteria specific to the purpose or purposes for installing the practice.

The field borders will be established to adapted species of permanent grass, legumes, and/or shrubs.

Field borders will be established around the field edges to the extent needed to meet the resource needs and producer objectives.

Plant material, seedbed preparation, seeding rates, dates, depths, and planting methods will be consistent with approved local criteria.

Ephemeral gullies and rills present in the planned border area will be smoothed as part of seedbed preparation.

**Additional Criteria To Reduce Erosion From Wind And Water**

Wind Erosion Reduction

Locate borders around the entire perimeter of the field, or as a minimum, provide a stable area on the upwind edge of the field as determined by prevailing wind direction data.

Plant stiff-stemmed, upright grasses to trap saltating soil particles.

Minimum height of grass shall be one foot during the critical erosion period.

### Water Erosion Reduction

Locate borders around entire perimeter of the field, or as a minimum, install borders to eliminate sloping end rows, headlands, and other areas where concentrated water flows will enter or exit the field.

### **Additional Criteria To Protect Soil And Water Quality**

#### Reducing Runoff and Increasing Infiltration

Locate borders around entire perimeter of the field, or as a minimum, install borders to eliminate sloping end rows, headlands and other areas where concentrated water flows will enter or exit the field.

#### Maintaining Field Setback Distances For Manure and Chemical Applications

Border widths will be designed to conform to minimum field application setback widths established by state or local regulations.

#### Sediment Trapping

Locate borders around the entire perimeter of the field, or as a minimum, in areas where runoff enters or leaves the field.

#### Reducing Soil Compaction from Equipment Parking and Traffic

Border widths will be designed to accommodate equipment parking, loading/unloading equipment, grain harvest operations, etc.

### **Additional Criteria For Management Of Harmful Insect Populations.**

#### Provide a Harbor For Beneficial Insects

Include herbaceous plants that attract beneficial insects. See planning considerations for including shrubs.

Mowing, harvesting, and pesticide applications will be scheduled to accommodate life cycle requirements of the beneficial insects.

or

#### Provide a Habitat to Cause Pest Insects to Congregate

Select plants for the field border that attract pest insects.

Use mechanical, cultural, and/or chemical techniques to reduce pest populations when and where they congregate in the field border.

### **Additional Criteria To Provide Wildlife Food And Cover**

Plants that provide wildlife food and cover shall be used.

Mowing, harvest, and weed control activities within the field border will be scheduled to accommodate reproduction and other requirements of target wildlife species.

## **PLANNING CONSIDERATIONS**

Field borders are more effective and provide more environmental benefits when planted around the entire field.

Field borders enhance the aesthetics and provide stability around the field edge. They also provide turn and travel areas for equipment and reduce airborne dust

To increase trapping efficiency, consider establishing a narrow strip of stiff-stemmed upright grass at the crop/field border interface.

Field borders can be used to comply with required field setback distances applicable to manure and chemical applications.

Wildlife enhancement and other benefits of native plants should be discussed during planning.

Native species should be used when feasible and meet producer objectives.

Consider overseeding the border with legumes for plant diversity and wildlife benefits.

Schedule mowing, harvesting, and weed control to accommodate wildlife nesting needs and other special requirements or purposes.

Waterbars or berms may be needed to breakup or redirect concentrated water flows within the borders.

If bank stabilization is a concern, select fibrous deep-rooted plants.

Consider plants tolerant to sediment deposition and chemicals planned for application.

Rows of shrubs (windbreak/shelterbelt, 380) adjacent to field borders will often enhance field borders ability to harbor beneficial insects, and may also provide additional wildlife benefits.

If installation or maintenance of the practice has potential of affecting cultural resources (Archaeological, historic, historic landscape, or traditional cultural properties), follow NRCS state policy for considering cultural resources.

## **PLANS AND SPECIFICATIONS**

Plans and specifications are to be prepared for the practice site. The following items should be specified. A job sheet is available to document these items:

- Border widths and lengths based on local design criteria
- Location within the field or farm boundary
- Vegetation to be used
- Site preparation
- Planting method
- Liming or fertilizer requirements
- Operation and maintenance requirements

## **OPERATION AND MAINTENANCE**

Field borders require careful management and maintenance for performance and longevity.

The following will be planned and applied as needed:

- Storm damage repair
- Sediment removal - when 6 inches of sediment have accumulated at the field border/cropland interface
- Shut off sprayers and raise tillage equipment to avoid damage to field borders
- Shape and reseed border areas damaged by chemicals, tillage or equipment traffic
- Fertilize, mow, harvest, and control noxious weeds to maintain plant vigor
- Ephemeral gullies and rills that develop in the border will be filled and reseeded.

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# **FILTER STRIP**

**(ACRES)**  
**CODE 393**

## **DEFINITION**

A strip or area of herbaceous vegetation situated between cropland, grazing land, or disturbed land (including forest land) and environmentally sensitive areas.

## **PURPOSE**

- To reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in runoff
- To reduce dissolved contaminant loadings in runoff
- To serve as Zone 3 of a Riparian Forest Buffer, Practice Standard 391
- To reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in surface irrigation tailwater
- To restore, create or enhance herbaceous habitat for wildlife and beneficial insects.
- To maintain or enhance watershed functions and values

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies

1. in areas situated below cropland, grazing land, or disturbed land (including forest land)
2. Where sediment, particulate organic matter and/or dissolved contaminants may leave these areas and are entering environmentally sensitive areas
3. In areas where permanent vegetative establishment is needed to enhance wildlife and beneficial insects, or maintain or enhance watershed function.

This practice applies when planned as part of a conservation management system.

## **CRITERIA**

### **General criteria applicable to all purposes**

Filter strips shall be designated as vegetated areas to treat runoff and are not part of the adjacent cropland rotation.

Overland flow entering the filter strip shall be primarily sheet flow. Concentrated flow shall be dispersed.

State listed noxious weeds will not be established in the filter strip and will be controlled if present.

Filter strip establishment shall comply with local, state and federal regulations.

### **Additional criteria to reduce sediment, particulate organics, and sediment-adsorbed contaminant loadings in runoff**

Filter strip flow length shall be determined based on field slope percent and length, and filter strip slope percent, erosion rate, amount and particle size distribution of sediment delivered to the filter

strip, density and height of the filter strip vegetation, and runoff volume associated with erosion producing events. The minimum flow length for this purpose shall be 20 feet.

Filter strip location requirements:

- a) The filter strip shall be located along the downslope edge of a field or disturbed area. To the extent practical it shall be placed on the approximate contour. Variation in placement on the contour should not exceed a 0.5% longitudinal (perpendicular to the flow length) gradient.
- b) The drainage area above the filter strip shall have greater than 1% but less than 10% slopes.
- c) The ratio of the drainage area to the filter strip area shall be less than 70:1 in regions with RUSLE-R factor values 0-35, 60:1 in regions with RUSLE-R factor values 35-175, and 50:1 in regions with RUSLE-R factor values of more than 175.
- d) The average annual sheet and rill erosion rate above the filter strip shall be less than 10 tons per acre per year

The filter strip shall be established to permanent herbaceous vegetation consisting of a single species or a mixture of grasses, legumes and/or other forbs adapted to the soil, climate, and nutrients, chemicals, and practices used in the current management system. Species selected shall have stiff stems and a high stem density near the ground surface. Stem density shall be such that the stem spacing does not exceed 1 inch.

#### **Additional criteria to reduce dissolved contaminants in runoff**

The criteria given in "Additional criteria to reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in runoff" also apply to this purpose.

Filter strip flow length required to reduce dissolved contaminants in runoff shall be based on management objectives, contaminants of concern, and the volume of runoff from the filter strip's drainage area compared with the filter strip's area and infiltration capacity.

The flow length determined for this purpose shall be in addition to the flow length determined for reducing sediment, particulate organics, and sediment-adsorbed contaminant loadings in runoff. The minimum flow length for this purpose shall be 30 feet.

#### **Additional criteria to serve as Zone 3 of a Riparian Forest Buffer, Practice Standard 391**

Except for the location requirements, the criteria given in "Additional criteria to reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in runoff" also apply to this purpose.

If concentrated flows entering Zone 3 are greater than the filter strip's ability to disperse them, other means of dispersal, such as spreading devices, must be incorporated.

#### **Additional criteria to reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in surface irrigation tailwater**

Filter strip vegetation may be a small grain or other suitable annual with a plant spacing that does not exceed 4 inches.

Filter strips shall be established early enough prior to the irrigation season so that the vegetation can withstand sediment deposition from the first irrigation.

The flow length shall be based on management objectives.

### **Additional criteria to restore, create, or enhance herbaceous habitat for wildlife and beneficial insects**

If this purpose is intended in combination with one or more of the previous purposes, then the minimum criteria for the previous purpose(s) must be met. Additional filter strip flow length devoted to this purpose must be added to the length required for the other purpose(s).

Any addition to the flow length for wildlife or beneficial insects shall be added to the downhill slope of the filter strip. Vegetation to enhance wildlife may be added to that portion of the filter strip devoted to other purposes to the extent they do not detract from its primary functions.

Plant species selected for this purpose shall be for permanent vegetation adapted to the wildlife or beneficial insect population(s) targeted.

If this is the only purpose, filter strip width and length shall be based on requirements of the targeted wildlife or insects. Density of the vegetative stand established for this purpose shall consider targeted wildlife habitat requirements and encourage plant diversity. Dispersed woody vegetation may be used to the extent it does not interfere with herbaceous vegetative growth, or operation and maintenance of the filter strip.

The filter strip shall not be mowed during the nesting season of the target wildlife.

Livestock and vehicular traffic in the filter strip shall be excluded during the nesting season of the target species.

### **Additional criteria to maintain or enhance watershed functions and values**

Filter strips shall be strategically located to enhance connectivity of corridors and non-cultivated patches of vegetation within the watershed.

Filter strips should be strategically located to enhance aesthetics of the watershed.

Plant species selected for this purpose shall be for establishment of permanent vegetation.

## **CONSIDERATIONS**

Filter strips should be strategically located to reduce runoff, and increase infiltration and ground water recharge throughout the watershed.

Filter strips for the single purposes of wildlife/beneficial insect habitat or to enhance watershed function should be strategically located to intercept contaminants thereby enhancing the water quality of the watershed.

To avoid damage to the filter strip consider using vegetation that is somewhat tolerant to herbicides used in the upslope crop rotation.

Consider using this practice to enhance the conservation of declining species of wildlife, including those that are threatened or endangered.

Consider using this practice to protect National Register listed or eligible (significant) archaeological and traditional cultural properties from potential damaging contaminants.

Filter strip size should be adjusted to a greater flow length to accommodate harvest and maintenance equipment.

## **PLANS AND SPECIFICATIONS**

Based on this standard, plans and specifications shall be prepared for each specific field site where a filter strip will be installed. A plan includes information about the location, construction sequence, vegetation establishment, and management and maintenance requirements.

Specifications will include:

- a) Length, width, and slope of the filter strip to accomplish the planned purpose (length refers to flow length across the filter strip).
- b) Species selection and seeding or sprigging rates to accomplish the planned purpose
- c) Planting dates, care, and handling of the seed to ensure that planted materials have an acceptable rate of survival
- d) A statement that only viable, high quality, and regionally adapted seed will be used
- e) Site preparation sufficient to establish and grow selected species

## **OPERATION AND MAINTENANCE**

For the purposes of filtering contaminants, permanent filter strip vegetative plantings should be harvested as appropriate to encourage dense growth, maintain an upright growth habit, and remove nutrients and other contaminants that are contained in the plant tissue.

Control undesired weed species, especially state-listed noxious weeds.

Prescribed burning may be used to manage and maintain the filter strip when an approved burn plan has been developed.

Inspect the filter strip after storm events and repair any gullies that have formed, remove unevenly deposited sediment accumulation that will disrupt sheet flow, reseed disturbed areas, and take other measures to prevent concentrated flow through the filter strip

Apply supplemental nutrients as needed to maintain the desired species composition and stand density of the filter strip.

To maintain or restore the filter strip's function, periodically regrade the filter strip area when sediment deposition at the filter strip-field interface jeopardizes its function, and then reestablish the filter strip vegetation, if needed. If wildlife habitat is a purpose, destruction of vegetation within the portion of the strip devoted to that purpose should be minimized by regrading only to the extent needed to remove sediment and fill concentrated flow areas.

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# **FIREBREAK**

(Feet)  
CODE 394

## **DEFINITION**

A strip of bare land or vegetation that retards fire.

## **PURPOSES**

To protect soil, water, air, plant, animal and human resources by preventing spread of wildfire or to control prescribed burns.

## **CONDITIONS WHERE PRACTICE APPLIES**

All land uses where protection from wildfire is needed or prescribed burning is applied.

## **CRITERIA**

Firebreaks may be temporary or permanent and shall consist of fire-resistant vegetation, non-flammable materials, bare ground, or a combination.

Firebreaks will be of sufficient width and length to contain the fire.

Firebreaks shall be located to minimize risk to the resources being protected.

Species selection will be based on their attributes in retarding fire and ease of maintenance.

Erosion control measures shall prevent sediment from leaving the site.

Comply with applicable laws and regulations, including the state's Best Management Practices (BMPs).

## **CONSIDERATIONS**

Use existing barriers such as streams, lakes, ponds, rock cliffs, roads, drainage canals, railroads, utility right-of-way, and cultivated land as natural firebreaks.

Locate firebreaks on the contour where possible to minimize risk of soil erosion.

Attempt to locate firebreaks near ridge crests and valley bottoms. If winds are predictable, firebreaks should be located perpendicular to the wind and on the windward side of the area to be protected.

Select plant species that provide wildlife habitat if compatible with purpose.

## **PLANS AND SPECIFICATIONS**

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Mow or graze vegetative firebreaks to avoid a build-up of dead litter and to control weeds. Inspect for and remove woody materials such as dead limbs and blown down trees from firebreak.

Inspect annually and rework bare ground firebreaks as necessary to keep them void of flammable vegetation.

Inspect annually and rework erosion control measures as necessary to ensure proper function.

Access by vehicles or people will be controlled to prevent damage to the firebreak.

Bare ground firebreaks which are no longer needed will be stabilized.

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# FISH RACEWAY OR TANK

(m, ft and m<sup>3</sup>/s, ft<sup>3</sup>/s)  
CODE 398

## DEFINITION

A channel or tank with a continuous flow of water constructed or used for high-density fish production.

## SCOPE

This standard applies to raceways or tanks that conduct flowing water to produce fish. It applies to earthen channels as well as those channels and tanks constructed of concrete, concrete block, timber, rock, fiberglass, or other materials. It does not apply to hatchery operations that utilize troughs or barrels and are primarily indoors.

## PURPOSE

To provide a facility containing flowing water of suitable temperature and quality for dependable production of fish; to manipulate the chemical, physical, and biological factors to enhance fish production, and to maintain water quality.

## CONDITIONS WHERE PRACTICE APPLIES

Where water and land resources are suitable for constructing a raceway or tank that can be used to produce a commercial fish crop.

## PLANNING CONSIDERATIONS

The cooperator's objective as well as the limitations and potentials of available aquaculture resources will dictate the level of development and management to be planned. An aquaculture resource assessment must be made to determine the feasibility of the raceway or tank culture system. Planning is complete when all practice components essential to reaching the cooperators management objectives and maintaining the water resource have been identified.

## DESIGN CRITERIA

The facility must be designed to provide protection from flooding, sedimentation and contamination by pollutants from outside sources.

Fish raceways are generally constructed as 1) linear channels where water flows in at one end and exits at the other end or 2) as circular, rectangular, or oval tanks where water enters through nozzles or jets in a manner that creates a rotary circulation within the tank and discharge typically is through the tank center by means of a standpipe or bottom drain. The raceway dimensions shall be designed based upon the available water and planned production level.

## WATER REQUIREMENTS

**A Quantity** — A water supply of sufficient volume must be available either by gravity or by pumping. For linear raceways, there shall be a continuous incoming water supply to provide a minimum velocity of 0.015 m/s (0.05 ft/s) flowing at a minimum average depth of 0.6 m (2 ft).



**Bulkheads.** Structural or earthen barriers called bulkheads are to be placed across raceway channels to create shorter sections, to establish and maintain the desired water levels, and to provide aeration of the water. In addition to serving as a barrier, they shall have an opening or throat section that allows complete drainage to the bottom of the raceway channel unless other drainage facilities are provided. Bulkheads may be constructed of earth, concrete, concrete block, rock masonry, steel or other durable metal, treated timber, or combinations of these. Earthen bulkheads are to have a minimum top width of 1.2 m (4 ft) and side slopes of 2:1 or flatter. Structural bulkheads used in earthen raceways must extend at least 61.0 cm (24 in) into the sides and bottom of the channel. Concrete bulkheads shall have a minimum top width of 15 cm (6 in) and a minimum bottom width of 20 cm (8 in). Openings and cores in concrete blocks shall be filled with either concrete or mortar mix. The opening or throat section of bulkheads may be constructed of concrete, concrete block, wood, or metal. It shall have slots or grooves along the vertical face that allow flashboards and screens to be installed.

**Drains.** A pipe drain with minimum diameter of 15 cm (6 in) shall be provided at the bottom of the bulkhead unless flashboards used to establish the desired water level can be removed to provide complete drainage. Where possible, each unit in a series should be constructed so that it can be drained independently of the other units.

**Screens.** Screens shall be provided at the inlet of the system if necessary to exclude wild fish. Screens shall also be placed at each bulkhead between sections and at the exit end to prevent loss of fish. They shall be placed at least 15 to 20 cm (6 to 8 in) upstream from the flashboards and shall extend at least 15 to 20 cm (6 to 8 in) above the expected water level to prevent fish from escaping by jumping.

**Aeration.** Each bulkhead shall be fitted with a weir overfall. Flashboards in the opening or throat section of the bulkhead may be used for this purpose. The width of the weir or weirs should be equal to the bottom width of the raceway but shall not be less than 1.2 m (4 ft) where flashboards are used to establish the desired water level. Two or more weirs separated by rigid center sections shall be installed when the width of the raceway exceeds 2.4 (8 ft). To increase aeration, a splash board or series of boards arranged to create successive splashes shall be considered in design. The minimum distance from the weir crest to the water level below should be no less than 0.31 m (1 ft).

## TANK RACEWAYS

Tank raceways are circular, rectangular, or oval and are constructed of concrete, metal, fiberglass, or other suitable material. Fiberglass and a variety of similar materials commonly referred to as “plastic” tanks are generally suitable if construction and support are sufficient to provide strength and durability. Noncircular tanks must have an interior dividing wall to obtain proper circulation. Tank raceways shall be constructed at locations accessible to water supplies, management personnel, and feed and harvest equipment.

**Water supply.** Water inlets to the tank may be through jets or nozzles or similar devices that provide a tangential force to the water in the tank. These nozzles should be located above the water surface to provide aeration. They may be submerged but should not be near the bottom because of the problem of uplift of waste particles. The nozzles shall be positioned so that flow in the tank is counterclockwise to take advantage of the natural tendency for water in North America to rotate in this direction.

**Waste removal.** Provisions for waste removal shall be incorporated in the design. Bottom troughs, screens, or center-positioned drain pipe shall be provided as part of the tank construction.

## **FACTORS APPLICABLE TO RACEWAYS AND TANKS**

**Predators.** Fences, screens, nets, wires, or other materials shall be provided as needed to prevent the loss of fish to predators. Traps or other devices that are potentially harmful for humans, livestock, or pets shall be placed only in secure locations not normally accessible except through special effort.

**Waste treatment.** Plans for treatment or use of waste that are generated or caused by the operation of fish raceways or tanks shall be developed and made a part of the design and installation of the practice. The treatments will include the construction of waste storage ponds, storage structures, treatment lagoons, settling basins, or other facilities. Waste utilization by the spreading of waste on land through irrigation or hauling is permissible if soils and land resources are available. Discharges into streams must meet state standards for the stream, based on size operation, and comply with National Pollutant Discharge Elimination System (NPDES) regulations.

**Protection.** A protection cover of vegetation shall be established on all exposed surfaces that have been disturbed. If soil or climatic conditions preclude the use of vegetation, other methods may be used for protection. Adequate provisions must be made to protect earth surfaces from wave erosion. Fences shall be installed as necessary. Road surfaces along raceways and the outer perimeter of tanks shall be treated as needed to provide access and reduce erosion. Dikes and levees should be crowned to provide drainage.

## **OPERATION AND MAINTENANCE**

A plan shall be prepared that provides for inspection, operation, and maintenance of vegetation, pipes, valves, raceways, tanks, dikes, levees, bulkheads, and other parts of the system.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing raceways and tanks and their appurtenances shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **FISH RACEWAY OR TANK SPECIFICATIONS**

### **ENGINEERING SPECIFICATIONS**

**Clearing.** All trees, brush, logs, stumps, roots, loose boulders, or other debris shall be cleared from the raceway or tank construction area and from the area where fill is to be placed for dikes or levees. If needed to establish vegetation, the topsoil and sod shall be stockpiled and later spread on the completed surfaces.

**Excavation.** All excavation necessary for the construction of raceways, bulkheads, or tank foundation and footings shall be performed in a workmanlike manner to the lines and grades shown on the drawings or as staked in the field.

**Fill placement.** The material placed in the dikes or levees shall be free of sod, roots, frozen soil, boulders larger than 15 cm (6 in) in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation, and the fill shall be brought up in approximately horizontal layers of such thickness that the required compaction can be obtained with the equipment used.

**Compaction.** The moisture content of the fill material shall be adequate for obtaining the required compaction. Construction equipment shall be operated over each layer of fill to ensure that the required compaction is achieved. Earth fill placed in close proximity to structures and pipelines shall be compacted using hand tampers or manually operated power tampers or vibrators.

**Concrete.** Concrete shall receive the detail in mix design and testing consistent with the size and requirements of the job. Mix requirements or necessary strength should be specified. Type of cement, air entrainment, slump, aggregate, or other properties are to be specified where necessary.

All concrete is to be placed, finished, and cured in an acceptable manner. Reinforcing steel is to be placed as indicated on the plans and held securely in place during concrete placement. Subgrades and forms are to be installed to line and grade as shown in the drawings, and the forms are to be mortar tight and unyielding as the concrete is placed.

Concrete tanks shall have a minimum thickness of 15 cm (6 in) and shall be steel reinforced. They shall have concrete bottoms. All interior surfaces shall be smooth and treated with epoxy sealer or other suitable material to permit sterilization. Washing new concrete tanks with acetic acid is recommended.

**Wood construction and metal fabrication.** All untreated wood construction, metal fabrication, and other miscellaneous materials such as screens, flashboards, splashboards, and inlet structures that are used in small quantities and are readily replaceable shall be of durable quality. All fabrication of materials will have a good workmanlike appearance.

Metal tanks will be assembled or installed according to manufacturers recommendations. The interior surface will be painted or treated with an epoxy coating or other suitable material that will preserve the metal and be compatible with fish culture. Where the tank's interior surface is rough or contains fiberglass matting, it must be covered or sealed with an approved resin or sealer.

**Overall quality and workmanship.** Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution are minimized and held within legal limits. All work will be conducted in a skillful and workmanlike manner.

The completed job shall present a workmanlike appearance. Fencing and vegetative cover to control erosion and pollution shall be established as needed. Appropriate safety measures such as warning signs, rescue facilities, guardrails, and fencing shall be provided as specified.

## **BIOLOGY SPECIFICATIONS GUIDE**

The practice specifications shall include the minimum biological requirements of each aquaculture species that is to be grown under these types of culture systems. The limits of essential water quality parameters shall be defined for each cultured species.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on downstream flows and aquifers that would affect other water uses.
3. Effects on the volume of downstream flow that might cause undesirable environmental, social, or economic effects.

## Quality

1. Effects on the visual quality of downstream water resource.
2. Short-term and construction-related effects on the quality of the onsite and downstream water.
3. Effects on the movement of dissolved substances below the root zone and toward the ground water.
4. Effects on wetlands and water-related wildlife habitats.

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# FISH STREAM IMPROVEMENT

(ft)  
CODE 395

## DEFINITION

Improving a stream channel to make a new fish habitat or to enhance an existing habitat.

## PURPOSE

To increase the production of desired species of fish.

## CONDITIONS WHERE PRACTICE APPLIES

In streams where poor habitat limits production of desired species.

## SPECIFICATIONS GUIDE

Methods for providing or improving food supply, shelter, spawning areas, water quality, or other elements of fish habitat.

## PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

### Quantity

1. Effects on the water budget.

### Quality

1. Effects on channel erosion and the movement of sediment and soluble and sediment-attached substances that would be carried by runoff.
2. Effects on wetlands or water-related wildlife habitats.
3. Short-term and construction-related effects on the quality of water resources.
4. Effects on stream temperatures to provide desired effects for aquatic and wildlife communities.
5. Effects on the visual quality of water resources

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# FISHPOND MANAGEMENT

(No.)  
CODE 399

## DEFINITION

Developing or improving impounded water to produce fish for domestic use or recreation.

## PURPOSE

To improve or maintain fish production and fishery use by making a favorable water habitat, supplementing natural food supplies, and reducing competition from unwanted plants and animals.

## CONDITIONS WHERE PRACTICE APPLIES

In ponds, lakes, and reservoirs where a crop of fish is wanted.

## SPECIFICATIONS GUIDE

Kind, amount, and treatment needed for a particular purpose.

## PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

### Quantity

1. Effects on the water budget.

### Quality

1. Effects of pesticide and nutrient use and fish feeding on surface and ground water quality.
2. Effects on the movement of dissolved substances to ground water.
3. Effects on wetlands or water-related wildlife habitats.
4. Effects on the visual quality of water resources.

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# FLOODWATER DIVERSION

(ft)  
CODE 400

## DEFINITION

A graded channel with a supporting embankment or dike on the lower side constructed on lowland subject to flood damage.

## SCOPE

This standard applies to the construction of a channel and embankment to divert floodwater. It does not apply to Diversions (362) or Floodways (404).

## PURPOSE

To divert floodwater from lowlands by the construction of a graded channel on the lowlands.

## CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable if:

1. Floodwater originating outside the lowland area to be protected is causing damage to agricultural land, crops, or improvements or is expected to cause damage to improvements to be made in the area.
2. An adequate outlet for the design flow is available, either by gravity flow or by pumping. The outlet shall be suitable for the quality and quantity of water and sediment to be disposed of, with consideration of possible damages above or below the point of discharge that might involve legal actions under state law. The outlet can be a Floodway (404) or a natural channel, river, lake, bay, or tidal estuary.
3. Land to be protected is suitable for agriculture within its capabilities after installation of required conservation practices.

## DESIGN CRITERIA

**Location.** The floodwater diversion shall be located to protect the maximum area of lowland, consistent with economic limitations, topographic requirements, and the desired slope of the hydraulic gradeline.

In selecting the location for floodwater diversions, consideration shall be given to the preservation of existing fish and wildlife habitat, trees of significant value for wildlife food, dens or shelter, and existing visual resources.

**Capacity.** Floodwater diversions that are to protect agricultural land shall have the capacity to carry the peak runoff to be expected from a 10-year frequency storm. If farmsteads, public roads, or other improvements are within the area to be protected, the design capacity shall be consistent with the hazard involved but shall not be less than the peak flow from a 25-year frequency storm.

**Hydraulic gradeline.** The hydraulic gradeline of the floodwater diversion shall tie in to the elevation of water in the outlet expected for the frequency storm selected for design, and shall be established with due regard for damages that may occur on the opposite side of the floodwater

diversion from the supporting embankment. It shall have a slope in the direction of flow that will result in a velocity that will not cause excessive erosion or sedimentation.

**Cross section.** The design cross section shall be set below the design hydraulic gradeline and shall include the total cross-sectional area bounded by the embankment, the berm between embankment and channel, the channel, and the flow area on the opposite side of the channel from the embankment.

**Velocity.** If site conditions indicate that erosion is likely to be a hazard because of a higher velocity resulting from a lower roughness coefficient immediately after construction and before establishment of vegetation, such lower value of roughness coefficient shall be estimated. The resultant velocities shall be considered in designing the channel and planning protective measures. The criteria for Open Channels (582) regarding channel stability, velocity, and roughness coefficient shall be followed.

The maximum permissible design velocity shall be based on site conditions and determined by procedures described in TR-25, Planning and Design of Open Channels. A desirable minimum velocity is 1.5 ft/s. On flat grades where the design velocity is below this value, the cross section shall be adjusted to obtain the most efficient section that depth and maintenance methods permit.

**Berm and embankment.** The minimum berm width between channel and embankment shall be based on the depth of the channel.

Depth of channel	Minimum berm
<i>ft</i>	<i>ft</i>
2 - 4	4
4 - 6	6
6 - 8	10
More than 8	15

Wider berms than indicated should be used if site conditions permit.

The embankment may be constructed from the channel excavation or from suitable borrow.

The design height of the embankment shall be the design water depth plus a freeboard of at least 2 ft. The constructed height shall be the design height plus an allowance for settlement based on consideration of soil material and the anticipated compaction during construction, but such allowance shall be no less than 5 percent of the design height.

The minimum requirements for the cross section of the embankment where fill is compacted by hauling or special equipment shall be:

Design water height	Minimum top width	Steepest side slope
<i>ft</i>	<i>ft</i>	<i>ft</i>
0-6	6	1.5:1
6-12	8	2:1

If because of soils or water conditions it is impractical to compact the embankment with hauling or special equipment, dumped fill may be used. Dumped fill shall have minimum cross section dimensions incorporated within the fill as follows:

Design water height	Minimum top width	Steepest side slope
<i>ft</i>	<i>ft</i>	<i>ft</i>
0-6	10	2:1
6-12	14	2.5:1

Side slopes of 3:1 on waterside and 2:1 on landside may be used instead of 2.5:1 for both slopes.

**Vegetative cover.** If needed, an adequate cover of grasses shall be established on the embankment to protect it against erosion by flood flows, wave action, or rainfall and runoff. Seedbed preparation, seeding, sprigging or sodding, fertilizer, mulching, and fencing shall comply with recommendations in applicable technical guides.

**Maintenance access.** Maintenance access shall be provided as specified in the standard for Open Channels (582).

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing floodwater diversions shall be in keeping with this standard and shall describe the requirements for construction to achieve the intended purpose.

## FLOODWATER DIVERSION SPECIFICATIONS

### SITE PREPARATION

The entire width of the site for the floodwater diversion, including channel, berm, and embankment, shall be cleared of stumps, roots, brush, and debris and selectively cleared of trees and boulders. All channel banks and sharp breaks shall be sloped no steeper than 1:1 unless such sloping would likely result in changing a stable slope into an unstable slope. Topsoil high in organic matter shall be removed. The ground surface where the embankment is to be placed shall be thoroughly scarified before placement of the embankment material.

### EXCAVATION AND CONSTRUCTION OF EMBANKMENT

Excavation of the channel and placement of spoil in the embankment shall progress simultaneously from the outlet in an upstream direction. The channel shall be excavated to the lines and grades shown in the plans and as staked in the field, and the embankment shall be built to the dimensions specified in the plans and as staked in the field. If the excavation and fill required do not balance, the responsible technician shall specify the areas where borrow is to be obtained for fill or the place and manner of disposition of excess excavated material.

Construction operations shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.

Vegetation shall be established as specified in the plans.

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Effect on the water budget, especially on volumes and rates of runoff, evaporation, infiltration, deep percolation, and ground water recharge.
2. Effects of changes in plant growth and transpiration because of changes in the amount of soil water in the vicinity of the structure.
3. Effects of eliminating filling of depressions and potholes on the flood plain.

### **Quality**

1. Effects of the movement of sediment and soluble and sediment-attached substances or other toxics carried by runoff.
2. Effects of erosion, including the downstream stability of streambanks and streambeds.
3. Effects of changes in ground water contamination by soluble substances because of decreases in infiltrating floodwater.
4. Effects on the visual quality of downstream water resources.

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# **FLOODWAY**

(ft)  
**CODE 404**

## **DEFINITION**

A channel, usually bounded by dikes, used to carry flood flows.

## **PURPOSE**

To carry floodwater from a side drainage across a flood plain into the channel of a main stream. Floodways are also used along the course of a main stream where, by means of dikes, part of the flood plain is used to carry floodwater and the rest is protected.

## **CONDITIONS WHERE PRACTICE APPLIES**

1. Overflow areas of streams or rivers where existing channels are inadequate to carry the floodwaters without flooding and damaging property, and the design storm discharge can be confined between dikes or a combination of channel and dikes without causing excessive erosion.
2. Sites where the storm runoff from side tributaries that will be ponded outside the floodway will not cause damages in excess of the benefits less the cost of the project.

This practice does not apply to Floodwater Diversions (400) that divert water from lowlands. A floodwater diversion can empty into a floodway. This practice does not apply to channel improvement where the spoil is set back from the excavated areas and where no provision is made to confine the floodwater to the channel side of the spoil.

An outlet for the floodway must be available to provide for discharge of the quantity of water for which the floodway is to be designed without creating stage increases in the outlet that could result in damages above or below the point of discharge that might involve legal actions under state laws.

## **CLASSIFICATION**

In as much as a large percentage of floodways includes dikes as a major feature of the floodway, the same classification used for dikes is used for floodways. The classes are defined in the standard for Dikes (356).

Class I floodways:

1. Include Class I dikes as a feature of the floodway or
2. Are constructed to protect areas where either of the following conditions apply:
  - a. There is a possibility of loss of life should dike failure occur.
  - b. High-value land or improvements are to be protected.

Class II floodways:

1. Include Class II dikes as a feature of the floodway or
2. Are constructed to protect agricultural lands of medium to high capability; improvements are generally limited to farmsteads and allied farm facilities.

Class III floodways:

1. Include Class III dikes as a feature of the floodway or
2. Are constructed to protect agricultural lands of relatively low capability or improvements of relatively low value.

## DESIGN CRITERIA

The design and installation of a floodway and each of its features shall be based on engineering surveys and investigations that shall be made as recommended in applicable sections of the SCS National Engineering Handbook and in TR-25, "Planning and Design of Open Channels". Rates of flow resulting from runoff from the storm against which protection is to be provided and the design for stability of the channel included in the floodway shall be determined from and based on these investigations. Criteria for channel stability, velocity, and coefficient of roughness contained in the standard for Open Channels (582) shall be followed.

Proportioning of the width and depth of flow in the floodway shall be based on consideration of the area to be occupied by the floodway with respect to the area to be protected, requirements for entrance of side drainage into the floodway, stage of water in the outlet for the design storm, velocities in the floodway at design flow and requirements for stability of the channel and dikes, and the effect on the water surface profile upstream from the floodway.

In designing a floodway, the effect of future upstream floodway construction that will increase the peak rate of flow should be considered. Provisions for future enlargement of the floodway to take care of this increase may be warranted.

In selecting the location and design of a floodway careful consideration shall be given to the preservation of valuable fish and wildlife habitat and trees that are of significant value for wildlife food or shelter and to visual resources.

From an economic standpoint, the best design for a floodway, including channel improvement and the correct proportioning of the width of the floodway and the height of dikes, results in a minimum cost for the dikes, channel improvements, and the value of the unprotected land in the floodway. The value of the unprotected land for this analysis would be the difference in its value if it could be protected and its value for floodway purposes.

**Class I floodways.** Class I floodways shall be designed to provide maximum feasible protection. If urban protection is one of the primary objectives of a project or segment thereof, the project shall be planned to keep water out of the main part of the urban area if the largest flood of record were repeated. Such protection shall rarely be less than the 100-year-frequency level.

Dikes used or constructed as a part of Class I floodways shall meet SCS criteria established for Class I dikes.

**Class II floodways.** If dikes are included as a feature of Class II floodways, they shall meet SCS standards for Class II dikes, and the design criteria established thereby shall also apply to the floodway.

If dikes are not included in Class II floodways, the floodway shall have the capacity to carry the peak runoff from a 10-year-frequency storm as a minimum.

**Class III floodways.** If dikes are included as a feature of Class III floodways, they shall meet SCS standards for Class III dikes, and the design criteria established thereby shall also apply to the floodway.

If dikes are not included in Class III floodways, the floodway shall have the capacity to carry the design flow selected on the basis of a study of site conditions.

**Maintenance.** Provisions for maintenance shall be as specified in the standard for Open Channels (582).

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing floodways shall be in keeping with this standard and shall describe the essential requirements for properly installing each feature of the floodway to achieve the intended purpose.

## **FLOODWAY SPECIFICATIONS**

Construction shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.

The areas to be excavated or occupied by dikes or spoil banks shall be cleared of trees, brush, other vegetation, and debris. Other areas in the floodway to be cleared as part of the required improvement shall be specified. Clearing shall be done in such a manner that as little vegetation as possible outside the limits of the floodway is destroyed. Special efforts shall be made to save large trees in the floodway that have significant value for wildlife food or shelter or for visual resources of the site. Cleared debris shall be removed from the floodway and disposed of as specified.

Excavation shall be made as provided in the plans and specifications and as staked in the field. Spoils from excavations shall be disposed of as specified.

Dike (356) construction shall be in accordance with the standards for the particular class of dike, as provided in the plans and specifications and as staked in the field.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **QUANTITY**

1. Potential changes in runoff, infiltration of runoff water into soil, percolation below the root zone, and the amount of ground water recharge.
2. Effects of soil moisture changes on vegetation or land use in the vicinity of the floodway.

### **QUALITY**

1. Potential to reduce erosion and sedimentation; the effect of sedimentation on water quality, and sediment damage to flood plains, streambanks, and downstream channels.
2. Effects on the area's visual quality.

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# FORAGE HARVEST MANAGEMENT

(Acre)  
CODE 511

## DEFINITION

The timely cutting and removal of forages from the field as hay, green-chop, or ensilage.

## PURPOSES

- Optimize the economic yield of forage at the desired quality and quantity
- Promote vigorous plant regrowth
- Maintain stand life for the desired time period
- Maintain desired species composition of the stand
- Use forage plant biomass as a nutrient uptake tool
- Control insects, diseases and weeds
- Maintain and/or improve wildlife habitat

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where machine harvested forage crops are grown.

## CRITERIA

### General criteria applicable to all purposes

Forage will be harvested at a frequency and height that will maintain a desired healthy plant community through its life expectancy.

#### **a. Stage of Maturity**

Harvest forage at the stage of maturity that provides the desired quality and quantity. Delay harvest if prolonged or heavy precipitation is forecast that would seriously damage cut forage.

Where weather conditions make it difficult to harvest the desired quality of forage, use mechanical or chemical conditioners and/or ensile.

#### **b. Moisture Content**

Harvest silage/haylage crops at the ideal moisture range for the type of storage structure(s) being utilized.

Treat direct cut hay crop silage (moisture content > 70%) with chemical preservatives or add dry feed stuffs to avoid fermentation and seepage digestible dry matter losses.

For optimal forage quality, rake, ted, or invert swaths, and bale when hay has sufficient moisture to prevent leaf loss.

Bale at optimum moisture levels to preserve forage quality and quantity. Approximate percent moisture should be as follows:

- Bale field cured hay at 15 to 20 percent moisture.
- Bale forced air dried hay at 20 to 35 percent moisture.
- Rake hay at 30 to 40 percent moisture.
- Ted or invert swaths when moisture is above 40 percent.

### **c. Length of cut**

When harvested for ensilage forage will be chopped to a size that allows adequate packing to produce the anaerobic conditions necessary to ensure the proper ensiling process.

### **d. Contaminants**

Forage shall not contain contaminants at levels injurious to the health of the livestock class and type being fed.

Contaminants are any objectionable matter or toxin that can cause illness, death, or rejection of the offered forage.

### **Additional criteria to improve or maintain stand life, plant vigor, and forage species mix**

#### **a. Stage of Maturity and Harvest Interval**

Cut forage plants at a stage of maturity or harvest interval range that will provide adequate food reserves and/or basal or auxiliary tillers or buds for regrowth and/or reproduction to occur without loss of plant vigor.

Cut reseeding annuals at a stage of maturity and frequency that ensures the production of viable seed or ample carryover of hard seed to maintain desired stand density.

If plants show signs of short-term environmental stress, management will be applied in a manner that ensures continued health and vigor of stand.

#### **b. Stubble Height**

Cut forage plants at a height that will promote the vigor and health of the desired species. Cutting heights will provide adequate residual leaf area; adequate numbers of terminal, basal, or auxiliary tillers or buds; insulation from extreme heat or cold; and/or unsevered stem bases that store food reserves needed for full, vigorous recovery.

Manipulate timing and cutting heights of harvest to ensure germination and establishment of reseeding or seeded annuals.

### **Additional criteria to use as a nutrient uptake tool**

Employ a harvest regime that utilizes the maximum amount of available or targeted nutrients.

### **Additional criteria to control disease, insect, and weed infestations**

If a foliar disease, insects, or weeds threaten stand survival or production objective, schedule harvest periods as needed to control disease, insect, and weed infestations.

Lessen incidence of disease, insect damage, and weed infestation by managing for desirable plant vigor.

### **Additional criteria to improve wildlife habitat values**

Maintain appropriate harvest schedule(s), cover patterns, and plant height to provide suitable habitat for the desired specie(s).

## **CONSIDERATIONS**

When pastures produce forage in excess of livestock demand during high growth rate periods, consider preserving forage quality by machine harvesting a portion of the standing crop. Coordinate this practice with the Prescribed Grazing (528).

Well-fertilized plants withstand more intense harvest schedules and may produce a higher quantity and quality of forage. Coordinate this practice with the Nutrient Management (590). Select cultivars that are suitable for the harvest regime, species mix, and forage quality desired. For specific nutrient uptake, select species that can maximize uptake. See Pasture and Hay Planting (512).

When insect and disease outbreaks exceed economic thresholds and are uncontrollable by harvest management pesticide applications may be needed. Another option is to select a resistant cultivar when the stand is replaced. See Pest Management (595).

To control forage plant diseases, insects, and weeds, clean harvesting equipment after harvest and before storing. Do not cut forages until dew, rain, or irrigation water on leaves has evaporated.

When weed infestation exceeds the economic threshold and is uncontrollable by forage harvest management alone, weed management should be planned and applied.

Take care not to produce stored forages whose quality is not that needed for optimum performance of the animal being fed. For instance, immature legume forages can be too low in fiber and lead to metabolic disorders in ruminants and an economic loss to the producer due to lowered animal performance.

Direct cut grass and legume silage can create silage leachate (seepage). Consider the collection, storage, and disposal of this leachate as part of an agricultural waste management system.

In conjunction with harvest options, explore storage and feeding options that will retain acceptable forage quality and minimize digestible dry matter loss.

In regions where rainfall and/or humidity levels cause unacceptable forage quality losses in at least one harvest during the year, consider ensiling the forage to reduce or eliminate field drying time. Other options are: the use of desiccants, preservatives, conditioners, macerating implements, or barn curing techniques to reduce field drying time, greenchopping, or grazing. These techniques can improve the timeliness of harvest and preserve forage quality.

To reduce safety hazard, avoid operating harvesting and hauling equipment on field slopes over 25 percent, particularly on cross slope traffic patterns.

## **PLANS AND SPECIFICATIONS**

Place the detailed specifications in a site specific job or design sheet, or in the practice narrative in the conservation plan.

These plans and specifications shall be consistent with this standard and shall describe the requirement for applying the practice to achieve its intended purpose.

## **OPERATION AND MAINTENANCE**

Before forage harvest, clear fields of debris that could damage machinery, or if ingested by livestock, lead to sickness (for example, hardware disease) or death.

Monitor weather conditions and take action accordingly before and after cutting to optimize forage wilting or curing time to preserve feed quality and prevent forage swaths or windrows from smothering underlying plants.

Inspect and repair harvesting equipment following manufacturer's preventative maintenance procedures.

All shields shall be in place during machine operation to prevent injury or death. Shut off machinery before working on or unplugging moving parts.

Select equipment sizes and capacities that will in a timely and economically feasible manner handle the acreage normally harvested.

Operate all forage harvesting equipment at the optimum settings and speeds to minimize loss of leaves.

Set shear-plate on forage chopper to the proper theoretical cut for the crop being harvested. Keep knives well sharpened. Do not use recutters or screens unless forage moisture levels fall below recommended levels for optimum chopping action.

Regardless of silage/haylage storage method, ensure good compaction and an air-tight seal to exclude oxygen and mold formation.

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# **FOREST HARVEST TRAILS AND LANDINGS**

(Acre)  
CODE 655

## **DEFINITION**

Laying out, constructing and using forest harvest trails and landings.

## **PURPOSE**

To allow for removal of a forest product while minimizing onsite and off-site damage to resources.

## **CONDITIONS WHERE PRACTICE APPLIES**

On forested areas where harvest operations are scheduled.

## **CRITERIA**

Timing and use of equipment will be commensurate with site and soil conditions to maintain site productivity and minimize soil erosion, displacement and compaction.

Harvest trails and landings will be of a size, gradient, number and location to accomplish tree removal and transport while minimizing adverse onsite and off-sites impacts. Adverse impacts include, but are not limited to, accelerated erosion, riparian zone degradation, stream channel and streambank damage, or unacceptable damage to vegetation or habitat.

Slash, debris and vegetative material left on the site after harvesting will not present an unacceptable fire or pest hazard or interfere with the intended purpose.

Water bars, rolling dips and other drainage measures for trails shall be of sufficient size, intervals and gradient for adequate drainage and erosion control.

Trails and landings shall be sufficiently revegetated to control erosion.

Comply with applicable laws and regulations, including the state's Best Management Practices (BMPs).

## **CONSIDERATIONS**

Assure safe ingress and egress to site.

Locate landings and trails to preserve the aesthetic quality.

Police landings and trails to remove refuse and garbage.

Trails may be closed for erosion control, safety and liability, and reduced maintenance costs.

Landings and trails may be used for wildlife food and cover plantings.

## **PLANS AND SPECIFICATIONS**

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Watercourses and water quality shall be protected during and after removal and transport of trees. Upon completion of harvest, landings and trails will be left in a stable condition.

Periodic Inspections of landings and trails will be conducted with necessary repairs applied.

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# **FOREST SITE PREPARATION**

(Acre)  
CODE 490

## **DEFINITION**

Treating areas to encourage natural regeneration of desirable trees and shrubs or to permit artificial regeneration by planting or direct seeding.

## **PURPOSE**

To prepare land for establishing a stand of desirable woody vegetation by controlling undesirable vegetation, removing slash and debris, or altering site conditions.

## **CONDITIONS WHERE PRACTICE APPLIES**

In understocked areas, in areas where a land cover change to forest is desired, or in areas having undesirable vegetation that inhibits or competes with preferred woody species.

## **CRITERIA**

The method, intensity and timing of site preparation will match the limitations of the site, safety, and equipment and the requirements of the regeneration species.

An appropriate site preparation method will be chosen to protect any desirable vegetation in understocked areas.

Remaining slash and debris shall not create habitat for or harbor harmful levels of pests.

Remaining slash and debris shall not hinder needed equipment operations or create undue fire hazard.

Accelerated erosion and/or runoff from site preparation will be controlled by supporting practices.

Comply with applicable laws and regulations, including the state's Best Management Practices (BMPs).

## **CONSIDERATIONS**

The chosen method should be cost effective and protect cultural resources, wildlife habitat, springs, seeps, wetlands and other unique areas.

## **PLANS AND SPECIFICATIONS**

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

Plans and specifications will address species; method of preparation; and protection required for seed, seedlings, or cuttings; and protection of the site.

## **OPERATION AND MAINTENANCE**

Operation and maintenance requirements are not applicable for this practice.

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# FOREST STAND IMPROVEMENT

(Acre)  
CODE 666

## DEFINITION

To manipulate species composition and stocking by cutting or killing selected trees and understory vegetation.

## PURPOSES

- To improve or sustain timber production.
- Improve understory forage production, aesthetics, wildlife habitat, recreation, hydrologic conditions.
- To harvest forest products.
- To initiate forest stand regeneration.
- To achieve a combination of purposes.

## CONDITIONS WHERE PRACTICE APPLIES

On forest land where competing vegetation hinders development and stocking of preferred tree and understory species or where some or all of the stand will be cut or killed for intended purposes.

## CRITERIA

Preferred tree and understory species are identified and retained to achieve the intended purpose.

Spacing, density and amounts of preferred trees and understory species to be retained will follow established guidelines for the intended purposes. Such guidelines shall contain stocking in terms of basal area, spacing, or trees per acre by species and size class distribution.

The method, felling direction and timing of tree cutting for harvesting shall facilitate efficient and safe tree removal and protect riparian zones, unique areas, and structures.

Soil erosion, displacement and compaction, hydrologic impact and damage to remaining vegetation will not exceed acceptable levels.

Slash, debris and vegetative material left on the site after treatment will not present an unacceptable fire or pest hazard or interfere with the intended purpose.

The extent, size of treatment area or intensity of the practice shall not exceed acceptable levels for the intended purpose and cumulative ecosystem effects.

Comply with applicable laws and regulations, including the state's Best Management Practices (BMPs).

## **CONSIDERATIONS**

Timing of treatment and retaining dead or dying trees will minimize impacts on nesting wildlife. Wildlife food and cover can be retained by minimal modifications to composition and spacing regardless of the purpose for treatment. Forested wildlife corridors can minimize fragmentation effects.

## **PLANS AND SPECIFICATIONS**

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Operation and maintenance requirements are not applicable for this practice.

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# GRADE STABILIZATION STRUCTURE

(No.)  
CODE 410

## DEFINITION

A structure used to control the grade and head cutting in natural or artificial channels.

## SCOPE

This standard applies to all types of grade stabilization structures, including a combination of earth embankments and mechanical spillways and full-flow or detention-type structures. This standard also applies to channel side-inlet structures installed to lower the water from a field elevation, a surface drain, or a waterway to a deeper outlet channel. It does not apply to structures designed to control the rate of flow or to regulate the water level in channels (587).

## PURPOSE

To stabilize the grade and control erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to enhance environmental quality and reduce pollution hazards.

## CONDITIONS WHERE PRACTICE APPLIES

In areas where the concentration and flow velocity of water require structures to stabilize the grade in channels or to control gully erosion. Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable.

## DESIGN CRITERIA

The structure must be designed for stability after installation. The crest of the inlet must be set at an elevation that stabilize upstream head cutting.

**Embankment dams.** Class (a) dams that have a product of storage times the effective height of the dam of 3,000 or more, those more than 35 ft in effective height, and all class (b) and class (c) dams shall meet or exceed the requirements specified in Technical Release No. 60 (TR-60). Class (a) dams that have a product of storage times the effective height of the dam of less than 3,000 and an effective height of 35 ft or less shall meet or exceed the requirements specified for ponds (378).

The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.

**Pond size dams.** If mechanical spillways are required, the minimum capacity of the principal spillway shall be that required to pass the peak flow expected from a 24-hour duration design storm of the frequency shown in table 1, less any reduction because of detention storage.

Table 1. - Design criteria for establishing minimum capacity of the principal spillway for dams with storage capacity of less than 50 acre-feet.

Maximum drainage area for indicated rainfall <sup>1</sup>			Effective height Of dam	Frequency of minimum design, 24-hour duration storm
0-3 in.	3 - 5 in.	5+ in.		
-----acres-----			<i>ft</i>	<i>yr</i>
200	100	50	35 or less	2
400	200	100	20 or less	2
400	200	100	20 - 35	5
600	400	200	20 or less	5

\* In a 5-year frequency, 24-hour duration storm

If the effective height of the dam is less than 20 ft and the emergency spillway has a stable grade throughout its length with no overfalls and has good vegetation along its reentry into the downstream channel, the principal spillway capacity may be reduced but can be no less than 80 percent of the 2-year frequency, 24-hour duration storm.

If criteria values exceed those shown in table 1 or the storage capacity is more than 50 acre-ft, the 10-year frequency, 24-hour duration storm must be used as the minimum design storm.

Grade stabilization structures with a settled fill height of less than 15 ft and 10-year frequency, 24-hour storm runoff less than 10 acre-ft, shall be designed to control the 10-year frequency storm without overtopping. The mechanical spillway, regardless of size, may be considered in design and an emergency spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm. The embankment can be designed to meet the requirements for water and sediment control basins (638) rather than the requirements for ponds (378).

**Full-flow open structures.** Drop, chute, and box inlet drop spillways shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices, the National Engineering Handbook, and other applicable SCS publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table 2, less any reduction because of detention storage. If site conditions exceed those shown in table 2, the minimum design 24-hour storm frequency is 25 years for the principal spillway and 100 years for the total capacity. Structures must not create unstable conditions upstream or downstream. Provisions must be made to insure reentry of bypassed storm flows.

Toe wall drop structures can be used if the vertical drop is 4 ft or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is equal to or greater than one-third of the height of the overfall.

The ratio of the capacity of drop boxes to road culverts shall be as required by the responsible road authority or as specified in table 2 or 3, as applicable, less any reduction because of detention storage, whichever is greater. The drop box capacity (attached to a new or existing culvert) must equal or exceed the culvert capacity at design flow.

Table 2. - Design criteria for establishing minimum capacity of full-flow open structures.

Maximum drainage area for indicated rainfall*			Vertical drop	Frequency of minimum design, 24-hour duration storm	
0 - 3 in.	3 - 5 in.	5+ in.		Principal spillway capacity	Total capacity
-----acres-----			ft	yr	yr
	---				
1,200	450	250	5 or less	5	10
2,200	900	500	10 or less	10	25

\* In a 5-year frequency, 24-hour duration storm.

Table 3. - Design criteria for establishing minimum capacity of side-inlet, open weir, or pipe-drop-drainage structure.

Maximum drainage area for indicated rainfall*			Vertical drop	Frequency of minimum design, 24-hour duration storm	
0 - 3 in.	3 - 5 in.	5+ in.		Receiving channel depth	Total capacity
-----acres-----			ft	ft	yr
	---				
1,200	450	250	0 - 5	0 - 10	--
1,200	450	250	5 - 10	10 - 20	10
2,200	900	500	0 - 10	0 - 20	25

\* In a 5-year frequency, 24-hour duration storm.

**Island-type structures.** If the mechanical spillway is designed as an island-type structure, its minimum capacity shall equal the capacity of the downstream channel. For channels with very small drainage areas, the mechanical spillway should carry at least the 2-year, 24-hour storm or the design drainage curve runoff. The minimum emergency spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table 2 for total capacity without overtopping the headwall extensions of the mechanical spillway. Provision must be made for safe reentry of bypassed flow as necessary.

**Side-inlet drainage structures.** The design criteria for minimum capacity of open-weir or pipe structures used to lower surface water from field elevations or lateral channels into deeper open channels are shown in table 3. The minimum principal spillway capacity shall equal the design drainage curve runoff for all conditions. If site condition values exceed those shown in table 3, the 50-year frequency storm shall be used for minimum design of total capacity.

**Landscape resources.** In highly visible public areas and those associated with recreation, careful considerations should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Shorelines can be shaped and islands created to add visual interest and valuable wildlife habitat. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

**General criteria.** Earth embankment and emergency spillways of structures for which criteria are not provided under the standard for ponds (378) or in TR-60 must be stable for all anticipated conditions. If earth spillways are used, they must be designed to handle the total capacity flow indicated in tables 2 or 3 without overtopping the dam. The foundation preparation, compaction,

top width, and side slopes must ensure a stable dam for anticipated flow conditions. Discharge from the structure shall be sufficient that no crop damage results from flow detention.

Necessary sediment storage capacity must equal the expected life of the structure, unless a provision is made for periodic cleanout.

The earth embankment pond structures are potentially hazardous and precautions must be taken to prevent serious injury or loss of life. Protective guardrails, warning signs, fences, or lifesaving equipment shall be added as needed.

If the area is used for livestock, the structures, earthfill, vegetated spillways, and other areas should be fenced as necessary to protect the structure. Near urban areas, fencing may be necessary to control access and exclude traffic that may damage the structure or to prevent serious injury or death to trespassers.

**Protection.** The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded or sodded as necessary to prevent erosion. If climatic conditions preclude the use of vegetation, nonvegetative coverings such as gravel or other mulches may be used.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing grade stabilization structures shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on volumes and rates of runoff, evaporation, deep percolation and ground water recharge.
2. Effects of the structure on soil water and resulting changes in plant growth and transpiration.

### **Quality**

1. Ability of structure to trap sediment and sediment-attached substances carried by runoff.
2. Effect of structure on the susceptibility of downstream stream banks and stream beds to erosion.
3. Effects of the proposed structure on the movement of dissolved substances to ground water.
4. Effects on visual quality of downstream water resources.

## **EFFICIENCIES**

Silt fencing has been shown to adequately reduce steep grade erosion, although it has to be maintained well. In 1993, W&H Pacific reported sediment reduction averages ranging between 36 and 65% on silt fences located at the toe of a slope. This is rather low, however, with proper installation and maintenance, Goldman, in 1986, reported sediment removal rates ranging from 75 to 86%.

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# GRASSED WATERWAY

(Acre)  
CODE 412

## DEFINITION

A natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation.

## PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

- To convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding
- To reduce gully erosion
- To protect/improve water quality.

## CONDITIONS WHERE PRACTICE APPLIES

In areas where added water conveyance capacity and vegetative protection are needed to control erosion resulting from concentrated runoff and where such control can be achieved by using this practice alone or combined with other conservation practices.

## CRITERIA

### General Criteria Applicable to All Purposes

Grassed waterways shall be planned, designed, and constructed to comply with all Federal, State, and local laws and regulations.

**Capacity.** The minimum capacity shall be that required to convey the peak runoff expected from a storm of 10-year frequency, 24-hour duration. When the waterway slope is less than 1 percent, out-of-bank flow may be permitted if such flow will not cause excessive erosion. The minimum in such cases shall be the capacity required to remove the water before crops are damaged.

**Velocity.** Design velocities shall not exceed those obtained by using the procedures, “n” values, and recommendations in the NRCS Engineering Field Handbook (EFH) Part 650, Chapter 7, or Agricultural Research Service (ARS) Agricultural Handbook 667, Stability Design of Grass-lined Open Channels.

**Width.** The bottom width of trapezoidal waterways shall not exceed 100 feet unless multiple or divided waterways or other means are provided to control meandering of low flows.

**Side slopes.** Side slopes shall not be steeper than a ratio of two horizontal to one vertical. They shall be designed to accommodate the equipment anticipated to be used for maintenance and tillage/harvesting equipment that will cross the waterway.

**Depth.** The minimum depth of a waterway that receives water from terraces, diversions, or other tributary channels shall be that required to keep the design water surface elevation at, or below

the design water surface elevation in the tributary channel, at their junction when both are flowing at design depth.

Freeboard above the designed depth shall be provided when flow must be contained to prevent damage. Freeboard shall be provided above the designed depth when the vegetation has the maximum expected retardance.

**Drainage.** Designs for sites having prolonged flows, a high water table, or seepage problems shall include Subsurface Drains (NRCS Practice Code 606), Underground Outlets (NRCS Practice Code 620), Stone Center Waterways or other suitable measures to avoid saturated conditions.

**Outlets.** All grassed waterways shall have a stable outlet with adequate capacity to prevent ponding or flooding damages. The outlet can be another vegetated channel, an earthen ditch, a grade-stabilization structure, filter strip or other suitable outlet.

**Vegetative Establishment.** Grassed waterways shall be vegetated according to NRCS Conservation Practice Standard Critical Area Planting, Code 342. Seedbed preparation, time of seeding, mixture rate, stabilizing crop, mulching, or mechanical means of stabilizing, fertilizer, and lime requirements shall be specified for each applicable area.

Establish vegetation as soon as conditions permit. Use mulch anchoring, nurse crop, rock, straw or hay bale dikes, filter fences, or runoff diversion to protect the vegetation until it is established.

## **CONSIDERATIONS**

Important wildlife habitat, such as woody cover or wetlands, should be avoided or protected if possible when siting the grassed waterway. If trees and shrubs are incorporated, they should be retained or planted in the periphery of grassed waterways so they do not interfere with hydraulic functions. Mid- or tall bunch grasses and perennial forbs may also be planted along waterway margins to improve wildlife habitat. Waterways with these wildlife features are more beneficial when connecting other habitat types; e.g., riparian areas, wooded tracts and wetlands. Water-tolerant vegetation may be an alternative on some wet sites.

Use irrigation in dry regions or supplemental irrigation as necessary to promote germination and vegetation establishment.

Provide livestock and vehicular crossings as necessary to prevent damage to the waterway and its vegetation.

Establish filter strips on each side of the waterway to improve water quality.

Add width of appropriate vegetation to the sides of the waterway for wildlife habitat.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for grassed waterways shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s).

## **OPERATION AND MAINTENANCE**

An operation and maintenance plan shall be provided to and reviewed with the landowner. The plan shall include the following items and others as appropriate.

A maintenance program shall be established to maintain waterway capacity, vegetative cover, and outlet stability. Vegetation damaged by machinery, herbicides, or erosion must be repaired promptly.

Seeding shall be protected from concentrated flow and grazing until vegetation is established. Minimize damage to vegetation by excluding livestock whenever possible, especially during wet periods.

Inspect grassed waterways regularly, especially following heavy rains. Damaged areas will be filled, compacted, and seeded immediately. Remove sediment deposits to maintain capacity of grassed waterway.

Landowners should be advised to avoid areas where forbs have been established when applying herbicides. Avoid using waterways as turn-rows during tillage and cultivation operations. Prescribed burning and mowing may be appropriate to enhance wildlife values, but must be conducted to avoid peak nesting seasons and reduced winter cover.

Mow or periodically graze vegetation to maintain capacity and reduce sediment deposition. Control noxious weeds.

Do not use as a field road. Avoid crossing with heavy equipment when wet.

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# **GRAZING LAND MECHANICAL TREATMENT**

(Acre)  
CODE 548

## **DEFINITION**

Modifying physical soil and/or plant conditions with mechanical tools by treatments such as; pitting, contour furrowing, and ripping or sub-soiling.

## **PURPOSES**

This practice should be applied as part of a conservation management system to support one or more of the following purposes:

- Fracture compacted soil layers and improve soil permeability.
- Reduce water runoff and increase infiltration.
- Break up sod bound conditions and thatch to increase plant vigor.
- Renovate and stimulate plant community for greater productivity and yield.

## **CONDITIONS WHERE THIS PRACTICE APPLIES**

This standard may be applied on pastureland, rangeland, grazed forest, and native pastures.

## **CRITERIA**

### **General Criteria Applicable For All The Purposes Stated Above.**

Mechanical treatments such as contour furrowing, pitting, ripping or subsoiling shall be designed and applied in a manner to accomplish the desired objectives and address the natural resource concerns. These treatments shall be limited to soils and slopes where surface disturbances will not result in unacceptable levels of soil erosion and/or sedimentation.

Areas to be treated shall be relatively free of undesirable or noxious plants that are likely to increase because of surface disturbance.

If natural plant community is desired, desirable forage species shall be of sufficient quantity and have a distribution pattern that allows the plants to take advantage of the improved moisture and to spread into disturbed areas.

Adequate rest from grazing shall be applied to ensure desired plant responses from this treatment.

## **CONSIDERATIONS**

Range Planting and Pasture and Hay Planting may be used in conjunction with Grazing Land Mechanical Treatment.

Mechanical treatment may not be desirable on areas to be used for recreation due to enhanced surface roughness of the site.

All treatments should be planned on the contour when conditions warrant.

## **PLANS AND SPECIFICATIONS**

Specifications for installation of Grazing Land Mechanical Treatment shall be prepared for each site or planning unit according to the criteria. Specifications shall be recorded using state developed specification sheets, job sheets, narrative statements in conservation plans, or other acceptable documents.

## **OPERATION AND MAINTENANCE**

Implementation of a good prescribed grazing plan will assist in the long term operation and maintenance of this practice. If the desired effects of this practice is lost over time, the practice may need to be repeated.

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# HEAVY USE AREA PROTECTION

(acre)  
CODE 561

## DEFINITION

Protecting heavily used areas by establishing vegetative cover, by surfacing with suitable materials, or by installing needed structures.

## SCOPE

This standard does not include critical area planting (342) or recreation area improvement (562).

## PURPOSE

To stabilize urban, recreation, or facility areas frequently and intensely used by people, animals, or vehicles.

## CONDITIONS WHERE PRACTICE APPLIES

On urban and recreation areas or other frequently and intensely used areas that require special treatment to protect them from erosion or other deterioration.

## DESIGN CRITERIA

**Drainage and erosion control.** Provision shall be made for surface and subsurface drainage, as needed, and for disposal of runoff without causing erosion.

**Base course.** All areas to be paved shall have a 6-in. base course of gravel, crushed stone, or other suitable materials. The material in place may be used if it is adequate.

Areas that support automobile traffic shall be designed for a wheel load of at least 4,000 lb.

**Surface treatment.** The thickness of the asphalt course, the kind and size of aggregate, the type of proportioning of bituminous materials, and the mixing and placing of these materials shall be in accord with good highway practice for the expected loading.

The quality and thickness of concrete and the spacing and size of reinforcing steel shall be appropriate for the expected loading and in accord with sound engineering practice.

The minimum thickness for a gravel surface shall be 2 in.

If other surfacing materials are used, such as cinders, tanbark, and sawdust, the minimum thickness shall be 2 in.

**Structures.** All structures shall be designed according to appropriate SCS standards and specifications or Engineering Handbook recommendations.

**Sprays and artificial mulches.** Sprays of asphalt, oil, plastic, manufactured mulches, and similar materials shall be installed according to the manufacturer's recommendations.

**Vegetative measures.** Liming, fertilizer, seeding, and sodding shall be according to the planned use and the local technical guide. If vegetation is not appropriate, other measures shall be used to prevent erosion.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for heavy use area protection shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, and transpiration.

### **Quality**

1. Effects on erosion and the movement of sediment, animal waste, and soluble and sediment-attached substances carried by runoff.
2. Effects of changes in surface and ground water caused by introduction of fertilizers for vegetated areas, and oils and chemicals associated with concrete and asphalt placement and other construction activities.
3. Effects of changes in surface water caused by the surfacing of confined animal feeding areas.

## **EFFICIENCIES**

Use of vegetative and mulching measures has shown a high reduction of sedimentary soil erosion. An average sediment reduction of about 80 to 90% in a review of over 20 field test plot studies of hydroseeding and various mulches on construction site soils in 1990 (Brown and Caraco, 1997). A 99% reduction in suspended solids load was reported with establishing a grass cover (Lee and Skogergboe, 1985). The grass cover increased the biomass of the test area from 0 to 2464 lb/ac (Lee and Skogergboe, 1985).

Construction phasing also may reduce sediment loss up to 42% (Brown and Caraco, 1997). Construction phasing involves performing earthmoving tasks only when absolutely needed. Construction is sub-divided into small sections, with work being accomplished on only one section at a time. More than one section may be worked on at one time if a balance between the sections exist (e.g. excavation at one section and a need for fill in another).

Silt fencing has been shown to adequately reduce steep grade erosion, although it has to be maintained well. In 1993, W&H Pacific reported sediment reduction averages ranging between 36 and 65% on silt fences located at the toe of a slope. This is rather low, but with proper installation and maintenance, Goldman, in 1986, reported sediment removal rates ranging from 75 to 86%.

Total suspended solids (TSS) have also been shown to be reduced with silt fence implementation. W&H Pacific reported reductions between 36 and 65%. Two other studies have shown TSS reductions between 75 and 86% (Wyant, 1993 and Horner et al, 1990). The wide range in efficiencies may be attributed to slope and soil type (W&H Pacific, 1993).

Several other erosion prevention techniques also were shown to effectively remove sediments with efficiencies ranging from about 53 to 99%. Harding, 1990, and Wall, 1991 reported efficiencies on straw and straw blankets ranging between 89.2 and 98.6%. Wall, 1991, found

sediment removal efficiencies for fiber mulches to be between 65 and 97.1%. In 1990, Harding reported a 98.7% efficiency of a blanket consisting of 70% wheat straw and 30% coconut fiber. Curled wood fiber blankets had about a 94% soil load reduction, as reported by Harding, 1990, and Wall, 1991. A nylon monofilament blanket was reported to be about 53% efficient when used with a 9% slope silt loam soil that was subjected to a 5.8", one hour simulated storm (Harding, 1990).

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# **HEDGEROW PLANTING**

(ft)  
**CODE 422**

## **DEFINITION**

Establishing a living fence of shrubs or trees in, across, or around a field.

## **PURPOSE**

To delineate field boundaries, serve as fences, establish contour guidelines, provide wildlife food and cover, provide screens, or improve the landscape.

## **CONDITIONS WHERE PRACTICE APPLIES**

In, across, or around fields.

## **SPECIFICATIONS GUIDE**

Methods of planting and maintaining desired vegetation.

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# HERBACEOUS WIND BARRIERS

(feet)  
CODE 422A

## DEFINITION

Herbaceous vegetation established in rows or narrow strips across the prevailing wind direction.

## PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following:

- Reduce soil erosion from wind.
- Protect growing crops from damage by wind-borne soil particles.
- Manage snow to increase plant available moisture.
- Provide food and cover for wildlife.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to cropland, or other land where crops are grown.

This standard includes the location of herbaceous wind barriers and their management for identified uses. Criteria for the establishment of perennial herbaceous vegetation are in practices standards for establishing permanent vegetation, or in other places in the Field Office Technical Guide. Refer to locally accepted University or extension agronomy guides, or other accepted technical references for criteria to establish annual herbaceous vegetation.

## CRITERIA

### General Criteria Applicable To All Purposes Named Above

#### a. Vegetation:

Barriers may consist of perennial or annual plants, growing or dead. Plant materials shall be selected for the following characteristics:

- Adaptation to the site.
- Erect non-spreading growth habit.
- Resistant to lodging.
- Good leaf retention.
- Minimum competition with adjacent crops.

#### b. Number of Rows:

Barriers may consist of one row of plants, providing the required porosity can be achieved with a single row, and that the row contains no gaps.

Where two or more rows are required to achieve the required porosity and to avoid gaps, the rows shall be spaced no more than 36 inches apart.

### **Additional Criteria To Reduce Soil Erosion from Wind**

#### **a. Barrier Height:**

Barriers designed for this purpose shall have a minimum expected height of 1.5 feet during the wind erosion period for which the barriers are designed.

#### **b. Barrier Porosity:**

Barriers established for this purpose shall be designed to achieve a porosity of 40-50 percent.

#### **c. Barrier Direction and Spacing:**

When barrier direction deviates from perpendicular to the prevailing wind erosion direction, the spacing between barriers shall be correspondingly reduced.

The spacing between barriers shall be measured along the prevailing wind erosion direction during those periods when wind erosion is expected to occur. Spacing shall not exceed 10 times the expected height of the barrier plus additional width permitted by the soil loss tolerance (T), or other planned soil loss objective.

The effective spacing between barriers shall be determined using current approved wind erosion prediction technology. Calculations shall account for the effects of other practices in the conservation management system.

### **Additional Criteria To Protect Growing Crops From Damage From Wind-borne Soil Particles**

#### **a. Barrier Height:**

Barriers designed for this purpose shall have a minimum expected height of 2 feet during those periods when growing crops are susceptible to damage by blowing wind or wind-borne soil particles.

#### **b. Barrier Porosity:**

Barriers established for this purpose shall be designed to achieve a porosity of 40-50 percent during the period when growing crops are to be protected.

#### **c. Barrier Direction and Spacing:**

When barrier direction deviates from perpendicular to the prevailing wind erosion direction, the spacing between barriers shall be correspondingly reduced.

The spacing between barriers shall be measured along the prevailing wind erosion direction during those periods when sensitive crops are susceptible to damage by wind-borne soil particles. Spacing shall not exceed 10 times the expected height of the barrier plus additional width permitted by the crop tolerance to wind erosion\* as specified in applicable Field Office Technical Guides, other accepted technical references, or other planned crop protection objective.

\* Crop tolerance to wind erosion is the maximum rate of soil blowing that crop plants can tolerate without significant damage due to abrasion, burial, or desiccation.

The spacing between barriers shall be determined using current approved wind erosion prediction technology to estimate wind erosion during specific cropstage periods. Calculations shall account for the effects of other practices in the conservation management system.

#### **Additional Criteria To Manage Snow To Retain Additional Soil Moisture**

##### **a. Barrier Height:**

Barriers designed for this purpose shall have a minimum expected height of 1.5 feet during periods of expected snow cover.

##### **b. Barrier Porosity:**

Barriers established for this purpose shall be designed to achieve a porosity of 60-75 percent during periods of expected snow cover.

##### **c. Barrier Direction and Spacing:**

When barrier direction deviates from perpendicular to the prevailing wind direction, the spacing between barriers shall be correspondingly reduced.

The effective spacing shall be measured along the direction of prevailing winds during periods of expected snow cover. For uniform distribution of drifting snow, spacing shall not exceed 12 times the expected height of the barrier.

#### **Additional Criteria To Provide Food and Cover For Wildlife**

##### **a. Vegetation:**

Barriers established for this purpose shall consist of plants that provide food and cover for the targeted wildlife species.

##### **b. Barrier Width:**

Barriers established for this purpose shall have a minimum width of two feet.

##### **c. Barrier Height:**

Barriers established for this purpose shall have a minimum expected height that provides adequate cover for the targeted wildlife species.

### **CONSIDERATIONS**

Transport of wind-borne sediment and sediment-borne contaminants offsite are reduced by this practice when used in a conservation management system.

Herbaceous wind barriers are more suitable than field windbreaks for use under center pivot irrigation systems due to height considerations. Windbreaks may be located outside the windward edge of the circle.

Spacing between barriers may be adjusted, within the limits of the criteria above, to accommodate widths of farm equipment to minimize partial or incomplete passes.

Selection of plants for use in barriers should favor species or varieties tolerant to herbicides used on adjacent crops.

Plants which may be alternate hosts for pests injurious to adjacent crops should not be selected for use in barriers.

Selection of plant species less palatable to animals may reduce damage to barriers from grazing wildlife.

Where water erosion from melting snow, accumulated within the barrier system, is a concern, the hazard can be reduced by supporting erosion control practices such as residue management.

Where feasible, aligning barriers across the slope can enhance moisture infiltration and reduce erosion.

When barriers are designed to enhance wildlife habitat, plant species diversity should be encouraged. The use of evergreens in barriers designed to provide winter cover may increase their value. Barriers that result in multiple structural levels of vegetation within the barrier will maximize wildlife use.

Some plants are damaged by blowing wind as well as by wind-borne soil particles. In such cases, the spacing between wind barriers may have to be reduced from that obtained using wind erosion prediction technology.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and maintenance of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation & Maintenance described in this standard.

Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Annual barriers shall be reestablished each year by planting at recommended dates, leaving rows standing after crop harvest, or leaving standing strips when incorporating a cover crop into the soil.

After establishment, perennial barriers shall be fertilized at the same time and rate as adjacent field crops, or as needed by the barriers. Weeds shall be controlled with cultivation, mowing, chemicals, or other acceptable methods.

Harvest of hay or seed from perennial barriers, grazing, or mowing for weed control, shall be managed to allow regrowth to the planned height before periods when wind erosion, crop damage, or drifting snow are expected to occur. Annual barriers may be grazed or harvested after critical periods have passed.

Wind-borne sediment accumulated in barriers shall be removed and distributed over the surface of the field as determined appropriate.

Barriers shall be re-established or relocated as needed.

Barriers designed to enhance wildlife habitat should not be mowed or pruned unless their height or width exceeds that required to achieve the wildlife objective, and they become competitive with the adjoining land use. When mowing or pruning is necessary, it shall be done during the non-nesting season.

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# HILLSIDE DITCH

(Ft.)  
CODE 423

## DEFINITION

A channel that has a supporting ridge on the lower side constructed across the slope at definite vertical intervals and gradient, with or without a vegetative barrier.

## SCOPE

This standard applies to the planning and design of hillside ditches on steep land. It does not apply to diversions (362) or terraces (600).

## PURPOSE

To control the flow of water in sloping areas by diverting runoff to protect outlet, thus minimizing erosion and runoff.

## CONDITIONS WHERE PRACTICE APPLIES

Areas that have sufficient soil depth for constructing a hillside ditch system.

## DESIGN CRITERIA

**Location.** Hillside ditch systems shall be designed to fit land conditions. They shall drain from the ridge to a stable outlet.

**Outlets.** Adequate outlets shall be provided before beginning construction to dispose of discharge without creating an erosion hazard. Such outlets may be a natural waterway or a constructed one, a stable watercourse, or stable disposal areas, such as well-established pasture.

**Length.** Maximum length draining in one direction shall be 400 ft. This length may be extended to 500 ft if necessary to reach a stable outlet.

**Grade.** The ditch grade may be either constant or variable but must not exceed 3 percent.

**Side slopes.** Side slopes shall be stable for the soil in which the ditch is constructed.

**Horizontal spacing and cross-sectional area.** The maximum horizontal spacing and minimum cross-sectional area per 100 ft of ditch shall be as follows:

Average slope	Maximum spacing	Minimum cross-sectional area per 100-ft length
<i>pct</i>	<i>ft</i>	<i>ft<sup>2</sup></i>
12 or less	40	0.35
12-25	35	.3
25-40	25	.2

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing hillside ditches shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects of snowcatch and melt on water budget components.

### **Quality**

1. Filtering effects of vegetation on movement of sediment and dissolved and sediment-attached substances.
2. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances by runoff.
3. Effects on the visual quality of the water resources.
4. Short-term and construction-related effects of this practice on the quality of downstream water.
5. Potential for development of saline seeps or other salinity problems resulting from increased infiltration in the presence of restrictive layers.

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# IRRIGATION CANAL OR LATERAL

(ft)  
CODE 320

## DEFINITION

A permanent irrigation canal or lateral constructed to convey water from the source of supply to one or more farms.

## SCOPE

This standard applies to channels and elevated canals, but not to irrigation field ditches.

## PURPOSE

To convey irrigation water from a source of supply to the beginning of a farm irrigation system. The conservation objectives are to prevent erosion or degradation of water quality or damage to land, to make possible proper water use, and to convey water efficiently to minimize conveyance losses.

## CONDITIONS WHERE PRACTICE APPLIES

All canals and laterals and related structures shall be an integral part of an irrigation water conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

Canals and laterals shall be located where they will not be susceptible to damage from side drainage flooding, or they must be protected from such damage.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Unlined canals and laterals shall not be constructed on sites where permeability of the soils is rapid or very rapid. If an excessively permeable soil site must be crossed, the canals and laterals shall be lined according to the standards for ditches and canal linings.

## DESIGN CRITERIA

**Capacity requirements.** The capacity of canals or laterals serving a farm or group of farms shall be determined by considering the delivery demands of all the farm irrigation systems served and the amount of water needed to cover the estimated conveyance losses in the canal or lateral. Capacity must be enough to handle any surface runoff that is to enter the canal.

**Velocities.** Canals and laterals shall be designed to develop velocities that are nonerosive for the soil materials through which the canal or lateral passes. Local information on the velocity limits for specific soils shall be used if available. If such information is not available, the maximum design velocities shall not exceed those shown in figure 6-2, chapter 6, TR-25.

Canals and laterals must be designed with enough capacity to carry the required flows at the velocities that will be developed under the maximum probable retardance conditions.

For capacity design, the value of “n” shall be selected according to the material in which the canal or lateral is constructed, the alignment, and the hydraulic radius. The probability of additional retardance because of weeds or moss shall also be considered.

For checking designs to see that velocities do not exceed permissible values, Manning’s “n” no greater than 0.025 shall be used, and applicable criteria in the standard for Open Channels (582) shall be followed.

**Freeboard.** Freeboard is the height of canal or lateral banks above the maximum water surface elevation that can be expected under the most severe design operating conditions. The required freeboard shall be at least one-third of the design flow depth (0.33d) and shall not be less than 0.5 ft.

**Side slopes.** Canals and laterals shall be designed to have stable side slopes. Local information on side slope limits for specific soils and/or geologic materials shall be used if available. If such information is not available, the design side slopes in the canal or lateral shall not be steeper than the following:

Material	Side slope
Solid rock, cut section	¼:1
Loose rock or cemented gravel, cut section	¾:1
Heavy clay, cut section	1:1
Heavy clay, fill section	2:1
Sand or silt with clay binder, cut or fill section	1-1/2:1

**Water surface elevations.** Water surface elevations shall be designed to provide enough hydraulic head for successful operation of all ditches or other water conveyance structures diverting from the canal or lateral.

**Canal or lateral banks.** The top width of canal or lateral banks shall be enough to insure stability, prevent excessive seepage, and facilitate maintenance. It shall not be less than 2 ft and shall equal or exceed the flow depth.

**Maintenance access.** Maintenance access, as specified in the standard for Open Channels (582), shall be provided along one or both sides of a canal or lateral, as required, for maintenance operations. If the top of the bank or berm is to be used for a roadway, the width shall be enough for that purpose.

**Protection from surface waters.** Runoff from adjacent areas shall be conveyed over or under the canal wherever practical. If runoff is permitted to enter the canal or lateral, the side slopes shall be protected from erosion, and provisions shall be made for its disposal.

**Related structures.** Plans for canal or lateral installations shall provide for adequate turnouts, checks, crossings, and other related structures needed for successful operation as a conservation irrigation facility. All related structures shall be designed and installed to meet SCS standards. Structures needed for the prevention or control of erosion shall be installed before the canal or lateral is put into operation.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing irrigation canals or laterals shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

## **IRRIGATION CANAL OR LATERAL SPECIFICATIONS**

### **FOUNDATION PREPARATION**

The foundation area for all canal and lateral embankments shall be cleared of all trees, brush, weeds, sod, loose rock, or other material not suitable for the subgrade.

### **PLACEMENT OF EARTHFILL**

Earthfill embankments shall be constructed to the neat lines and grades shown on the plans and established at the field location. Embankment materials shall be free of brush, roots, sod, large rocks, or other material not suitable for making compacted fills. The moisture content and methods of placing and compacting the material shall be of such that a firm, stable embankment results. Below the design water surface elevation, fill material shall be placed in horizontal lifts of such thickness that proper compaction and any prescribed densities are obtained.

### **EXCAVATION**

Excavation shall be to the neat lines and grades shown on the plans and established at the field location. Excavated materials shall be used in designated fill locations or spoil areas. Excavation in borrow areas shall be at locations prescribed and to lines and grades established in the field. Overexcavation in the channel area or overfill on the canal or lateral banks shall be permitted if it does not interfere with the function of the canal or related structures and if the finished section is generally smooth.

### **CONSTRUCTION OPERATIONS**

Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Potential for a change in plant growth and transpiration because of changes in the volume or level of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effect on the water table of the field in providing suitable rooting depth for anticipated land uses.

### **Quality**

1. Effects on erosion of banks and beds and the movement of sediment, and the soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substances to ground water.

3. Short-term and construction-related effects on the quality of downstream water courses.
4. Potential for uncovering or redistributing toxic material.
5. Effects on wetlands or water-related wildlife habitats.
6. Effects on the visual quality of water resources.
7. Effects of water levels on salinity of soils, soil water, or downstream waters.

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# IRRIGATION FIELD DITCH

(ft)  
CODE 388

## DEFINITION

A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields in a farm distribution system.

## SCOPE

This standard applies to open channels and elevated ditches of 25 ft<sup>3</sup>/s or less capacity formed in and with earth materials. It does not include canals and laterals or ditches constructed and removed during a season and ditches shaped or constructed for lining installations or irrigation canals or laterals that deliver water to a farm.

## PURPOSE

To prevent erosion or loss of water quality or damage to the land, to make possible proper irrigation water use, and to efficiently convey water to minimize conveyance losses.

## CONDITIONS WHERE PRACTICE APPLIES

Field ditches shall serve an integral part of an irrigation water distribution system designed to facilitate the conservation use of soil and water resources.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Field ditches shall be constructed in earth material that contains enough fines to prevent excessive seepage losses and where shrinkage cracks will not endanger the ditch. The sealing effect of sediment carried in the irrigation water may be considered.

## DESIGN CRITERIA

**Capacity requirements.** Field ditches shall have the capacity to deliver to the field a flow adequate to meet:

1. The design peak consumptive use of the crops to be grown in the field, with proper provisions for the expected field irrigation efficiency.
2. The largest irrigation stream required for the irrigation methods planned for the field.

The capacity shall be increased to provide for the additional flow required to compensate for the ditch seepage loss and to safely carry surface runoff from adjacent lands that must be transported to wasteways or overflow points. For capacity design, the value of "n" shall be selected according to the material in which the ditch is constructed, the alignment and hydraulic radius, and additional retardance because of weeds or moss.

**Velocities.** Field ditches shall be designed to develop velocities that are nonerosive for the soil materials through which they pass. Local information on the velocity limit for specific soils shall be used if available. If such information is not available, the maximum design velocity shall not exceed those shown in figure 6-2, chapter 6, TR-25.

Field ditches shall be designed with enough capacity to carry the required flows at the velocities that will be developed under the maximum probable retardance conditions.

For checking designs to see that velocities do not exceed permissible values, a Manning's "n" no greater than 0.025 shall be used, and applicable criteria in the SCS standard for open channels (582) shall be followed.

**Cross section.** Freeboard in field ditches shall be not less than one-third of the maximum design depth of water. Side slopes shall be stable. The top width of banks as measured at the elevation providing the required freeboard shall be not less than 12 in. and shall equal or exceed the flow depth.

If a field ditch is to be constructed on an embankment, the side slopes of the embankment shall not be steeper than:

Height to water surface on centerline of fill	Steepest allowable side slope of fill
Less than 3 ft	1-1/2:1
3-6 ft	2:1
More than 6 ft	2-1/2:1

**Water surface elevations.** All field ditches shall be designed so that the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to be used to provide the necessary head, the backwater effect must be considered in computing freeboard requirements. The required elevation of the water surface above the field surface will vary with the type of takeout structure or device used and the amount of water to be delivered through each. A minimum head of 4 in. shall be provided.

**Related structures.** Erosion- or water-control structures, culverts, diversions, or other related structures needed to supplement the field ditch shall be designed and installed to meet SCS standards for the particular structure and type of construction.

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing irrigation field ditches shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

## IRRIGATION FIELD DITCH SPECIFICATIONS

### FOUNDATION PREPARATION

The foundation area for all ditch embankments and ditch pads shall be cleared of all trees, weeds, sods, loose rock, or other material not suitable for the subgrade.

### PLACEMENT OF EARTHFILL

Earthfill embankments shall be constructed to the neat lines and grades shown on the plans and established at the field location. Embankment materials shall be free of brush, roots, sod, large rocks, or other material not suitable for making compacted fills. The moisture content and methods of placing and compacting fill material shall be of such that a firm, stable embankment results. The fill material shall be placed in horizontal lifts of such thickness that proper compaction and prescribed densities are obtained.

## **EXCAVATION**

Excavation shall be to the neat lines and grades shown on the plans and established at the field location. Excavated materials shall be used in designated fill locations or spoil areas.

Overexcavation in the channel area or overfill on the ditch banks shall be permissible if it does not interfere with the function of the ditch or the related structures and if the finished section generally is smooth.

## **CONSTRUCTION OPERATIONS**

Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation.
2. Potential for a change in plant growth and transpiration because of changes in the volume or level of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effect on the water table of the field in providing suitable rooting depth for anticipated land uses.

### **Quality**

1. Effects on erosion and the movement of sediment, and the soluble and sediment attached substances carried by runoff.
2. Effects on the movement of dissolved substances to ground water.
3. Short-term and construction-related effects on the quality of downstream water courses.
4. Potential for uncovering or redistributing toxic material.
5. Effects on wetlands or water-related wildlife habitats.
6. Effects on the visual quality of water resources.
7. Effects of water level control on salinity of soils, soil water or downstream water.

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# IRRIGATION LAND LEVELING

(acre)  
CODE 464

## DEFINITION

Reshaping the surface of land to be irrigated to planned grades.

## SCOPE

This standard applies to the design criteria and construction requirements for leveling irrigated land on the basis of detailed engineering survey and layout. It does not include precision land forming (462) or land smoothing (466).

## PURPOSE

To permit uniform and efficient application of irrigation water without causing erosion, loss of water quality, or damage to land by waterlogging and at the same time to provide for adequate surface drainage.

## CONDITIONS WHERE PRACTICE APPLIES

All land to be leveled shall be suitable for irrigation and for the proposed methods of water application.

Water supplies and irrigation deliveries to the area to be leveled shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application method to be used.

Soils shall be deep enough so that after leveling work is done an adequate, usable root zone remains that will permit satisfactory crop production with proper conservation measures. Limited areas of shallower soils may be leveled to provide adequate irrigation grades or a better field arrangement. The finished leveling work must not result in exposed areas of highly permeable materials that can inhibit proper distribution of water over the field.

All leveling work shall be planned as an integral part of an overall farm irrigation system to facilitate the conservation use of soil and water resources. The boundaries, elevations, and direction of irrigation of individual field leveling jobs shall be of such that the requirements of all adjacent areas in the farm unit can be met.

## DESIGN CRITERIA

**Field grades.** If more than one method of water application or more than one kind of crop is planned, the land must be leveled to meet the requirements of the most restrictive method and crop.

All leveling work must be designed within the slope limits required for the methods of water application to be used, to provide for the removal of excess surface water, and to control erosion caused by rainfall.

Reverse grades in the direction of irrigation shall not be permitted.

**Slope to control erosion caused by rainfall.** Design field grades shall be such that erosion caused by rainfall can be controlled within the limits permissible for conservation farming.

**Slope for level irrigation methods.** The maximum fall in the length of run shall not exceed one-half the design depth of application for a normal irrigation.

The difference in elevation across an individual border strip shall not exceed 0.10 ft (0.03 m).

**Slope for graded irrigation methods.** The maximum slope in the direction of irrigation if rainfall erosion is not a significant problem shall be as follows:

1. Furrows — 3 percent,
2. Corrugations — 8 percent,
3. Borders for nonsod-forming crops, such as alfalfa or grain — 2 percent,
4. Borders for erosion-resistant grass or grass-legume crops or for nonsod-forming crops on sites where water application by the border method will not be required until after good crop stands have been established — 4 percent.

In humid areas where potential for rainfall erosion is great, the maximum slope for furrows shall be 0.5 percent, and 2 percent for borders for sodforming grasses and 0.5 percent for other crops.

Slopes may be uniform in the direction of irrigation or may increase or decrease. On slopes of more than 0.5 percent where leveling designs provide for increasing or decreasing slopes, the maximum grade in an irrigation run shall be no more than twice the minimum. Short, level sections are permissible at the upper or lower ends of irrigation runs to facilitate water control or to reduce runoff.

The maximum cross slope for borders shall be 0.1 ft (0.03 m) per border strip width. The allowable cross slope for furrows and corrugations depends on the stability of the soil, the size of furrows that are to be used, and the rainfall pattern in the area. Cross slopes must be such that “breakthroughs” from both irrigation water and runoff from rainfall are held to a minimum.

**Slope for subsurface irrigation methods.** In areas where irrigation is practiced through ground-water level control, it may be desirable to grade the surface to a plain having no slope.

**Surface drainage.** Farm irrigation systems shall include plans for removing or otherwise providing for control of excess irrigation and storm water. Leveling designs must provide field elevations and field grades that will permit proper functioning of the planned drainage facilities.

**Maximum field elevation.** All leveling work shall be designed so that the highest point in the field is far enough below the elevation of the water source to permit delivery of needed irrigating streams onto the field surface. The field elevation shall be at least 4 in. (101 mm) below the water surface elevation at the point of delivery.

**Borrow computations.** Excavation and fill material required for or obtained from such structures as ditches, ditch pads, and roadways shall be considered part of the overall leveling design, and the appropriate yardage shall be included when balancing cuts and fills and determining borrow requirements.

## PLANS AND SPECIFICATIONS

Plans and specifications for irrigation land leveling shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

# **IRRIGATION LAND LEVELING SPECIFICATIONS**

## **SITE PREPARATION**

The land to be leveled shall be cleared of brush, crop residue, trash, and vegetative material that can materially reduce the effectiveness of leveling operations.

## **BORROW LOCATION**

Soil for leveling operations shall be obtained from the designated cut areas in the field or from other designated borrow areas as specified in the plan.

## **LEVELING OPERATIONS**

The land shall be leveled to the designed grade or grades. Fills of more than 6 in. (152 mm) shall be constructed by placing the soil in successive layers. Leveling operations shall not be performed if the ground is frozen or if soil moisture conditions will excessively damage soil structure, which could result in poor crop growth or detrimental settlement.

Construction operation shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits.

After cuts and fills are completed, the land shall be smoothed to remove minor irregularities.

## **FINISHED GRADE**

All leveling work shall be finished according to the design and to the tolerances specified. The completed job shall be workmanlike and present a good appearance.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration evaporation, transpiration, and deep percolation.
2. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.
3. Potential to manage irrigation water through root zone management.

### **Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Effects on the movement of dissolved substances below the root zone or to ground water.
4. Effects of water level control on the salinity of soils, soil water or downstream water.
5. Short-term and construction-related effects on the quality of downstream water courses.
6. Potential of uncovering or redistributing such toxic material as saline soil.
7. Effects on the visual quality of downstream water.

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# IRRIGATION PIT OR REGULATING RESERVOIR

(No.)  
CODE 552A

## DEFINITION

A small storage reservoir constructed to regulate or store a supply of water for irrigation.

## SCOPE

This standard applies to open pits excavated below the ground surface to intercept and store either surface water or unconfined groundwater for irrigation. It applies to pits if part of the water is impounded above natural ground, provided that the depth of water above the ground surface, as measured at the spillway crest elevation, does not exceed 3 ft.

This standard establishes the minimum acceptable level for the planning and functional design of irrigation pits. It does not include detailed criteria or construction specifications for individual pits or components of the storage facility.

## PURPOSE

To collect and store water until it can be used beneficially to satisfy crop irrigation requirements.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies only to sites meeting all the following criteria and conditions:

1. The existing water supply available to the irrigated area is insufficient to meet conservation irrigation requirements during part of all the irrigation season.
2. Construction of an irrigation pit is the most practical means of obtaining a needed additional supply of water.
3. An adequate supply of good-quality water is available for storage from surface runoff, streamflow, or from a subsurface source.
4. Topographic, geologic, water table, and soils conditions at the site are satisfactory for the feasible development of the irrigation pit.
5. If surface runoff enters the pit, the contributing drainage area is or can be protected against erosion so that normal sedimentation does not materially shorten the planned life of the pit.

## DESIGN CRITERIA

**Capacity.** Irrigation pits shall be designed to have a usable capacity sufficient to satisfy irrigation requirements in the design area throughout the growing season of the crop or crops being irrigated. In computing capacity requirements, due consideration shall be given, where applicable, to groundwater inflow, surface runoff, precipitation, evaporation, and seepage. Additional capacity shall be provided as necessary for sediment storage. The usable capacity of a pit that depends wholly on groundwater as a source of supply shall be that part of the pit that is below the static water level.

**Pit design.** Irrigation pits shall be designed according to the criteria for excavated ponds in the standard for Ponds (378).

**Outlet works.** Suitable outlet works shall be provided for the controlled release of irrigation water. The capacity of the outlet works shall be no less than that required to provide the outflow rate needed to meet peak period irrigation system demands.

## **PLANS AND SPECIFICATIONS**

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

## **IRRIGATION PIT OR REGULATING RESERVOIR IRRIGATION PIT SPECIFICATIONS**

Irrigation pits shall be constructed according to the specifications for Ponds (378).

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential for irrigation water management.

### **Quality**

1. Effects on erosion and the movement of sediment, pathogens, and the soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substances to ground water.
3. Short-term and construction-related effects on the quality of downstream water courses.
4. Potential of uncovering or redistributing toxic material.
5. Effects on wetlands or water-related wildlife habitats.
6. Effects on the visual quality of water resources.

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# IRRIGATION PIT OR REGULATING RESERVOIR

(No.)  
CODE 552B

## DEFINITION

A small storage reservoir constructed to regulate or store a supply of water for irrigation.

## SCOPE

This standard applies to reservoirs created by impounding structures and pits excavated below the ground surface for the short-period storage of either diverted surface water, water from pumped or flowing wells, or water from an irrigation delivery system. Regulating reservoirs created by earth embankments shall be within the scope of the standard for Ponds (378).

This standard also applies to concrete and steel regulating reservoirs used to collect water from two or more small irrigation wells for application with a sprinkler or drip irrigation system.

This standard establishes the minimum acceptable quality level for the planning and functional design of irrigation regulating reservoirs. It does not include detailed design criteria or construction specifications for individual reservoirs or components of the regulating facility.

## PURPOSE

To store water for relatively short periods to:

1. Provide for regulating fluctuating flows in streams or canals,
2. Provide suitable (usually larger) irrigation streams,
3. Provide for improved management of irrigation water,
4. Permit more efficient use of available labor,
5. Avoid nighttime operation, and
6. Provide storage for reuse irrigation systems.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies only to sites meeting all the following criteria and conditions:

1. The existing available irrigation stream is of such size that regulation is necessary to accomplish the intended purposes. For small irrigation wells, collection facilities are needed for efficient operation of the pumping plants.
2. Water must be stored to be used between times of rotation deliveries.
3. An adequate and dependable volume of good quality water is or can be made available.
4. Topographic, geologic, and soil conditions are suitable for the practical construction of a regulating reservoir having an adequate storage capacity. Pervious soils in the reservoir area can be sealed so that seepage losses are not excessive.
5. If surface runoff enters the reservoir, the contributing drainage area is or can be protected against erosion so that normal sedimentation does not materially shorten the planned life of the reservoir.

## DESIGN CRITERIA

**Capacity.** Irrigation regulating reservoirs shall have a usable capacity sufficient to permit the existing irrigation stream to be regulated so that irrigation water can be applied with a reasonably high efficiency. In computing capacity requirements, due consideration shall be given, where applicable, to diverted inflow, surface runoff, precipitation, evaporation, and seepage. Excessive seepage losses shall be prevented by the use of an adapted method of sealing or lining. Additional capacity shall be provided, as necessary, for sediment storage.

Capacity requirements for regulating reservoirs used as part of a system for collecting water from two or more small wells shall be based on the discharge capacities of the contributing wells and on the operation frequency of the sprinkler system.

**Reservoir design.** Irrigation regulating reservoirs created by earthen dams, enclosed embankments, excavated pits, and the related appurtenant structures shall be designed according to the standard for Ponds (378).

Concrete and steel regulating reservoirs shall be designed according to the standard for Troughs or Tanks (614).

**Inlet protection.** If the inflow enters the reservoir, the side slope of the reservoir shall be protected against erosion by the use of a pipe inlet or some other suitable structure. The capacity of the inlet structure shall be no less than that required to accommodate the maximum anticipated rate of inflow.

**Overflow protection.** An overflow protection structure having a capacity equal to or greater than the inlet stream shall be provided for an enclosed embankment. This structure may be designed and installed in combination with the outlet works.

**Outlet works.** Outlet works shall be provided for the controlled release of irrigation water. The outlet works may consist of a gated conduit through or over the embankment for gravity flow to the irrigated area or to a pumping plant. They may also consist of a pumping plant designed to lift water directly from the reservoir basin.

The capacity of the outlet works shall be no less than that required to provide the outflow rate needed to meet peak period irrigation system demands.

## PLANS AND SPECIFICATIONS

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

## IRRIGATION PIT OR REGULATING RESERVOIR REGULATING RESERVOIR SPECIFICATIONS

Earthen irrigation regulating reservoirs shall be constructed according to the construction and materials specifications for Ponds (378).

Concrete and steel regulating reservoirs shall be constructed according to approved standard drawings and the associated construction and material specifications established for Troughs or Tanks (614).

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.

### **Quality**

1. Effects of erosion and the movement of sediment, pathogens, and the soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substances to ground water.
3. Short-term and construction-related effects on the quality of downstream water courses.
4. Potential of uncovering or redistributing toxic material.
5. Effects on wetlands or water-related wildlife habitats.
6. Effects on the visual quality of water resources.

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# IRRIGATION STORAGE RESERVOIR

(No. and acre-ft)  
CODE 436

## DEFINITION

An irrigation water storage structure made by constructing a dam.

## SCOPE

This standard applies to irrigation water storage structures designed to be filled during the season of low irrigation demand to provide water needed for irrigation during some other part of the year or in some future year. It does not apply to structures designed primarily for flow control or those designed to store water for only a few hours or a few days.

This standard pertains to the planning and functional design of irrigation storage reservoirs. It does not include detailed design criteria or construction specifications for individual structures or components of the storage facility.

## PURPOSE

To conserve water by holding it in storage until it can be beneficially used to meet crop irrigation requirements.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies only to sites meeting all the following criteria:

1. The water supply available to the irrigated area is insufficient to meet conservation irrigation requirements during part or all the conservation season.
2. Water is available for storage from surface runoff streamflow, or a subsurface source during periods of low or nonirrigating use.
3. Topographic, geologic, and soils conditions are satisfactory at some suitable site for constructing an economically feasible storage reservoir.

## DESIGN CRITERIA

**Irrigation.** The amount of water required to properly irrigate the crops in the area to be irrigated and the variations in water demand within the growing season must be known to adequately evaluate storage requirements. All demand hydrographs shall be computed from the consumptive use-time relationship, increased to reflect the anticipated level of farm irrigation efficiency plus any losses to be expected in conveying the water from the point of diversion to the farm and field. If water is required for such purposes as leaching or frost control, the amount needed shall be included in the demand hydrograph.

**Storage.** Irrigation storage reservoirs shall be designed to have a usable capacity sufficient to satisfy irrigation requirements in the design area, unless limited by characteristics of the reservoir site or by the available watershed yield (including limitations imposed by water rights). Additional capacity shall be provided as needed for sediment storage.

The stored water releases required to meet irrigation demands shall be those increments of the water demand hydrograph that exceed the available direct flows from other sources.

**Capacity.** In computing the reservoir capacity required to satisfy irrigation demands, due consideration shall be given to the length of the storage period, the anticipated inflow during this period, and the seepage and evaporation losses to be expected under the proposed plan of operation.

If the storage capacity is limited by the characteristics of the site to less than that required to meet the irrigation demands of the proposed area or if the water supply available for storage is insufficient to meet these demands, the quantity of water that can be made available at the reservoir outlet and the acreage that can adequately be irrigated shall be computed as a means of evaluating the benefits of the proposed installation. The benefits may be evaluated on the basis of the more frequent availability of water to satisfy irrigation demands for the full design area.

**Type of structures.** The type of dam and appurtenant structures to be used shall be selected for each site on the basis of hydrologic studies and engineering and geologic investigations of the site conditions and the materials available for construction.

The reservoir may be created by an impounding embankment used to intercept surface runoff or by an enclosed embankment used to store pumped water.

**Foundation, embankment, and spillway.** Earthen dams and embankments and related appurtenant structures shall be designed to meet the criteria in the standard for ponds (378) or in TR-60, as appropriate.

Drop spillways, chute spillways, and box spillways shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices, the National Engineering Handbook, Section 5-Hydraulics; Section 11-Drop Spillways; or Section 14-Chute Spillways, as appropriate.

**Overflow protection.** An overflow protection structure with a capacity equal to or greater than the inlet stream shall be provided for an enclosed embankment. This structure may be designed and installed in combination with the outlet works.

**Outlet works.** Outlet works shall be provided for the controlled release of irrigation water. Outlet works may consist of a gated conduit through or over the dam for gravitational flow to the irrigated area or to a pumping plant or they may consist of a pumping plant designed to lift water directly from the reservoir basin.

The capacity of the outlet works shall not be less than that required to provide the outflow rate needed to meet peak period irrigation system demands.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing irrigation storage reservoirs shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

## **IRRIGATION STORAGE RESERVOIR SPECIFICATIONS**

Irrigation storage reservoirs within the scope of the standard for ponds (378) shall be constructed according to the construction and materials specifications for ponds (378). Those within the scope of the criteria in TR-60 shall be constructed according to guide specifications in the National Engineering Handbook, Section 20.

## **PLANNING CONSIDERATION FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation, and ground-water recharge.
2. Effect on downstream flows or aquifers that would affect other water uses or users.
3. Effects on the volume of downstream flow that could have undesirable environmental, social, or economic effects.
4. Potential use for irrigation water management.

### **Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substance to ground water.
3. Effects on downstream waters that could cause undesirable effects on aquatic and wildlife communities.
4. Short-term and construction-related effects on the quality of downstream water courses.
5. Effects on the temperature of downstream water that could cause undesirable effects on aquatic and wildlife communities.
6. Effects on wetlands or water-related wildlife habitats.
7. Potential for earth moving to uncover or redistribute toxic materials.
8. Effects on the visual quality of water resources.

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# IRRIGATION SYSTEM, MICROIRRIGATION

(No. and Acre)  
CODE 441

## DEFINITION

An irrigation system for distribution of water directly to the plant root zone by means of surface or subsurface applicators.

## PURPOSE

This practice may be applied as part of a conservation management system to support one or more of the following purposes.

- To efficiently and uniformly apply irrigation water and maintain soil moisture for optimum plant growth.
- To apply chemicals.

## CONDITIONS WHERE PRACTICE APPLIES

On sites where the soils and topography are suitable for irrigation and proposed plants and where a microirrigation system has been determined to be the most desirable method of irrigation. Microirrigation systems, including subsurface drip irrigation (SDI), shall consist of bubblers (generally < 60 gal/hr), drip or trickle emitters and tapes (generally < 2 gal/hr), or spray or spinners (generally < 45 gal/hr).

Microirrigation is suited to orchard and row crops, windbreaks, greenhouse crops, and residential and commercial landscape systems and on steep slopes where other methods would cause excessive erosion or on areas where other application devices interfere with cultural operations.

## CRITERIA

### General Criteria Applicable To All Purposes

Planned work shall comply with all Federal, state, and local laws and regulations.

The system shall be designed to uniformly apply water and/or chemicals directly to the plant root zone to maintain soil moisture within the range for good plant growth without excessive water loss, erosion, reduction in water quality, or salt accumulation.

**Depth of application.** Net depth of application shall be sufficient to replace the water used by the plant during the plant peak use period or critical growth stage without depleting the soil moisture in the root zone of the plant below the management allowed depletion (MAD). Gross depth of application shall be determined by using field application efficiencies consistent with the conservation use of water resources. Applications shall include adequate water for leaching to maintain a steady state salt balance. The net depth of application shall be expressed as inches per day per unit of design area.

$$F_n = 1.604 \frac{QNTE}{AF}$$

Where:  $F_n$  = net application depth,  
in/day/design area

Q = discharge rate, gal/hr/emitter

N = number of orifices or emitters

T = hours of operation per day, 22 hours maximum

E = field application efficiency, expressed as a decimal, not greater than 0.90 for design purposes.

A = ft<sup>2</sup> of field area served by N (number of emitters)

F = the design area as a percentage of the field area, expressed as a decimal

1.604 = units conversion constant

**System capacity.** The system design capacity shall be adequate to meet the intended water demands during the peak use period for all plants to be irrigated in the design area. Design capacity shall include an allowance for reasonable water losses (evaporation, runoff, and deep percolation) during application periods. The system shall have the capacity to apply a specified amount of water to the design area within the net operation period.

The system should have a minimum design capacity sufficient to deliver the peak daily irrigation water requirements in 90% of the time available, but not to exceed 22 hours of operation per day. The rationale for using a design capacity less than the peak daily irrigation water requirement shall be fully explained and agreed upon by the end user. Field application efficiency (E) for design purposes shall not exceed 90 percent.

**Emitter discharge rate.** The design discharge rate of applicators shall be determined from manufacturer's data for the expected operating range. The discharge rate shall not create runoff within the immediate application area. For bubbler irrigation, a basin beneath the plant canopy is required for water control, with applications confined to the basin area.

**Number and spacing of emitters.** The number and spacing of emitters along the lateral line shall be adequate to provide water distribution to the plant root zone and percent plant wetted area ( $P_w$ ). National Engineering Handbook (NEH), Part 623, Chapter 7, shall be used to determine the  $P_w$ .

**Operating pressure.** The design operating pressure shall be in accordance with manufacturer recommendations. The system operating pressure must compensate for pressure losses through system components and field elevation effects.

**Emitter manufacturing variability.** The manufacturer's coefficient of variation ( $C_v$ ) shall be less than 0.07 for point source emitters and less than 0.20 for line source emitters.

#### **Allowable pressure variations.**

Manifold and lateral lines. Manifold and lateral lines, operating at the design pressure, shall be designed to provide discharge to any applicator in an irrigation subunit operated simultaneously such that they will not exceed a total variation of 20 percent of the design discharge rate. Pressure shall conform to manufacturer's recommendations.

Main and submain lines. Main and submain lines shall be designed to supply water to all manifold and lateral lines at a flow rate and pressure not less than the minimum design requirements of each subunit. Adequate pressure shall be provided to overcome all friction losses in the pipelines and appurtenances (valves, filters, etc.). Pipe sizes for mains and submains shall maintain flow velocities and emission uniformity within recommended limits. Economic considerations shall include both installation and operating costs. Main and submain lines shall be designed and installed according to NRCS conservation practice standard Irrigation

Water Conveyance, Pipelines, Code 430.

**Filters.** A filtration system (filter element, screen, strainer, or filtration) shall be provided at the system inlet. Under clean conditions, filters shall be designed for a head loss of 5 psi or less. The filter shall be sized to prevent the passage of solids in sizes or quantities that might obstruct the emitter openings. Filtration systems shall be designed to remove solids equal to or larger than one-fourth the emitter opening diameter, or the emitter manufacturer's recommendations, whichever is more stringent.

The filter system shall provide sufficient filtering capacity so that backwash time does not exceed 10% of the system operation time. Within this 10% time period, the pressure loss across the filter shall remain within the manufacturer's specification and not cause unacceptable uniformity. Filter/strainer systems designed for continuous flushing shall not have backwash rates exceeding 1.0% of the system flow rate or exceeding the manufacturer's specified operational head loss across the filter.

**Pressure regulators.** Pressure regulators shall be used where topography and the type of applicator dictate their use. Pressure regulators shall not be planned to compensate for improperly designed pipelines.

**Chemical water treatment.** Proper maintenance and water treatment shall be followed to prevent clogging based upon dripper and water quality characteristics. ASAE EP405.1 contains guidelines for chemical water treatment.

**System flushing.** Appropriate fittings shall be installed above ground at the ends of all mains, submains, and laterals to facilitate flushing. A minimum flow velocity of 2 ft/sec is considered adequate for flushing.

**Subsurface Irrigation.** The tubing shall not be placed greater than 18 inches below the surface of the ground or spaced greater than 5 feet apart for row crops. Dripline uniformity shall be designed for a minimum of 85 percent.

Water flow in the dripline shall be level to 2 percent downgrade with a maximum length of 660 feet. If these conditions are not met, the design shall be supported by engineering (hydraulic) documentation that show uniform distribution of 85 percent or greater.

**Chemigation.** System emission uniformity (EU) shall not be less than 90 percent where fertilizer or pesticides are applied through the system.

Injectors (chemical, fertilizer or pesticides) and other automatic operating equipment shall be located adjacent to the pump and power unit, placed in accordance with manufacturer's recommendation and include integrated back flow prevention protection.

Chemigation shall be accomplished in the minimum length of time needed to deliver the chemicals and flush the pipelines. Application amounts shall be limited to the minimum amount necessary, as recommended by the chemical label.

## CONSIDERATIONS

Where natural precipitation and/or stored soil water is not sufficient for germination, special provisions shall be made for germination, or the microirrigation system shall apply water at a rate sufficient to adequately wet the soil to germinate seeds or establish transplants. The depth of a subsurface system for use on annual crops shall be limited by the ability of the system to germinate the seeds, unless it is stated in writing that other provisions will be made for this function.

Water quality is usually the most important consideration when determining whether a microirrigation system is feasible. Well and surface water often contains high concentrations of undesirable minerals (chemicals). Surface water can contain organic debris, algae, moss, bacteria, soil particles, etc. Well water can also contain sand. The irrigation water supply shall be properly tested to determine feasibility and treatment needed for use in microirrigation systems.

Microirrigation can influence runoff and deep percolation by raising the soil moisture level and decreasing available soil water storage capacity, increasing the probability of runoff or percolation below the root zone from storm events. Surface water quality may be affected by the movement of sediment, soluble chemicals, and sediment attached substances carried by runoff. Ground water quality may be affected by the movement of dissolved substances below the root zone.

Microirrigation may affect downstream flows or aquifers and the amount of water available for other water uses.

Chemigation may or may not be required at the same time the plant requires irrigation, which may affect the economics of chemigation. Weather conditions should be considered before applying chemicals. Chemicals should not be applied if rainfall is imminent. Pest or nutrient management planning should address the timing and rate of chemical applications.

On systems where chemicals are injected, care shall be taken so the injected nutrients do not react with other chemicals in the irrigation water to cause precipitation and plugging. Microirrigation will effect a change in plant growth and transpiration because of changes in the volume of soil water.

There may be a potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive layers.

Field shape and slope frequently dictate the most economical lateral direction. Whenever possible, laterals should be laid downslope for slopes of less than 5% if lateral size reduction can be attained. For steeper terrain, lateral lines should be laid along the field contour and pressure compensating emitters should be specified or pressure control devices used along downslope laterals.

$P_w$  is not required on high water table soils when the water table is managed at a depth where capillary action (upflux) will supply a portion or the entire daily consumptive use rate.

## **PLANS AND SPECIFICATIONS**

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

## **OPERATION AND MAINTENANCE**

An operation and maintenance (O&M) plan shall provide specific instructions for operating and maintaining the system to ensure that it functions properly, including reference to periodic inspections and the prompt repair or replacement of damaged components. Typical maintenance items include:

- Clean or backflush filters when needed.
- Flush lateral lines regularly.
- Check applicator discharge often; replace applicators as necessary.
- Check operating pressures often; a pressure drop (or rise) may indicate problems.

- Check pressure gauges to ensure proper operation; repair/replace damaged gauges.
- Inject chemicals as required to prevent precipitate buildup and algae growth.
- Check chemical injection equipment regularly to ensure it is operating properly.
- Check and assure proper operation of backflow protection devices.

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# **IRRIGATION SYSTEM, SPRINKLER**

(No. and Acre)  
**CODE 442**

## **DEFINITION**

A planned irrigation system in which all necessary facilities are installed for efficiently applying water by means of perforated pipes or nozzles operated under pressure.

## **SCOPE**

This standard applies to the sprinkler irrigation system through which water is distributed by means of sprinklers or spray nozzles. It applies to all components of the onfarm system except for special structures such as permanently installed mains and laterals (Irrigation Pipeline, 430, and Pumping Plants, 533). It does not include Trickle Irrigation Systems (441).

## **PURPOSE**

To efficiently and uniformly apply irrigation water to maintain adequate soil moisture for optimum plant growth without causing excessive water loss, erosion, or reduced water quality.

## **CONDITIONS WHERE PRACTICE APPLIES**

Sprinkler irrigation plans shall be based on an evaluation of the site and the expected operating conditions. The soils and topography shall be suitable for irrigation for the proposed crops.

Enough good-quality water must be available for practical irrigation of the crops to be grown. The sprinkler method of water application is suited to most crops, to most irrigable lands, and to most climatic conditions where irrigated agriculture is feasible.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on the water budget, especially the volume and rate of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Potential for changes in plant growth and transpiration because of changes in the volume of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. The effect on the water table of the field in providing suitable rooting depth for anticipated land uses.
5. Potential ability to manage irrigation water through control of water in the root zone.

### **Water Quality**

1. Effects on erosion and the movement of sediment, and soluble and sediment-attached substances carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Potential effects on the movement of dissolved substances below the root zone or to ground water.
4. Effects of soil water levels on such nutrient processes as nitrification and denitrification.

5. Effects of soil water levels in controlling the salinity of soils, soil water or downstream water quality.
6. Effects on the visual quality of downstream water resources.

## DESIGN CRITERIA

**Depth of application.** The net depth of application shall be based on the available moisture capacity of the soil in the root zone of the crop irrigated or a lesser amount consistent with the land user's operation plan. The gross depth shall be determined by using field application efficiencies consistent with the conservation of water resources.

**Capacity.** In regularly irrigated areas, sprinkler irrigation systems shall have either (1) a design capacity adequate to meet the moisture demands of all crops to be irrigated in the design area or (2) enough capacity to meet the requirements of several selected irrigations during critical crop growth periods when less than full irrigation is planned. In computing capacity requirements, allowance must be made for reasonable water losses during application periods.

Systems for special-purpose irrigation shall have the capacity to apply a stated amount of water to the design area in a specified net operating period.

**Design application rate.** The design rate of application shall be within a range established by the minimum practical application rate under local climatic conditions and the maximum rate consistent with the intake rate of the soil and the conservation practices used on the land. If two or more sets of conditions are in the design area, the lowest maximum application rate for areas of significant size shall apply.

**Distribution patterns and spacing.** A combination of sprinkler spacing, nozzle sizes, and operating pressure that most nearly provides the design application rate and distribution shall be selected. The velocity of prevailing winds and other conditions must be considered.

If available from the manufacturers, uniformity coefficient data shall be used in selecting sprinkler spacing, nozzle sizes, and operating pressure. The uniformity coefficient shall be not less than as shown below:

- 70% for orchards
- 75% for deep-rooted (4 ft or more) field and forage crops
- 85% for high-value or shallow-rooted crops and for any crop where fertilizer or pesticides are applied through the system.

In the absence of such data, sprinkler performance tables provided by the manufacturers shall be used in selecting nozzle sizes, operating pressure, and wetted diameter for the required sprinkler discharge. The maximum spacing shall comply with the following criteria:

1. For low-, intermediate-, and moderate-pressure sprinklers, the spacing along lateral lines ( $S_l$ ) shall not exceed 50 percent of the wetted diameter, as given in the manufacturer's performance tables, when the sprinkler is operating under optimum pressure. The spacing of laterals along the main line ( $S_m$ ) shall not exceed 65 percent of this wetted diameter. If winds that can affect the distribution pattern are likely, spacing ( $S_m$ ) shall be reduced to 60 percent for average velocities of 5 mi/h, to 50 percent for average velocities of 10 mi/h, and to 30 percent for average velocities greater than 10 mi/h.
2. For high-pressure sprinklers and for the giant hydraulic type, the maximum distance (diagonal) between two sprinklers on adjacent lateral lines shall not exceed two-thirds of the wetted diameter under favorable operating conditions. If winds that can affect the distribution pattern are likely, the diagonal spacing shall be reduced to 50 percent of the

- wetted diameter for average velocities of 5 mi/h and to 30 percent for average velocities greater than 10 mi/h.
- For perforated pipelines, the spacing recommendations of the manufacture for the design application rate, number and size of perforations, and operating pressure shall be followed.

**Lateral lines.** Lateral lines shall be so designed that the total pressure variation at the sprinkler heads, resulting from friction head and static head, does not exceed 20 percent of the design operating pressure of the sprinklers.

Except for undertree operation, riser pipes used in lateral lines shall be long enough to prevent interference with the distribution pattern when the tallest crop is irrigated. Riser lengths shall not be less than shown below:

Sprinkler discharge (gal/min)	Riser length (in)
Lessthan10	6
10-25	9
25-50	12
50-120	18
Morethan120	36

**Main lines.** The design of main lines, submains, and supply lines shall insure that the quantities of water required are conveyed to all lateral lines at the maximum required pressure.

If the pressure required for sprinkler system operation is provided by pumping, main line pipe sizes shall insure that there is an economical balance between the capitalized cost of the pipe and annual pumping costs.

**Pump and power unit.** The pump capacity and the power unit shall be adequate to operate the sprinkler system efficiently when maximum capacity is being pumped against maximum total dynamic head.

**Operation and maintenance.** An operation and maintenance plan must be prepared for use by the owner or others responsible for operating the system. The plan should provide specific instructions for operating and maintaining the system to insure that it functions properly. It should also provide for periodic inspections and prompt repair or replacement of damaged components.

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing irrigation sprinkler systems shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

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# IRRIGATION SYSTEM, SURFACE AND SUBSURFACE

(No. and acre)  
CODE 443

## DEFINITION

A planned irrigation system in which all necessary water-control structures have been installed for the efficient distribution of irrigation water by surface means, such as furrows, borders, contour levees, or contour ditches, or by subsurface means.

## SCOPE

This standard applies to the planning and design of the overall irrigation water distribution and waste water disposal system for a farm or farming unit. It does not apply to detailed design criteria and construction specifications for individual structures or components of the system or for the methods of irrigation water application to be used.

## PURPOSE

To efficiently convey and distribute irrigation water to the point of application without causing excessive erosion, water losses, or reduction in water quality.

## CONDITIONS WHERE PRACTICE APPLIES

Areas must be suitable for irrigation with the quality of water available. Water supplies must be sufficient in quantity and quality to make irrigation practical for the crops to be grown and also must be adequate for the water application methods to be used.

Each irrigation system must be designed as an integral part of an overall plan of conservation land use and treatment for the farm that is based on the capabilities of the land and the needs of the farm enterprise.

## DESIGN CRITERIA

**Land treatment units.** All conservation farm irrigation systems shall be designed to meet the particular needs of the various land treatment units to be served.

**Conservation irrigation methods.** All farm irrigation systems designs shall be based on the use of conservation water application methods that are suited to the site conditions (combination of soil and slope) and the crops to be grown. Adapted methods are those methods that will provide for efficient use of water without destructive soil erosion.

**Capacity.** The capacity of the system and its components shall be adequate to meet the peak use requirements of the crops to be grown and the required rate of water delivery for the irrigation methods to be used.

If various irrigation methods will be used on the same field, the system capacity must be adequate for the method requiring the highest rate of water delivery. Likewise, if crops with different peak use requirements are to be grown, the system capacity must be based on the crop having the highest use rate.

All ditches and other structures shall be of sufficient size to permit the delivery of required quantities of water without overtopping. All structures shall be designed for the maximum flow

conditions to be expected and shall provide for a freeboard consistent with their size and construction and according to appropriate SCS standards.

**Water surface elevation.** All systems for irrigation by surface methods shall be designed so that the water surface elevation at field takeout points is sufficient to provide the required flow onto the field surface. A head of at least 4 in. shall be provided.

Subsurface irrigation systems shall be designed to hold the water table at or between predetermined elevations below the ground surface at all points in the design area.

**Location of head ditches or pipelines.** Head ditches or pipelines used for surface irrigation shall be located so that irrigation water can be applied uniformly over the entire field without causing erosion. Ditch or pipeline spacing shall be of such that irrigation runs are not longer than the maximums specified in local irrigation guides or that determined by adequate field evaluations. If more than one kind of crop is to be grown or more than one method of irrigation is to be used, the ditch or pipeline spacing shall not exceed the allowable length of run determined for the limiting crop or method.

Feeder ditches or conduits for subsurface irrigation shall be spaced so that the variation in depth from the land surface to the water table is not greater than is permissible for adequate irrigation of the limiting crop to be grown.

**Erosion control.** The design of farm irrigation systems must provide for conveying and distributing irrigation water without causing damaging soil erosion. All unlined ditches shall be located on nonerosive gradients. If water must be conveyed down slopes that are steep enough to cause excessive flow velocities, the irrigation system design shall provide for the installation of such erosion-control structures as drops, chutes, buried pipelines, or erosion-resistant ditch linings.

**Water control.** Farm irrigation systems shall include such structures as measuring devices, division boxes, checks, turnouts, pipelines, lined ditches, valves, and gates, as needed, to control and regulate the water for efficient application.

**Seepage control.** Except where seepage is specifically desired for subsurface irrigation, designs shall provide for minimizing these losses. For surface irrigation systems, ditches shall be located so that they do not cross areas of highly permeable soils. If site conditions require conveyance of water across excessively permeable areas, the irrigation system design shall provide for the use of pipelines, flumes, or lined ditches as needed, to prevent excessive losses, of water by seepage into the soil.

**Waste water disposal.** Irrigation system designs shall include facilities of adequate capacity for the safe removal of excess irrigation and storm water from the field surface. Pickup or waste water ditches constructed for this purpose must be on nonerosive gradients or be stabilized by lining or structural measures if erosion is a hazard. If field elevations do not permit the disposal of waste water by gravity flow, the design shall provide for the installation of pumping units and other needed appurtenant structures. Waste water ditches must be protected from bank erosion by structures for the entry of waste water or by vegetative cover on gently sloping banks. If excess water will be reused as irrigation water, the irrigation system design shall provide for pickup ditches so that water does not flow directly from furrows or borders into irrigation head ditches.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for surface and subsurface irrigation systems shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATION FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Potential for changes in plant growth and transpiration because of changes in the volume of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the volume of downstream flow that could have undesirable environmental, social, or economic effects.
5. Effect on the water table of the field in providing a suitable rooting depth for anticipated land uses.
6. Potential use for irrigation water management.

### **Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Effects on the movement of dissolved substances below the root zone or to ground water.
4. Effects of water level control on the salinity of soils, soil water or downstream water quality.
5. Effects of water levels on such soil nutrient processes as plant nitrogen use or denitrification.
6. Effects on the temperatures of downstream waters that could cause undesirable effects on aquatic and wildlife communities.
7. Effects on wetlands or water-related wildlife habitats.
8. Effects on the visual quality of water resources.

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# IRRIGATION SYSTEM, TAILWATER RECOVERY

(No.)  
CODE 447

## DEFINITION

A facility to collect, store, and transport irrigation tailwater for reuse in a farm irrigation distribution system.

## SCOPE

This standard applies to the planning and functional design of irrigation tailwater recovery systems, including pickup ditches, sumps, pits, and pipelines. It does not apply to detailed design criteria or construction specifications for individual structures or components of the recovery system.

## PURPOSE

To conserve farm irrigation water supplies and water quality by collecting the water that runs off the field surface for reuse on the farm.

## CONDITIONS WHERE PRACTICE APPLIES

Tailwater recovery systems are suitable for use on sloping lands that are served by a properly designed and installed surface irrigation system to facilitate the conservation use of soil and water resources. They are also suitable for use in areas where recoverable irrigation runoff flows or can be anticipated under the management practices used or expected to be used.

## DESIGN CRITERIA

**Collection facilities.** Facilities for the collection of irrigation tailwater are an integral part of irrigation systems, surface and subsurface (443).

**Sump or pit.** A sump or pit is needed to store the collected tailwater until it is redistributed in the farm irrigation system. The desired control of water at the point where the tailwater is returned to the irrigation system shall be considered in determining the size of the sump.

Small sumps with frequently cycling pumping plants may be used where the tailwater discharges into an irrigation regulation reservoir or into a pipeline with the flow controlled by a float valve. However, if the irrigation distribution system does not include facilities for regulating fluctuating flows, tailwater sumps shall be made large enough to provide the regulation needed to permit efficient use of the water.

Sumps must be equipped with inlets designed to protect the side slopes and the collection facilities from erosion. A dike or ditch shall be provided if necessary to limit the entrance of surface water to the designed inlet. Sediment traps shall be installed if needed.

Sumps or pits shall be designed and constructed according to applicable SCS standards and specifications.

**Return facilities.** All tailwater recovery systems require facilities of some kind to convey the tailwater from the storage sump to the point of reentry into the farm irrigation system. These facilities may consist of a pump and pipeline to return the water to the upper end of the field, or they may consist of a gravity outlet having a ditch or pipeline to convey the water to a lower section of the farm irrigation system.

The capacity of return facilities shall be determined by an analysis of expected runoff rates, the proposed sump storage capacity, and the anticipated use to be made of the tailwater.

If the return flow is used as an independent irrigation stream rather than as a supplement to the primary irrigation water supply, the rate of flow must be adequate for the methods of water application employed.

Pipelines, lined or unlined ditches, and pumping plants used in return facilities shall be designed and constructed according to applicable SCS standards and specifications.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for irrigation tailwater recovery systems shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATION FOR WATER QUANTITY AND QUALITY**

### **Quality**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation, and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Effects on the volume of downstream flow that could cause undesirable environmental, social, or economic effects.
4. Potential use of irrigation water management.

### **Quality**

1. Effects on the movement of sediment and soluble and sediment-attached substance on downstream water carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Effects on the movement of dissolved substances to ground water.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

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**IRRIGATION WATER CONVEYANCE**  
**FLEXIBLE MEMBRANE DITCH AND CANAL LINING**  
(ft)  
**CODE 428B**

**DEFINITION**

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral.

**SCOPE**

This standard applies to buried membrane linings made of flexible materials, such as plastic, rubber, or asphalt. It includes design and construction criteria for the ditch section that affects the installation of the lining as well as for the lining itself.

**PURPOSE**

To prevent waterlogging of land, to maintain water quality, and to reduce water loss.

**CONDITIONS WHERE PRACTICE APPLIES**

Ditches and canals to be lined shall serve as an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall either be located where they are not susceptible to damage from side drainage flooding or they shall be protected from such damage.

**DESIGN CRITERIA**

**Capacity.** A lined ditch or canal shall have enough capacity to meet its requirement as part of the planned irrigation water distribution system without danger of overtopping. Design capacity shall be based on the following, whichever is greater:

1. The capacity shall be enough to deliver the water needed for irrigation to meet the design peak consumptive use of the crops in the area served.
2. Capacity shall be enough to provide an adequate irrigation stream for all methods of irrigation planned for use in the area served.

**Velocity.** The velocity in canals or ditches lined with flexible membranes shall not exceed the nonerosive velocity for the soil material used for the protective cover or the material through which the canal or ditch passes, whichever is less. Local information on velocity limits for specific soils may be used if available. If such information is not available, the maximum design velocity shall not exceed those shown in figure 6-2, chapter 6, SCS TR-25, except that the design velocity shall not exceed 3 ft/s (0.9 m/s).

The velocity in ditch reaches from which water is to be delivered onto the field through turnouts, siphon tubes, or similar means shall be less than supercritical and sufficiently low to permit operation of the planned takeout structure or device.

Canals and laterals lined with flexible membranes must be designed with enough capacity to carry the required flows at the velocity that will be developed under the maximum probable retardance conditions.

For capacity design, the value  $n$  shall be selected according to the material in which the canal or lateral is constructed, the alignment, the hydraulic radius, and the potential weed and moss hazard.

For checking designs to see that velocities do not exceed permissible values in erodible soils, a Manning's  $n$  no greater than 0.025 shall be used.

**Freeboard.** The required freeboard varies according to the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall provide 3 in. (76 mm) of lining above the designed water surface. This minimum freeboard requirement is based on the assumption that the finished channel bottom elevations will vary no more than 0.1 ft (30 mm) from the design elevations. If a construction deviation greater than 0.1 ft (30 mm) is permitted, the minimum freeboard shall be increased.

**Side slopes.** Canals and ditches with buried membrane linings must be constructed with side slopes that will be statically stable. Slope requirements vary according to the type of cover material, but the side slopes shall not be steeper than 3:1.

**Protective cover.** Membrane linings shall be protected by an earth or an earth and gravel covering not less than 6 in. (152 mm) thick and must extend not less than 6 in. (152 mm) above the top edge of the lining. In areas subject to traffic by livestock, the minimum thickness of the protective cover shall be 9 in. (228 mm). The material on the bottom 3 in. (76 mm) of cover shall not be coarser than silty sand.

**Membrane thickness.** The required membrane thickness depends on the expected subgrade conditions, the hydrostatic forces that will be acting on the membrane, and the susceptibility of the lining to damage during or after installation. The minimum nominal thickness shall be:

Material	Asphalt	Plastic sheeting	Nonreinforced rubber	Reinforced rubber
	<i>mil</i>	<i>mil</i>	<i>mil</i>	<i>Mil</i>
Coarse soils (SM-SSP-SW)	225	8	30	30
Gravel (GC-GM-GP-GW)	—	12	30	30

**Water surface elevations.** All lined ditches and canals shall be designed so that the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to provide the necessary head, the backwater effect must be considered in computing freeboard requirements. The required elevation of the water surface above the field surface varies according to the type of takeout structure or device used and the amount of water to be delivered. A minimum head of 4 in. (101 mm) shall be provided.

**Related structures.** Plans for ditch or canal lining installations shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation. These structures can be installed before, during, or after the lining

placement. They must be constructed or installed in such a way as to not damage or impair the effectiveness of the lining.

**Materials.** Flexible membrane liners shall equal or exceed the physical requirements indicated for materials under “Specifications”.

## PLANS AND SPECIFICATIONS

Plans and specifications for installing flexible membrane irrigation ditch and canal lining shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

## IRRIGATION WATER CONVEYANCE, FLEXIBLE MEMBRANE DITCH AND CANAL LINING SPECIFICATIONS

### INSTALLATION

**Preparing subgrades.** Subgrades on which flexible membranes will be placed shall be raked to remove all large clods, roots, brush, sod, or rocks that might endanger the membrane. Rolling the subgrade is recommended to provide an extra measure of safety against punctures. In rocky areas, a cushion layer of fine soil shall be provided as a protection against irregularities that cannot be removed by rolling.

**Placing membranes.** Plastic and rubber membranes shall be carefully spread in a relaxed condition over the raked and smoothed subgrade. Rubber sheets may be pulled out smooth, but all liners shall be installed in a relaxed state. For polyethylene film, care shall be taken to insure that at least 5 percent slack is provided. Prefabricated asphalt membranes shall be pulled out so that they lay flat on the subgrade.

If the width or length of the lining specified requires placing sheets together, all joints shall be watertight, and the strength of the bonded seam in any direction shall not be less than 80 percent of breaking strength (ultimate tensile strength) of the membrane when the specimen is pulled in shear.

**Anchoring membranes.** Small anchor trenches about 10 in. (254 mm) wide and 12 in. (304 mm) deep shall be used to anchor the sides of the membrane. These trenches shall be located along the berm on both sides of the canal. They shall be a minimum of 4 in. (101 mm) back on the berm from the top of the side slope and at the elevation required to maintain the specified freeboard. The membrane shall conform to the trench shape and shall extend a minimum of 8 in. (203 mm) up the side opposite the canal. The trenches shall be carefully backfilled and compacted after the membrane is in place.

The upstream end of each section of plastic or rubber membrane shall be anchored in a trench dug across the canal. This trench shall be about 10 in. (254 mm) wide and 12 in. (304 mm) deep and shall connect with the two side anchor trenches. The upstream end of the membrane section shall lap down a minimum of 12 in. (304 mm) into this transverse trench. After the membrane is in place, the trench shall be carefully backfilled with selected compacted material. Prefabricated asphalt membranes shall be anchored at the upstream end of the lining section and at such intermediate points as are specified for individual jobs.

No anchors shall be required at the downstream end of membrane sections. The downstream end of the membrane shall be lapped a minimum of 3 ft (0.9 m) over the anchored upstream end of the next section. Placement of the protective cover material will secure the joint.

**Placing protective cover.** Material to be used as protective cover on membrane linings shall be free of large clods and sharp rocks and shall be carefully placed to the specified depth without damaging the membrane.

**Construction operations.** Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall be workmanlike and present a good appearance.

## MATERIALS

The flexible sheets or films to be used as buried membrane linings in irrigation ditches or canals shall be suitably constructed of high-quality ingredients and shall be certified by the manufacturer to be suitable for this intended use. Pigmented polyvinyl or polyethylene plastic, rubber, asphalt, or similar materials that are highly resistant to bacteriological deterioration shall be acceptable base materials for buried membrane linings.

The fabricated membranes shall be uniform throughout and shall be free from dirt, oil, foreign matter, pits, tears, holes, or other defects that can affect their serviceability. They shall be packaged so as to prevent damage from rough handling during shipment and so as to facilitate placement at the job site. Each package shall be marked with the name of the material, the manufacturer's name or symbol, the quantity contained therein, and the thickness or unit weight of the material.

Flexible membrane liners of the materials shown shall equal or exceed the physical requirements listed in table 1 (polyethylene and ethylene copolymer plastic film); table 2 (reinforced rubber sheeting); and table 3 (unreinforced rubber sheeting). Polyvinyl chloride plastic sheeting shall meet the requirements indicated in ASTM-D-3083, table 4, table 5 (unreinforced chlorisulfonated polyethylene), and table 6 (reinforced chlorisulfonated polyethylene).

**Table 1. Requirements for polyethylene and ethylene copolymer plastic film.**

Test description		Requirements		Test method
		Type I polyethylene	Type II copolymer	
Tensile strength				
Each direction, minimum average	<i>lb/in.<sup>2</sup></i>	1,800	2,000	ASTM-D-882, Method "A"
Ultimate elongation				
Each direction, minimum average	<i>pct</i>	500	500	ASTM-D-882, Method "A"
Impact resistance				
Minimum average	<i>g/mil</i>	45	65	ASTM-D-1709, Method "B"
Water vapor permeability	<i>perm-mil</i>	0.7	1.5	ASTM-E-96
Tear resistance (Elmendorf)				
Each direction, minimum	<i>g/mil</i>	80	80	ASTM-D-1922
Soil burial				
Tensile retained, each direction, minimum	<i>pct</i>	95	95	ASTM-D-3083
Elongation retained, each direction, minimum	<i>pct</i>	80	80	
Luminous transmittance, maximum	<i>pct</i>	1.0	1.0	National Bureau of Standards Publication PS-17

**Table 2. Requirements for reinforced rubber sheeting**

Test description	Requirements			Test method
	As much as 20 mils thick	20 mils thick and greater		
Breaking strength, minimum				
Warp direction	<i>lb/in.</i>	75	100	ASTM-D-751
Fill direction	<i>lb/in.</i>	75	100	ASTM-D-751
Ultimate elongation, maximum				
Warp direction	<i>pct</i>	30	30	ASTM-D-751
Fill direction	<i>pct</i>	30	30	ASTM-D-751
Ozone resistance, procedure "B" 50 pphm, 100 °F	<i>days</i>	7	7	ASTM-D-1149 and ASTM-D-518
Hydrostatic strength retained after ozone exposure, 7 days (Mullen)	<i>pct</i>	100	100	Federal Specification CCC 191 b, Method 5512
Heat aging, 7 days at 212 °F				
Tensile strength retained	<i>pct</i>	90	90	ASTM-D-573
Elongation retained	<i>pct</i>	90	90	ASTM-D-573
Tear resistance, minimum, warp or fill direction	<i>lb</i>	8	8	ASTM-D-751 (tongue)
Hydrostatic burst (Mullen), minimum	<i>lb/in.<sup>2</sup></i>	100	175	ASTM-D-751
Dimensional stability, 7 days at 212 °F, change in length or width	<i>pct</i>	± 1.0	± 1.0	( <sup>1</sup> )
Low temperature flexibility (optional) No cracking or flaking		- 40 °F	- 40 °F	Federal Specification CCC 191 b, Method 5874
Commercial field splice strength				
Shear force, minimum tensile	<i>pct</i>	75	75	Commercial field splice 1-inch wide strip, pulled in shear at 10 in./min, after 7 days cure room temperature

<sup>1</sup>A 1-ft<sup>2</sup> sample, 10 in. bench marks in warp and fill direction, placed on aluminum or stainless plate in changing air over.

**Table 3. Requirements for unreinforced rubber sheeting**

Test description		Requirements		Test method
		Type A	Type B	
Tensile strength, minimum	<i>lb/in.<sup>2</sup></i>	1,200	1,200	ASTM-D-412
Modulus at 300% elongation, minimum	<i>lb/in.<sup>2</sup></i>	600	600	ASTM-D-412
Ultimate elongation, minimum	<i>pct</i>	300	300	ASTM-D-412
Shore "A" hardness		60 ± 10	60 ± 10	ASTM-D-2240
Ozone resistance, procedure A				ASTM-D-1149
No cracks, 50 pphm at 100 °F, 20% elongation	<i>days</i>	7	—	ASTM-D-518
No cracks, 100 pphm at 100 °F, 50% elongation	<i>days</i>	—	7	ASTM-D-518
Heat aging, 7 days at 212 °F				ASTM-D-573
Tensile strength retained	<i>pct</i>	75	75	
Elongation retained	<i>pct</i>	75	75	
Water vapor permeability at 80 °F	<i>perm mil</i>	0.002	0.05	ASTM-E-96 (procedure BW)
Tear resistance, minimum	<i>lb/in.<sup>2</sup></i>	150	150	ASTM-D-624 Die "B"
Dimensional stability, 7 days at 212 °F, change in length or width	<i>pct</i>	± 0.5	± 0.5	
Commercial field splice strength shear force, minimum tensile	<i>pct</i>	60	60	Commercial field splice, 1-inch-wide strip pulled in shear at 10 in./min, after a 7-day cure at room temperature.

NOTE: Type A sheeting is recommended for general-purpose outdoor use. Type B sheeting is suggested if an extreme outdoor environment makes a highly wearable lining necessary.

**Table 4. Requirements of polyvinyl chloride plastic sheeting**

Test description		Requirements	Test method
Tensile strength, each direction, minimum average	<i>lb/in.<sup>2</sup></i>	2,000	ASTM-D-882
Elongation at break, minimum	<i>pct</i>	250	ASTM-D-882, Method A
Volatile loss, maximum	<i>pct</i>	0.7	ASTM-D-1203, Method A
Water extraction, maximum weight loss	<i>pct</i>	0.5	ASTM-D-1239
Tear resistance, each direction, minimum	<i>g/mil</i>	160	ASTM-D-1922
Resistance to soil burial (percent change max. in original value)			(120-day soil burial)
Breaking factor	<i>pct</i>	-5	
Elongation at break	<i>pct</i>	-20	
Modulus at 100% elongation	<i>pct</i>	± 10	
Bonded seam strength, percent breaking factor	<i>pct</i>	80	ASTM-D-3083 Para. 9.3 (1-inch width)

**Table 5. Unreinforced chlorisulfonated polyethylene**

Test description		Requirements	Test method
Tensile strength, minimum psi	<i>pct</i>	1,000	ASTM-D-412
Ultimate elongation, minimum	<i>pct</i>	250	ASTM-D-412
Ozone resistance, 50 pphm, 20% strain, 100 °F, 8,000 hrs	<i>pct</i>	± 0	ASTM-D-1149
Heat aging, 14 days at 212 °F			
Tensile strength, minimum psi	<i>pct</i>	1,000	
Elongation at break	<i>pct</i>	150	
Tear resistance, minimum	<i>lb/in</i>	250	ASTM-D-624 Die B
Commercial field splice			ASTM-D-882, Method A
Strength, shear force, minimum tensile	<i>pct</i>	60	(7 days cure)
Weight change after 7 days at 70 °C in water, maximum	<i>pct</i>	5	ASTM-D-471

**Table 6. Reinforced chlorisulfonated polyethylene**

Test description		Minimum requirements 30 mil thick and greater	Test method
Breaking strength, minimum			ASTM-D-751
Rubber	<i>lb/in</i>	100	
Fabric	<i>lb/in</i>	75	
Ultimate elongation, maximum			
Rubber	<i>pct</i>	150	
Fabric	<i>pct</i>	20	
Ozone resistance, 50 pphm, 20% strain at 100 °F, 8,000 hrs	<i>pct</i>	± 0	ASTM-D-1149
Hydrostatic strength after ozone exposure, 7 days (Mullen), % retained	<i>pct</i>	100	Fed. Spec. CCC 191b Method 5512, ASTM-D-518
Heat aging, 14 days at 212 °F of original			
Tensile strength	<i>pct</i>	90	
Elongation % retained of original	<i>pct</i>	90	
Tear resistance, lbs minimum			ASTM-D-751
Warp or fill direction	<i>pct</i>	10	(tongue)
Puncture resistance, lbs minimum	<i>pct</i>	120	FTMS-101B, Method 2031
Commercial field splice			
Strength—shear force, % of minimum break	<i>pct</i>	75	ASTM-D-882, 7 days cure

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## PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

### Quantity

1. Effects on the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential uses for irrigation water management.
4. Potential changes in growth and transpiration of vegetation located next to the conveyance because of the elimination of leakage from the system.

### Quality

1. Effects of installing the lining on the erosion of the earth conveyance and the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects of the practice on the movement of dissolved substances to ground water.
3. Effects of wetlands or water-related wildlife habitats.
4. Effects on the visual quality of water resources.

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**IRRIGATION WATER CONVEYANCE**  
**GALVANIZED STEEL DITCH AND CANAL LINING**  
(ft)  
**CODE 428C**

**DEFINITION**

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral.

**SCOPE**

This standard applies to linings made of galvanized steel installed in a preformed ditch or canal section.

Linings to which this standard apply are restricted to ditches having characteristics as follows:

- Bottom width.....Not to exceed 30 in.
- Velocity.....Not to exceed 15 ft/s

This standard applies to both the ditch and the steel lining.

**PURPOSE**

To prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water losses.

**CONDITIONS WHERE PRACTICE APPLIES**

Ditches and canals to be lined shall serve as integral parts of an irrigation water distribution or conveyance system designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall either be located where they will not be susceptible to damage from side drainage flooding or be protected from such damage.

Steel linings shall not be installed in areas high in salt or other chemical concentrations injurious to galvanized steel unless the liners are protected with coatings or anodic protection specifically designed to protect the liner from these chemicals.

**DESIGN CRITERIA**

**Capacity.** A lined ditch or canal shall have enough capacity to meet its requirement as part of the planned irrigation water distribution or conveyance system without danger of overtopping. Design capacity shall be based upon the following, whichever is greater:

1. The capacity shall be adequate to deliver the volume of water required to meet the peak consumptive use of the crops.
2. The capacity shall be large enough to provide an adequate irrigation stream for all methods of irrigation planned.

For design purposes, the carrying capacity of steel-lined ditches and canals shall be considered to be equal to the capacity as computed by Manning's Formula, using a coefficient of roughness  $n$  of not less than 0.013.

**Velocity.** A design velocity in excess of 1.7 times the critical velocity shall be restricted to straight reaches that discharge into a section or structure designed to reduce the velocity to less than the critical velocity. The maximum velocity in these straight reaches shall be 15 ft/s.

**Freeboard.** The required freeboard varies with the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be 3 in.

If the velocity is within  $\pm 30$  percent of critical, the freeboard shall be at least 6 in. The minimum freeboard requirement is based on the assumption that the finished channel bottom elevations will vary no more than 0.1 ft from the design elevations. Construction deviations greater than 0.2 ft shall not be permitted. If a construction deviation greater than 0.1 ft is permitted, the minimum freeboard shall be increased an additional 3 in.

Additional freeboard shall be provided as required by slope, velocity, depth of flow, alignment, obstructions, curves, and other site conditions.

**Water surface elevations.** All lined ditches and canals shall be designed so that the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to provide the necessary head, the backwater effect must be considered in computing freeboard requirements. The required elevation of the water surface above the field surface varies according to the type of takeout or device used and the amount of water to be delivered. A minimum head of 4 in. shall be provided.

**Ditch or canal pad or foundation.** Ditch and canal banks shall be built up with earth to a height sufficient to support the full height of the lining and to provide an anchorage for the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 2 in. above the top of the lining.

Berms and ditch banks shall be wide enough to prevent excessive deposition in cut sections and to insure support of the lining in fill sections. The minimum width shall be 1 ft. If the bank or berm is to be used as a roadway, the minimum top width shall be adequate for the purpose. Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability.

**Related structures.** Plans for ditch or canal lining installations shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation.

Structures shall be constructed or installed in such a way that the capacity or the freeboard of the ditch is not reduced and the effectiveness of the lining is not impaired.

All structures shall meet SCS standards and specifications for the type of structure used.

Bulkheads, formed to fit the lining and of sufficient size to extend at least 12 in. into the earthen ditch pad for the entire width of the ditch lining, shall be installed at the beginning and end of the lining section and at intervening points, as needed, to provide adequate anchorage.

**Materials.** Galvanized lining material shall meet the requirements detailed in the specifications under "Materials".

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing galvanized steel irrigation ditches and canal linings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Potential changes in growth and transpiration of vegetation located next to the conveyance because of the elimination of leakage from the system.

### **Quality**

1. Effects of installing the lining on the erosion of the earth conveyance and the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances to ground water.
3. Effects on wetlands or water-related wildlife habitats.
4. Effects on the visual quality of water resources.

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**IRRIGATION WATER CONVEYANCE**  
**NONREINFORCED CONCRETE DITCH AND CANAL LINING**  
(Ft)  
CODE 428A

**DEFINITION**

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch, irrigation canal, or lateral.

**SCOPE**

This standard applies to concrete linings made of nonreinforced Portland cement concrete that is cast in place in a performed ditch or canal section but does not include linings of pneumatically applied mortar.

This standard is restricted to installations in ditches or canals that have a bottom width not greater than 6 ft, a design capacity not greater than 100 ft<sup>3</sup>/s, and a maximum velocity of 15 ft/s.

This standard includes design and construction criteria for shaping or reshaping the ditch section as well as for the lining.

**PURPOSE**

To prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water loss.

**CONDITIONS WHERE PRACTICE APPLIES**

Ditches and canals to be lined shall serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall be located where they are not susceptible to damage from side drainage flooding, or they shall be protected from such damage.

Nonreinforced concrete linings shall be installed only in well-drained soils or on sites where subgrade drainage facilities are installed with or before the lining. These linings shall not be installed on sites susceptible to severe frost heave or on sites where experience has indicated that the sulfate salt concentration in the soil causes rapid concrete deterioration.

On sites where sulfate concentrations exist, concrete linings may be used only if they are made using special sulfate-resistant cement as follows:

### Types of Cement Required for Concrete Exposed to Sulfate Attack

Percentage water-soluble Sulfate (as SO <sub>4</sub> ) in soil samples	Sulfate (as SO <sub>4</sub> ) in water samples, ppm	Cement type
0.00 to 0.10	0 to 150	I or IP
0.10 to 0.20	150 to 1,500	II, II w/Class F pozzolan <sup>1</sup> or IP (MS) <sup>1</sup>
0.20 to 2.0	1,500 to 10,000	V, V w/Class F pozzolan <sup>2</sup> , II w/Class F pozzolan <sup>2</sup> , or IP (MS) <sup>2</sup>
2.0 or more	10,000 or more	V plus Class F pozzolan <sup>2</sup>

<sup>1</sup>R factor less than 1.5 for substituted or blended cement.

<sup>2</sup>R factor less than 0.75 for substituted or blended cement, where  $R = (\text{CaO}-5) / \text{Fe}_2\text{O}_3$

## DESIGN CRITERIA

**Capacity.** A lined ditch or canal shall have enough capacity to meet its requirement as part of the planned irrigation water distribution or conveyance system without damage of overtopping. Design capacity shall be based on the following, whichever is greatest.

1. Capacity shall be enough to deliver the water needed for irrigation to meet the design peak consumptive use of the crops in the area served.
2. Capacity shall be enough to provide an adequate irrigation system for all methods of irrigation planned for use in the area served.
3. For design purposes, the capacity shall be considered to be equal to the capacity as computed with the Manning Formula by using a coefficient of roughness *n* of not less than 0.015.

**Velocity.** To avoid unstable surge flows, restrict a design velocity in excess of 1.7 times the critical velocity to straight reaches that discharge into a section or structure designed to reduce the velocity to less than critical velocity. The maximum velocity in these straight reaches shall be 15 ft/s. The velocity in ditch reaches from which water is to be delivered onto the field through turnouts, siphon tubes, or to similar means shall be less than super-critical and sufficiently low to permit operation of the planned takeout structure or device.

**Freeboard.** The required freeboard varies according to the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of the storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be 3 in. of lining above the designed water surface.

This minimum freeboard requirement is based on the assumption that the finished channel bottom elevation will vary no more than 0.1 ft from the design elevation. If a construction deviation greater than 0.1 ft is permitted, the minimum freeboard shall be increased.

More freeboard shall be provided if required by slope velocity, depth of flow, alignment, obstruction, curves, and other site conditions.

**Water surface elevations.** All lined ditches and canals shall be designed so that the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to be used to provide the necessary head, the backwater effect must be considered in computing freeboard requirements. The required elevation of the water surface varies with the type of takeout structure or device used

and the amount of water to be delivered through each. A minimum head of 4 in. shall be provided.

**Lining thickness.** The thickness of canal linings must be established on the basis of engineering consideration on each job. Location, canal size, velocity, subgrade conditions, method of construction, operation, and climate shall be evaluated in establishing the thickness to be used. The minimum thickness for nonreinforced concrete linings in rectangular sections shall be 3 ½ in. For trapezoidal or parabolic sections, the minimum thickness shall be as shown in table 1.

**Ditch or canal side slopes** Nonreinforced concrete linings generally are used in ditches and canals that have either trapezoidal or parabolic cross section.

They may be used in rectangular sections if the sidewall height is not greater than 1 ½ ft. Side slopes for usual construction methods shall not be steeper than shown below:

Hand-placed, formed concrete:

- Height of lining less than 1 ½ ft.....Vertical

Hand-placed, screened concrete:

- Height of lining less than 2 ½ ft .....3/4 to 1
- Height of lining more than 2 ½ ft .....1 to 1

Slip form concrete:

- Height of lining less than 3 ft.....1 to 1
- Height of lining more than 3 ft.....1 ¼ to 1

**Ditch or canal banks.** Ditch and canal banks shall be built up with earth to at least the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 2 in. above the top of the lining. Banks and berms shall be wide enough to insure stability of fills and to prevent excessive deposition in cut sections.

If the bank or berm is to be used as a roadway, the minimum top width shall be adequate for the purpose.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability.

**Related structures.** Plans for installing ditch or canal linings shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation. These structures can be installed before, during, or after placement of the lining. They must be constructed or installed in such a way as not to damage the lining or to impair its effectiveness.

Table 1. — Minimum required thickness for nonreinforced concrete ditch and canal linings

Design velocity <sup>1</sup>	Minimum thickness by climatic area <sup>2</sup>	
	Warm	Cold
<i>ft/s</i>	<i>in</i>	<i>in</i>
Less than 9.0 .....	1.5	2.0
9.0 - 12.0 .....	2.0	2.5
12.0-15.0 .....	2.5	3.0

<sup>1</sup>Velocities in short chute sections shall not be considered design velocity.

<sup>2</sup>Climatic area:

Warm - Average January temperature is 40 °F and above

Cold - Average January temperature is less than 40 °F.

**Materials.** All materials shall meet or exceed the minimum requirements indicated under specifications for "Materials."

## PLANS AND SPECIFICATIONS

Plans and specifications for installing nonreinforced concrete irrigation ditch and canal linings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## IRRIGATION WATER CONVEYANCE, NONREINFORCED CONCRETE DITCH AND CANAL LINING SPECIFICATIONS

### INSTALLATION

**Foundation preparation.** The foundation area for all ditch embankments and/or ditch pads shall be cleared of all trees, weeds, sod, loose rock or other materials not suitable for the subgrade. All trees with root systems that are a hazard to the ditch or canal lining shall be removed.

**Placement of earthfill.** The moisture content and methods of placing and compacting the material shall insure that a firm, stable embankment results. The fill material shall be placed in horizontal lifts of such thickness that proper compaction and prescribed densities are obtained.

Embankment materials shall be free of brush, roots, sod, large rocks, frozen soil, or other material not suitable for making compacted fills.

**Excavation.** Ditches and canals shall be excavated to the neat lines of the specified cross section and finished with a smooth, firm surface. Overexcavated areas shall be backfilled with moist soil compacted to the density of the surrounding material. No abrupt deviations from design grade or horizontal alignments shall be permitted.

**Concrete placement and curing.** All surfaces on which concrete linings are to be placed shall be moist when the concrete is poured. Slip forms and screeding equipment shall be operated so as to place the concrete uniformly across the perimeter of the ditch or canal, with a minimum thickness not less than that specified. Concrete shall not be placed on mud, excessively dry soil, uncompacted fill, ice or frozen subgrade.

Concrete linings shall be constructed to at least the thickness shown on the plans or as specified for the job or both. Finished lining grades shall not vary above or below the design channel grade by more than the deviation assumed in computing the freeboard requirements and as specified for the job. Concrete linings shall have a smooth and uniform finish and shall be free of honeycomb.

Concrete shall be cured for not less than 5 days by (1) impounding water over the exposed surface, (2) covering with burlap or a similar material that is kept continuously moist, or (3) spraying a concrete sealing compound evenly over all exposed surfaces according to the manufacturer's directions.

**Contraction and construction joints.** Contraction joints, at least ¼ in. wide, shall be cut transversely in the concrete to a depth of about one-third the thickness of the lining at a uniform spacing not greater than 10 ft. Construction joints shall be the butt type formed square with the lining surface and at right angles to the ditch or canal. Contraction and construction joints shall be tooled so that the edges will have a smooth finish.

**Construction operations.** Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall be workmanlike and shall present a good appearance.

If conditions warrant, concrete shall be protected from freezing for at least 3 days after placement.

The use of accelerators or antifreeze compounds shall not be allowed.

Concrete damaged by freezing shall be considered defective work and must be removed and replaced according to these specifications.

## **MATERIALS**

**Concrete.** Concrete used in ditch and canal linings shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on the side slopes. A dense, durable product shall be required. The concrete mix shall be one that can be certified as suitable to produce a 28-day compressive strength of 2,000 lb/in.<sup>2</sup> or greater.

Ready mix may be used if the concrete is mixed and delivered according to ASTM Designation C-94, and the cement content and maximum size aggregate conform to the requirements shown in the preceding paragraphs. Ready-mix concrete shall be discharged from the truck mixer within 1 ½ hours after water is mixed with the cement and aggregates, or the cement with the aggregates. If the air temperature exceeds 90 degrees F, the discharge time shall be reduced to 45 minutes.

**Cement.** The cement used shall be Portland cement, Types I, IP (MS), II, or V as specified for the job. Approved Class F pozzolans with LDI factor less than 3 percent may be used to replace not more than 15 percent of the cement by absolute volume. The R factor for class F pozzolan will be determined by the formula  $R = (\text{CaO} - 5) / \text{Fe}_2\text{O}_3$ . This requirement applies to fly ashes used in blended or interground cement or fly ash used as a substitute for cement at the time of batching. Refer to the table on page 1 of this standard for R factor values. The cement content shall not be less than 4.5 bags/yd<sup>3</sup> of concrete.

**Water.** Water used in mixing shall be clean and free from harmful amounts of sediments, salts, or organic impurities.

**Aggregates.** Aggregates shall conform to ASTM Designation C-33, Standard Specification for Concrete Aggregates, except that pit-run aggregates may be used if they are well graded, clean, and durable. Maximum size shall not exceed one-half the specified lining thickness.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Potential changes in growth and transpiration of vegetation located next to the conveyance because of the elimination of leakage from the system.

## Quality

1. Effects of installing the lining on the erosion of the earth conveyance and the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances to ground water.
3. Effects on wetlands or water-related wildlife habitats.
4. Effects on the visual quality of water resources

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**IRRIGATION WATER CONVEYANCE**  
**ALUMINUM TUBING PIPELINE**  
(ft)  
**CODE 430AA**

**DEFINITION**

A pipeline and appurtenances installed in an irrigation system.

**SCOPE**

This standard applies only to buried aluminum pipelines coated with plastic tape on the exterior surface.

**PURPOSE**

To prevent erosion or loss of water quality or damage to land, to make possible proper water use, and to reduce water conveyance losses.

**CONDITIONS WHERE PRACTICE APPLIES**

All pipelines shall be planned and located to serve as an integral part of an irrigation water distribution system designed to facilitate the conservation of water on a farm or group of farms.

All areas served by the pipelines shall be suitable for irrigation

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects on the components of the water budget, especially infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

**Water Quality**

1. Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

## DESIGN CRITERIA

**Working pressure.** The maximum permissible working pressure in the line shall be determined by the following equation:

$$P = 2St/d$$

Where:

S = 7,500 lb/in.<sup>2</sup>

P = Maximum working pressure in lb/in.<sup>2</sup>

d = Inside diameter of tube in in.

t = Tube nominal wall thickness in in.

**Capacity.** Design capacity shall be based on whichever of the following is greater:

1. The capacity shall be adequate to deliver the volume of water required to meet the peak consumptive use of the crop.
2. The capacity shall be adequate to provide an adequate irrigation stream for all methods of irrigation planned.

For design purposes, the value of *n* in Manning's Formula shall be considered to be 0.01, except where joints, connections, and condition of the pipe indicate that a higher value is required.

**Stands for low-pressure lines open to the atmosphere.** Stands shall be used when water enters the pipeline to avoid entrapment of air; to prevent surge pressures and collapse because of vacuum failure; and to prevent pressure from exceeding the design working stress of the pipe. The stand shall be design to:

1. Allow a minimum of 1 ft of freeboard. The maximum height of the stand above the centerline of the pipeline must not exceed the maximum working head of the pipe.
2. Have the top of each stand at least 4 ft. above the ground surface except for surface gravity inlets, which shall be equipped with trash racks and covers.
3. Have a downward water velocity in stands not in excess of 2 ft/s. The inside diameter of the stand shall not be less than the inside diameter of the pipeline.

The cross sectional area of stands may be reduced above a point 1 ft above the top of the upper inlet, but the reduced cross section shall not be such that it would produce an average velocity of more than 10 ft/s if the entire flow were discharging through it.

If the water velocity of an inlet pipe exceeds three times the velocity of the outlet, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 in. and shall be constructed so that the bottom is at least 24 in. below the invert of the outlet pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 ft/s. Suitable provisions shall be made for cleaning sand traps.

The dimensions of gate stands shall be adequate to accommodate the gate or gates required and shall be large enough to make the gates accessible for repair.

The size of float valve stands shall be adequate to provide accessibility for maintenance and to dampen surge.

Stands must be constructed in a manner to insure vibration from the pump discharge pipe is not carried to the stand.

**Vents for low-pressure lines open to the atmosphere.** Vents must be designed into the system to provide for the removal of air and prevention of vacuum collapse. They shall:

1. Have a minimum freeboard of 1 ft above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum working head of the pipe.
2. Have a cross sectional area at least one-half the cross sectional area of the pipeline (both inside measurements) for a distance of at least one pipeline diameter up from the centerline of the pipeline. Above this elevation, the vent may be reduced to 2 in. in diameter.
3. Vents shall be located:
  - a. At the downstream end of each lateral,
  - b. At summits in the line,
  - c. At points where there are changes in grade in a downward direction of flow of more than 10 degrees,
  - d. Immediately below the pump stand if the downward velocity in the stand exceeds 1 ft/s.
4. A combined air-release-vacuum-release valve may be used instead of an open vent. Air-vacuum release valves shall have a 2-in. minimum diameter. For lines 6 in. or less in diameter, 2-in. valves shall be used; for lines 7 in. through 10 in. in diameter, 3-in. valves shall be used; and for lines 12 in. in diameter, 4-in. valves shall be used.

**Outlets.** Appurtenances to deliver water from a pipe system to the land, a ditch, or any surface pipe system are known as outlets. Outlets shall have a capacity to deliver the required flow to (1) the hydraulic gradeline of a pipe or ditch or (2) a point at least 6 in. above the field surface.

**Drainage.** Provision shall be made to completely drain the pipeline. Drainage outlets should be provided at all low points in the system and may either discharge into a dry well or to a point of lower elevation. If these gravity discharge points are unavailable, provision shall be made to empty the line by pumping.

**Check, pressure-relief, and air-and vacuum-release valves for high-pressure closed systems.** A check valve shall be installed between the pump discharge and the pipeline if detrimental backflow may occur.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, a surge chamber or a pressure-relief valve shall be installed in closed systems in which a check valve protects the line from reversal of flow and excessive surge pressure may develop. Pressure-relief valves shall be no smaller than  $\frac{1}{4}$  in. nominal size for each diameter inch of the pipeline and shall be set at a maximum of 5 lb/in.<sup>2</sup> above the pressure rating of the pipe. If needed to relieve surge, pressure-relief valves or surge chambers shall be installed at the end of the pipeline.

Air-release and vacuum-release valves shall be placed at all summits in the pipeline and at the end of the line if needed to provide a positive means of air release valve or escape. Air-release and vacuum-release valve outlets of at least  $\frac{1}{2}$ -in. nominal diameter shall be used in lines 4 in. or less in diameter, at least 1-in. outlets in lines 5 to 8 in. in diameter, and at least 2-in. outlets in lines 10 to 16 in. in diameter.

**Joints and connections.** All connections shall be constructed to withstand the working pressure of the line without leakage and to leave the inside of the line free of any obstructions that can reduce the line capacity below design requirements. All such fittings as risers, ells, tees, and reducers should be of similar metal. If dissimilar metals are used, however, the fittings shall be protected against galvanic corrosion. For example, separate dissimilar metals with a rubber or plastic insulator. The connection between the pump discharge pipe and the aluminum line shall be made of suitable insulating material, such as rubber or plastic.

**Quality of water.** Water-quality tests shall be made for all aluminum pipeline installations. A copper content in excess of 0.02 p/m produces nodular pitting and rapid deterioration of the pipe if water is allowed to remain stagnant.

**Materials.** Pipe and coating materials shall equal or exceed the physical requirements specified under "Materials".

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing aluminum tubing irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

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**IRRIGATION WATER CONVEYANCE**  
**ASBESTOS-CEMENT PIPELINE**  
(ft)  
**CODE 430BB**

**DEFINITION**

A pipeline and appurtenances installed in an irrigation system.

**SCOPE**

This standard applies to buried asbestos-cement pipelines with rubber gasket joints.

**PURPOSE**

To prevent erosion or loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

**CONDITIONS WHERE PRACTICE APPLIES**

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

**DESIGN CRITERIA**

**Working pressure.** The pipelines shall be designed to meet all service requirements without a static or working pressure at any point greater than the minimum allowable working pressure of the pipe used at that point. The static or working pressure of pipelines open to the atmosphere shall include freeboard.

The maximum design working pressure shall be based on a safety factor of no less than 3.0 applied to the certified applied hydrostatic proof pressure as determined by the Hydrostatic Proof Test Procedure in ASTM-C-500. Hydrostatic proof test pressures and associated maximum working pressures for standard pipe classifications shall be as specified in ASTM-C-500, table 1.

For pipelines to be used principally for conveyance, where adequate hydraulic analysis of surge, water hammer, or other pressure change is made on the basis of anticipated operating conditions and where combined loading stresses are determined, a safety factor of not less than 2.0 may be applied to the hydrostatic proof pressure and 1.5 to the crushing strength to determine the maximum design working pressure. The minimum acceptable working pressure classification shall be 25 lb/in<sup>2</sup>.

**External load limit.** A safety factor of at least 1.50 shall be applied to the certified three-edge bearing test in computing allowable heights of fill over the pipe. The earth loads shall be computed by the method outlined in SCS TR-5.

**Capacity.** The design capacity of the pipeline shall be based on whichever of the following criteria is greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.
2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

**Friction losses.** For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient,  $c$  equal to 140.

**Flow velocity.** The full-pipe design water velocity in the pipeline when operating at system capacity shall not exceed 5 ft/s. If this limit is exceeded, special considerations must be given to the flow conditions and measures needed to adequately protect the pipeline against surge.

**Outlets.** Appurtenances to deliver water from the pipe system to the land, to a ditch or reservoir, or to any surface pipe system shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow to: (1) the hydraulic gradeline of a pipe or ditch, (2) a point at least 6 in. above the field surface, or (3) the design surface elevation in a reservoir.

**Check valves.** A check valve shall be installed between the pump discharge and the pipeline where backflow may occur.

Stands open to the atmosphere. Stands shall be placed at each inlet to the irrigation pipe system and at such other points as required. In addition to their other functions, all stands shall serve as vents. Stands shall be constructed of steel pipe or other approved material and shall be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline. Open stands shall be designed to meet or exceed the following criteria:

1. Each stand shall allow at least 1 ft of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that neither the static head nor the design working head nor the design working head plus freeboard shall exceed the allowable working pressure of the pipe.
2. The top of each stand shall extend at least 4 ft above the ground surface except for surface gravity inlets or where visibility is not a factor. Gravity inlets or stands shall be equipped with a trash guard.
3. Downward water velocities in stands shall not exceed 2 ft/s. The inside diameter of the stand shall not be less than the inside diameter of the pipeline. This downward velocity criterion applies only to stands having vertical offset inlets and outlets.
4. If the water velocity in the inlet (from the pump or other water source) equals or exceeds three times the velocity in the outlet pipeline, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.
5. The cross-sectional area of stands may be reduced above a point 1 ft above the top of the upper inlet or outlet pipe, but not so much that it would produce an average velocity of more than 10 ft/s if the entire flow were discharging through it.
6. Vibration-control measures such as special couplers or flexible pipe, shall be provided as needed to insure that vibration from pump discharge is not transmitted to stands.

Sand traps that also serve as a stand shall have a minimum inside dimension of 30 in. and shall be constructed so that the bottom is at least 24 in. below the invert of the outlet to the pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 ft/s.

Gate stands shall be of sufficient dimension to accommodate the gate or gates and shall be large enough to make the gates accessible for repair.

Float valves stands shall be large enough to provide accessibility for maintenance and to dampen surge.

Stands closed to the atmosphere. If pressure-relief valves and air-and-vacuum valves are used instead of open stands, all requirements detailed under "Stands Open to the Atmosphere" shall apply except as modified below.

The inside diameter of the closed stand shall be equal to or greater than that of the pipeline for at least 1 ft above the top of the uppermost inlet or outlet pipe. To facilitate attaching the pressure-relief valve and the air-and-vacuum valve, the stand may be capped at this point, or if additional height is required, the stand may be extended to the desired elevation by using the same inside diameter or a reduced cross section. If a reduced section is used, the cross-sectional area shall be such that it would produce an average velocity of no more than 10 ft/s if the entire flow were discharged through it. If no vertical offset is required between the pump discharge pipe and the outlet pipeline and the discharge pipe is "doglegged" below ground, the stand shall extend at least 1 ft above the highest part of the pump discharge pipe.

An acceptable alternative design for stands requiring no vertical inlet offset (when inlet velocity is less than three times that of the outletting pipeline) shall be to:

1. Construct the "dogleg" section of the pump discharge pipe with the same nominal diameter as that of the pipeline.
2. Install the pressure-relief valve and the air-and-vacuum valve on top of the upper horizontal section of the "dogleg."

Pressure-relief and air-and-vacuum valves shall be installed on stands with the nominal size pipe required to fit the valves' threaded inlets.

**Vents.** Vents must be designed into systems open to the atmosphere to provide for the removal and entry of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 ft above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum allowable working pressure of the pipe.
2. Have a cross-sectional area at least one-half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least one pipe-line diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2-in. in diameter.

These cross-sectional requirements shall apply when an air-and-vacuum valve is used instead of a vent, but the reduced section shall be increased to the nominal size pipe required to fit the valve's threaded inlet. An acceptable alternative is to install this valve in the side of a service outlet riser, provided that the riser is properly located and adequately sized. If both an air-and-vacuum valve and a pressure-relief valve are required at the location, the 10-ft/s velocity criterion given under "Stands" shall apply to the reduced section.

3. Be located at the downstream end of each lateral at summits in the line, and at points where there are changes in grade in a downward direction of flow of more than 10 degrees.

**Air-release valve.** The three basic types of air-release valves available for use on irrigation pipelines are described below:

An air-release valve, a continuous acting valve that has a small venting orifice generally ranging between 1 1/16 in. and 3/8 in. in size. This valve releases pockets of air from the pipeline once the line is filled and under working pressure.

An air-and-vacuum valve, which has a large venting orifice, exhaust large quantities of air from the pipeline during filling operations and allows air to reenter the line and prevents a vacuum from forming during emptying operations. This type of valve is sometimes called air-vacuum-release valve or air-vent-and-vacuum-relief valve. It is not continuous acting because it does not allow further escape of air at working pressure once the valve closes.

A combination air valve, sometimes called combination air-release-and-air-vacuum valve or combination air-and-vacuum-relief valve. It is continuous acting and combines the functions of both the air-release valve and the air-and-vacuum valve. Both valves are housed in one valve body.

Air-and-vacuum valves may be used at any or all the locations listed under "Vents" instead of the vents. An air-and-vacuum valve also may be used in conjunction with a pressure-relief valve as an alternative to open pump stands. A pipeline is considered open to the atmosphere if at least one stand, vent, or service outlet is unclosed and located so that it cannot be isolated from the system by line gates or valves.

On asbestos-cement pipelines not open to the atmosphere, air-and-vacuum valves shall be installed at all locations specified under "Vents," on all pump stands, and at inline control devices where there is a need for air removal and entry during filling and emptying operations.

The diameter of the orifice (opening that controls air-flow during filling and emptying operations) of an air-and -vacuum valve shall equal or exceed that specified in figure 1 for the appropriate diameter of the pipeline.

A combination air valve may be used instead of an air-and-vacuum valve, provided that the large venting orifice is properly sized.

Air-release valves or combination air-valves shall be used as needed to permit air to escape from the pipeline while the line is at working pressure. Small orifices of these types shall be sized according to the working pressure and venting requirements recommended by the valve manufacturer.

Manufacturers of air valves marketed for use under this standard shall provide dimensional data, which shall be the basis for selection and acceptance of these valves.

**Pressure-relief valves.** Pressure-relief valves may be used on asbestos-cement pipelines as an alternative to stands open to the atmosphere. A pressure-relief valve shall serve the pressure-relief function of the open stand or vent for which it is an alternative.

Pressure-relief valves do not function as air-release valves and shall not be used as substitutes for such valves if release or entry of air is required. A pressure-relief valve shall be installed between the pump discharge and the pipeline if excessive pressures are likely to build up when all valves are closed. A pressure-relief valve shall be installed on the discharge side of the check valve if a reversal of flow occurs and at the end of the pipeline if it is needed to relieve surge at the end of the line.

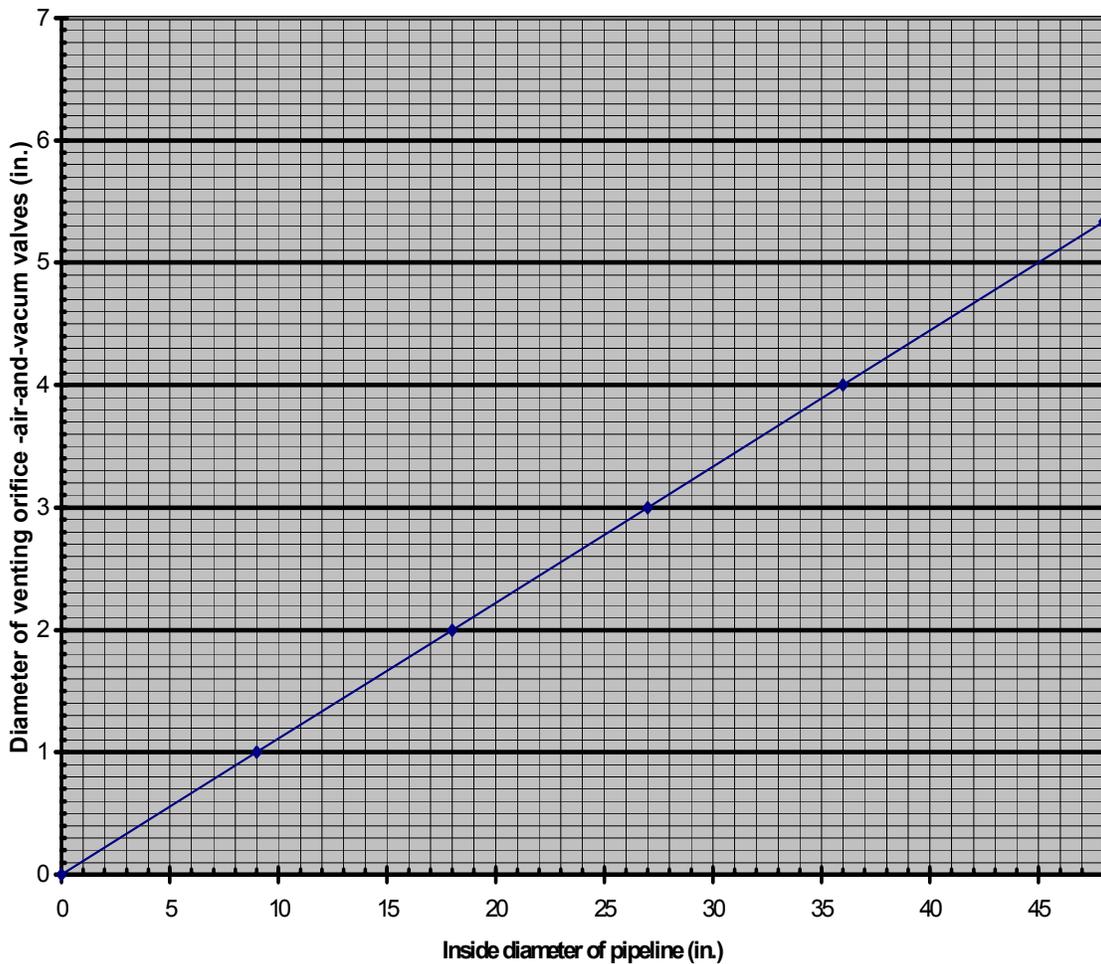
Pressure-relief valves for all classes of asbestos-cement pipe shall be no smaller than 1/4-in. for each inch of the pipeline diameter and shall be set to open at a pressure no greater than 5 lb/in.<sup>2</sup> above the pressure rating of the pipe.

The pressure at which the valve starts to open shall be marked on pressure-relief valves. Adjustable pressure-relief valves shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

Manufacturers of pressure-relief valves marketed for use under this standard shall provide capacity tables, based on performance tests, that give the discharge capacities of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be the basis for design of pressure setting and of acceptance of these valves.

**Drainage.** Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures or if a drainage of the line is specified for the job. If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets can drain into dry wells or to points or lower elevation. If drainage cannot be thus provided by gravity, provisions shall be made to empty the line by pumping or by other means.

**Figure 1. Sizing of air-and-vacuum valves**



**Flushing.** If provision are needed for flushing the line free of sediment or other foreign material, a suitable valve shall be installed at the distal end of the pipeline.

**Thrust control.** Abrupt changes in pipeline grade, changes in horizontal alignment, or reduction in pipe size normally require an anchor or thrust blocks to absorb any axial thrust of the pipeline. Thrust blocks may also be needed at the end of the pipeline and at inline control valves.

The pipe manufacture’s recommendations for thrust control shall be followed. In the absence of such recommendations, the following formula shall be used to design thrust blocks:

$$A = ((98 HD^2)/B)\sin(a/2)$$

Where:

- A = Area of thrust block required
- H = Maximum working pressure in ft
- D = Inside diameter of pipe in ft
- B = Allowable passive pressure of the soil in lb/ft<sup>2</sup>
- a = Deflection angle of pipe bend

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90° deflection angle of pipe bend.

If adequate soil tests are not available, the passive soil pressure may be estimated from the following:

Table 1.—Allowable soil bearing pressure

Natural soil material	Depth of cover to center of thrust block			
	2 ft	3 ft	4 ft	5 ft
Sound bedrock	8,000	10,000	10,000	10,000
Dense sand and gravel mixture (assumed Ø = 40°)	1,200	1,800	2,400	3,000
Dense fine to coarse sand (assumed Ø = 35°)	800	1,200	1,650	2,100
Silt and clay mixture (assumed Ø = 25°)	500	700	950	1,200
Soft clay and organic soils (assumed Ø = 10°)	200	300	400	500

**Materials.** All materials described and required in this standard shall meet or exceed the minimum requirements indicated in “Specification for Materials.”

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing asbestos-cement irrigation pipelines shall be in keeping with this standard and shall describe the requirements necessary for installing the practice to achieve its intended purpose.

## ASBESTOS-CEMENT PIPELINE SPECIFICATIONS

### INSTALLATION

**Minimum depth of cover.** Pipe shall be installed deep enough to insure protection from hazards imposed by traffic crossings, farming operations, freezing temperatures, or soil cracking. The minimum depth of cover shall be 2 ft; but in soils susceptible to deep cracking, the minimum cover shall be 3 ft.

At low places on the ground surface, extra fill may be placed over the pipeline to provide the minimum depth of cover. The fill shall be no less than 10 ft wide and the side slopes no steeper than 6:1. If extra protection is needed at vehicle crossings, encasement pipe or other approved methods may be used.

**Trench construction.** The trench at any point below the top of the pipe shall be only wide enough to permit the pipe to be easily placed and joined and to allow the backfill material to be uniformly placed under the haunches and along the sides of the pipe.

The trench bottom shall be uniform so that the pipe lays on the bottom without bridging. Clods, rocks, and uneven spots that can damage the pipe or cause nonuniform support shall be removed.

If trenches are excavated in soils containing rock or other hard materials, if the soils are susceptible to appreciable swelling and shrinking on wetting and drying, or if the trench bottom is unstable, the trenches shall be overexcavated and backfilled with selected materials, as needed, to provide a suitable base. If water is in the trench, it shall be drained away, and laying of the pipe shall be postponed until a suitable base is obtained.

The trench alignment shall be such that the pipe can be laid without excessive deflections at the joints.

**Placement.** The pipe shall be uniformly and continuously supported over its entire length of firm stable material. Blocking or mounding shall not be used to bring the pipe to final grade.

The pipe shall be placed so that the maximum deflection in any one coupling does not exceed 5 degrees for pipe sizes 12 in. and less and 3 degrees for larger sizes. Short radius curves may be introduced into the alignment by using short sections of pipe and giving each coupling no more than the maximum allowable deflection.

**Joints and connections.** All joints and connections shall be designed and constructed to withstand the design maximum working pressure for the pipeline without leakage and to leave the inside of the line free of any obstruction that can reduce its capacity below design requirements.

All fittings, such as couplings, reducers, bends, tees, and crosses, shall be installed according to the recommendations of the pipe manufacturer.

Fittings made of steel or other metals susceptible to corrosion shall be adequately protected by wrapping them with plastic tape or by applying a coating having high corrosion-preventative qualities. If plastic tape is used, all surfaces shall be thoroughly cleaned and then coated with a primer compatible with the tape before wrapping them.

**Thrust blocks.** Thrust blocks must be formed against a solid hand-excavated trench wall that is undamaged by mechanical equipment. They shall be constructed of concrete; the space between the pipe and the trench wall shall be filled to the height of the outside diameter of the pipe or as specified by the manufacturer.

**Backfill.** Backfill material shall be free of large rocks or stones, frozen clods, and other debris that can damage the pipe.

The material shall be placed so that (1) the pipe will not be displaced or damaged, (2) there will be no unfilled spaces in the backfill, and (3) the backfill will be level with the natural ground or at the design grade required to provide the minimum depth of cover after settlement.

**Testing.** Pipelines shall be tested for leaks by observing their normal operation any time after the contractor has installed all appurtenances on the pipeline and indicated the pipeline is ready for testing.

The line shall be inspected in its entirety while the maximum working pressure is maintained. All visible leaks shall be promptly repaired and the line retested.

It shall be demonstrated by testing that the pipeline will function properly at design capacity. At or below design capacity there shall be no objectionable flow conditions. Objectionable flow conditions shall include water hammer, continuing unsteady delivery of water, damage to the pipeline, or detrimental discharge from control valves.

**Basis of acceptance.** The acceptability of the pipeline shall be determined by inspections to check compliance with all the provisions of this standard with respect to the design of the line, the pipe and pipe markings, the appurtenances used, and the minimum installation requirements.

**Certification and guarantee.** If requested by the state conservation engineer, the pipe manufacturer must certify that the pipe meets the requirements specified in this standard.

The installing contractor shall certify that the installation complies with the requirements of this standard. He shall furnish a written guarantee that protects the owner against defective workmanship and materials for a period not less than 1 year. The certification identifies the manufacturer and markings of the pipe used.

## **MATERIALS**

Quality of asbestos-cement pipe. Asbestos-cement irrigation pipe and coupling sleeves shall be made of an intimate mixture of Portland cement (ASTM-C-150) or of Portland blast furnace slag Cement (ASTM-C-595) or of Portland-Pozzolan cement (ASTM-C-595), silica and asbestos fiber and shall be free of organic substances. The material shall be formed under pressure and thoroughly cured to produce pipe meeting the requirements of these specifications.

The pipe shall be Types I, II, and III, corresponding to the chemical requirements given below:

- Type I—For use on sites where moderately aggressive water and soil of moderate sulfate content are expected to come in contact with the pipe. When tested according to the Uncombined Calcium Hydroxide Test Procedure provided in ASTM-C-500, the amount of uncombined calcium hydroxide in the pipe shall not exceed 3 percent.
- Type II—For general use on sites where either moderately or highly aggressive water or water and soil of both moderate and high sulfate content are expected to come in contact with the pipe. When tested according to the Uncombined Calcium Hydroxide Test Procedure provided in ASTM-C-500, the uncombined calcium hydroxide in the pipe shall not exceed 1 percent.
- Type III—For use only on sites where contact with aggressive waters and sulfates are not expected. There are no chemical requirements for Type III pipe.

**Pipe requirements.** Asbestos-cement irrigation pipe shall meet all the requirements of these specifications (430-BB) and shall be classified according to its allowable maximum operating pressure: 25, 75, 90 and 125.

Asbestos-cement pressure pipe shall meet all the requirements of ASTM-C-296 and shall be classified according to its pressure class: 100, 150, and 200.

Asbestos-cement transmission pipe shall meet all requirements of ASTM-C-668 and shall be in classifications representing numerically one-tenth of the minimum hydrostatic strength. Such classifications are 30, 35, 40, 45, 50, 60, 70, 80, and 90.

Each standard, random, or short length of pipe and coupling sleeve shall be hydrostatically tested by the manufacturer before shipment. They shall have sufficient strength to withstand the applied hydrostatic proof pressure prescribed in table 1 when tested according to the hydrostatic Proof Test Procedure provided in ASTM-C-500.

The maximum allowable working pressure for the various types and classification of asbestos-cement pipe are listed in table 1.

Each length of pipe shall have sufficient flexural strength to withstand, without failure, the total load prescribed in tables 2 and 3 for the classes and sizes listed when tested according to the Flexure Proof Test Procedure in ASTM-C-500.

Asbestos-cement pipe shall have the minimum crushing strength indicated in tables 4 and 5 when tested according to the Crushing Test Procedure in ASTM-C-500.

**Fittings and couplers.** All fittings and couplers shall meet or exceed the pressure rating of the pipe with which they are used.

Coupling sleeves shall be made of asbestos-cement and shall be machined with rubber ring retaining grooves so that a watertight seal is provided when the joint is assembled. Assembly of pipe and coupling shall provide necessary and separation.

**Markings.** Each standard or random length of pipe shall bear the name or trademark of the manufacturer, nominal size, pipe classification, and date of manufacture. The type of pipe (Types I, II, or III, corresponding to the chemical requirements) shall be marked on the pipe or stated in the manufacturer's literature pertaining to the pipe.

Each asbestos-cement coupling sleeve shall bear the name or trademark of the manufacturer, nominal size, classification, and the letter T to indicate that it has been hydrostatically tested.

**Gaskets.** Rubber ring gaskets required for proper assembly of pipe and coupling shall conform to the manufacturer's dimensions and tolerances. They shall equal or exceed the specifications for gaskets indicated in ASTM-D-1869.

Table 1.—Applied hydrostatic proof pressure

Specification No.	Pipe Classification	Working Pressure	Applied proof pressure	Size range
		-----lb/in. <sup>2</sup> -----		
SCS 430-BB irrigation pipe	25 lb	25	75	3 - 36
	75 lb	75	225	3 - 36
	90 lb	90	270	3 - 36
	125	125	375	3 - 36
ASTM-C-296 pressure pipe	Class 100	100	350	3 - 36
	Class 150	150	525	3 - 36
	Class 200	200	700	3 - 36
ASTM-C-668 transmission pipe	30	75	225	6 - 42
	35	87	262	—
	40	100	300	—
	45	112	337	—
	50	125	375	—
	60	150	450	—
	70	175	525	—
	80	200	600	—
	90	225	675	—

Table 2.—Minimum flexural strength  
(Total applied load in lb)

Nominal size	Working pressure classification						
	SCS 430-BB irrigation pipe				ASTM-C-296 pressure pipe		
	25 lb	75 lb	90 lb	125 lb	Class 100	Class 150	Class 200
<i>in</i>							
3	300	500	—	750	755	853	915
4	600	1,000	—	1,300	1,200	1,470	1,870
5	900	1,500	—	2,000	—	—	—
6	1,300	2,000	2,000	3,300	2,800	3,700	4,900
8	2,500	3,700	4,000	6,000	5,330	7,600	10,130

NOTE: Based on a 9-ft span for all sizes. See ASTM-C-500, Flexure Proof Test

Table 3.—Minimum flexural strength  
(Total applied load in lb)

Nominal size	Pipe classification ASTM-C-668 transmission pipe								
	30	35	40	45	50	60	70	80	90
<i>in</i>									
6	—	—	2,300	2,500	2,800	3,200	3,700	4,000	4,900
8	3,700	4,400	5,100	5,700	6,400	6,900	7,600	8,800	10,100

NOTE: Based on a 9-ft span for all sizes. See ASTM-C-500, Flexure Proof Test

Table 4.—Minimum crushing strength for asbestos-cement pipe  
(lb/lineal ft)

Nominal size	Working pressure classification						
	SCS 430-BB irrigation pipe				ASTM-C-296 pressure pipe		
	25 lb	75 lb	90 lb	125 lb	Class 100	Class 150	Class 200
<i>in</i>							
3	1,500	2,300	—	4,400	4,600	6,700	8,800
4	1,100	1,900	—	4,200	4,100	5,400	8,700
5	1,000	1,650	—	4,000	—	—	—
6	1,000	1,400	1,600	3,700	4,000	5,400	9,000
8	1,300	1,650	2,000	4,000	4,000	5,500	9,300
10	1,500	1,900	2,100	4,300	4,400	7,000	11,000
12	1,500	2,200	2,300	4,600	5,200	7,600	11,800
14	1,500	2,600	—	5,000	5,200	8,600	13,500
16	1,500	2,750	—	5,400	5,800	9,200	15,400
18	1,800	2,900	—	5,800	6,500	10,100	17,400
20	2,000	3,100	—	6,400	7,100	10,900	19,400
24	2,400	3,500	—	7,500	8,100	12,700	22,600
30	3,000	4,100	—	9,000	9,700	15,900	28,400
36	3,600	5,000	—	10,500	11,200	19,600	33,800

Table 5.—Minimum crushing strength for asbestos-cement pipe  
(lb/lineal ft)

Nominal size <i>in</i>	Pipe classification ASTM-C-668 transmission pipe								
	30	35	40	45	50	60	70	80	90
6	—	—	2,400	3,200	4,000	4,700	5,700	6,700	9,000
8	2,000	2,400	2,800	3,400	4,000	4,800	5,500	7,400	9,300
10	2,000	2,500	3,000	3,500	4,500	5,500	7,000	9,000	11,000
12	2,000	2,500	3,000	4,000	5,200	6,400	7,800	10,000	12,500
14	2,000	2,500	3,000	4,000	5,200	7,000	8,800	11,000	13,500
15	2,300	2,800	3,300	4,300	5,500	7,400	9,300	12,000	14,500
16	2,500	3,000	3,500	4,500	5,800	7,500	9,500	12,400	15,400
18	2,500	3,000	4,000	5,000	6,500	8,500	11,000	14,000	18,000
20	2,500	3,500	4,500	5,500	7,100	9,500	12,000	15,000	20,000
21	2,500	3,500	4,500	5,800	7,300	9,700	12,500	16,000	21,000
24	2,800	3,800	5,000	6,200	8,100	11,000	15,000	19,000	24,000
27	3,500	4,200	5,500	7,000	8,800	12,500	16,500	20,500	27,000
30	3,500	4,500	6,000	7,500	9,700	13,500	18,000	22,500	30,000
33	3,500	5,000	6,500	8,000	10,500	14,500	19,500	24,500	33,000
36	4,000	5,000	7,000	9,000	11,200	16,000	21,000	26,000	36,000
39	4,200	5,300	7,500	9,700	12,000	17,200	22,500	28,000	39,000
42	4,300	5,700	8,000	10,500	13,000	18,500	24,000	30,000	42,000

## PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

### Quantity

1. Effects on the components of the water budget, especially infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

### Quality

1. Effects of installing the pipeline, replacing other types of conveyances, on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

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**IRRIGATION WATER CONVEYANCE**  
**HIGH-PRESSURE, UNDERGROUND, PLASTIC PIPELINE**  
(ft)  
**CODE 430DD**

**DEFINITION**

A pipeline and appurtenances installed in an irrigation system.

**SCOPE**

This standard applies to underground thermoplastic pipelines ranging from ½ in. to 27 in. in diameter that are closed to the atmosphere and that are subject to internal pressures of 80 lb/in.<sup>2</sup> or greater.

The standard includes the design criteria and minimum installation requirements for high-pressure, plastic irrigation pipelines and specifications for the thermoplastic pipe.

**PURPOSE**

To prevent erosion or loss of water quality or damage to the land, to make possible proper management of irrigation water, and to reduce water conveyance losses.

**CONDITIONS WHERE PRACTICE APPLIES**

All pipelines shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

Water supplies, water quality, and rates of irrigation delivery for the area served by the pipelines shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application method to be used.

Plastic pipelines installed according to this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects on components of the water budget, especially infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

**Water Quality**

1. Effects of installing the pipeline, replacing other types of conveyances, on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.

2. Effects on the movement of dissolved substances into the soils and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

## DESIGN CRITERIA

**Working pressure and flow velocity.** The minimum acceptable class of pipe shall be that having a pressure rating for water of 80 lb/in.<sup>2</sup>.

The pipeline shall be designed to meet all service requirements without an operating pressure, including hydraulic transients, or static pressure at any point greater than the pressure rating of the pipe used at that point. As a safety factor against surge or water hammer, the working pressure should not exceed 72 percent of the pressure rating of the pipe, nor should the design flow velocity at system capacity exceed 5 ft/s. If either of these limits is exceeded, special consideration must be given to the flow conditions and measures taken to adequately protect the pipeline against surge.

**Capacity.** The design capacity of the pipeline shall be based on whichever of the following criteria is greater:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.
2. The capacity shall be sufficient to provide an adequate stream for all methods of irrigation planned.

**Friction losses.** For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient, *c*, equal to 150.

**Outlets.** Appurtenances required to deliver water from the pipeline to an individual sprinkler or to a lateral line of sprinklers or surface pipe located on the ground surface shall be known as outlets. Outlets shall have adequate capacity to deliver the design flow to the individual sprinkler, surface lateral line of sprinklers, or surface pipe at the design operating pressure.

**Check valves.** A check valve shall be installed between the pump discharge and the pipeline where backflow may occur.

**Pressure-relief valves.** A pressure-relief valve shall be installed between the pump discharge and the pipeline if excessive pressure can build up when all valves are closed. Pressure-relief valves shall be installed on the discharge side of the check valve where a reversal of flow may occur and at the end of the pipeline if needed to relieve surge at the end of the line.

Pressure-relief valves shall be no smaller than ¼-in. nominal size for each inch of the pipeline diameter and shall be set to open at a pressure no greater than 5 lb/in.<sup>2</sup> above the pressure rating of the pipe.

The pressure at which the valves start to open shall be marked on each pressure-relief valve. Adjustable pressure-relief valves shall be sealed or otherwise altered to prevent changing the adjustment from that marked on the valve.

Manufacturers of pressure-relief valves marketed for use under this standard shall provide capacity tables, based on performance tests, that give the discharge capacities of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be the basis for design of pressure setting and of acceptance of these valves.

**Air-release valves.** The three basic types of air-release valves for use on irrigation pipelines are described below:

An air-release valve, a continuously acting valve that has a small venting orifice, generally ranging between 1/16 and 3/8 in. in size. This valve releases pockets of air from the pipeline once the line is filled and under working pressure.

An air-and-vacuum valve, which has a large venting orifice, exhausts large quantities of air from the pipeline during filling and allows air to reenter the line and prevents a vacuum from forming during emptying. This type of valve is sometimes called air-vacuum-release valve or air-vent-and-vacuum-relief valve. It is not continuous acting because it does not allow further escape of air at working pressure once the valve closes.

A combination air valve is sometimes called a combination air-release and air-vacuum valve or combination air-and-vacuum-relief valve. It is continuous acting and combines the functions of both the air-release valve and the air-and-vacuum valve. Both valves are housed in one valve body.

If needed to provide positive means for air escape during filling and air entry while emptying, air-and-vacuum valves or combination air valves shall be installed at all summits, at the entrance, and at the end(s) of the pipeline. Such valves generally are needed at these locations if the line is truly closed to the atmosphere. However, they may not be needed if other features of the pipe system, such as permanently located sprinkler nozzles or other unclosed service outlets, adequately vent the particular location during filling and emptying operations.

The ratio of air-release valve diameter to pipe diameter for valves intended to release air when filling the pipe should not be less than 0.1. However, small-diameter valves may be used to limit water hammer pressures by controlling air release where control of filling velocities is questionable. Equivalent valve outlet diameter of less than 0.1 are permitted for continuously acting air release valves. Adequate vacuum relief must be provided.

Air-release valves or combination air valves shall be used as needed to permit air to escape from the pipeline while the line is at working pressure. Small orifices of these types shall be sized according to the working pressure and venting requirements recommended by the valve manufacturer.

Manufacturers of air valves marketed for use under this standard shall provide dimensional data, which shall be the basis for selection and acceptance of these valves.

**Drainage.** Provision shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures, drainage is recommended by the manufacturer of the pipe, or drainage of the line is specified, for the job. If provisions for drainage are required drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping or by other means.

**Flushing.** If provisions are needed for flushing the line free of sediment or other foreign material, a suitable valve shall be installed at the distal end of the pipeline.

**Thrust control.** Abrupt changes in pipeline grade, horizontal alignment, or reduction in pipe size normally require an anchor or thrust blocks to absorb any axial thrust of the pipeline. Thrust control may also be needed at the end of the pipeline and at in-line control valves. Thrust blocks and anchors must be large enough to withstand the forces tending to move the pipe, including those of momentum and pressure as well as forces due to expansion and contraction.

The pipe manufacturer's recommendations for thrust control shall be followed. In absence of the pipe manufacturer's requirements, the following formula must be used in designing thrust blocks:

$$A = (98HD^2)/B(\sin(a/2))$$

Where:

- A=Area of thrust block required in ft
- H=Maximum working pressure in ft
- D=Inside diameter of pipe in ft
- B=Allowable passive pressure of the soil in lb/ft<sup>2</sup>
- a=Deflection angle of pipe bend

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90° deflection angle of pipe bend.

If adequate soil tests are not available, the passive soil pressure may be estimated from table 1.

**Materials.** All materials shall meet or exceed the minimum requirements indicated in "Specifications for Materials."

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing high-pressure underground plastic pipeline shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

Table 1. — Allowable soil bearing pressure

Natural soil material	Depth of cover to center of thrust block			
	2 ft	3 ft	4 ft	5 ft
Sound bedrock ..	8,000	10,000	10,000	10,000
Dense sand and gravel mixture (assumed Ø = 40°) .....	1,200	1,800	2,400	3,000
Dense fine to coarse sand (assumed Ø = 35°) .....	800	1,200	1,650	2,100
Silt and clay mixture (assumed Ø = 25°) .....	500	700	950	1,200
Soft clay and organic soils (assumed Ø = 10°) .....	200	300	400	500

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**IRRIGATION WATER CONVEYANCE**  
**LOW PRESSURE, UNDERGROUND, PLASTIC PIPELINE**  
(ft)  
**CODE 430EE**

**DEFINITION**

A pipeline and appurtenances installed in an irrigation system.

**SCOPE**

This standard applies to underground thermoplastic pipelines from 4 to 18 in. in diameter that are subject to internal pressures up to 50 lb/in.<sup>2</sup>.

The standard includes the design criteria for these irrigation pipelines, the minimum installation requirements, and the specifications for the thermoplastic pipe to be used. It applies to pipelines with stands and vents open to the atmosphere and to pipelines not open to the atmosphere but provided with pressure-relief valves and air-and-vacuum valves.

**PURPOSE**

To prevent erosion or loss of water quality or damage to the land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

**CONDITIONS WHERE PRACTICE APPLIES**

All pipelines shall be planned and located to serve an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

The water supply and quality and rate of irrigation delivery for the area served by the pipeline shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Plastic pipelines installed according to this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects on the water budget, especially on infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

## Water Quality

1. Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil, percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

## DESIGN CRITERIA

**Working pressure.** The pipeline shall be designed to meet all service requirements without a static or working pressure including hydraulic transients, at any point greater than the maximum allowable working pressure of the pipe used at that point. The static or working pressure of pipelines open to the atmosphere shall include freeboard.

Maximum allowable working pressure for low-head plastic irrigation pipe shall be 50 ft or head or 22 lb/in.<sup>2</sup>.

Pipelines constructed of 50-lb/in.<sup>2</sup> plastic irrigation pipe or the IPS pipe covered by this standard shall have a working pressure no greater than 50 lb/in.<sup>2</sup>.

Plastic pipeline requiring a working pressure greater than 50 lb/in.<sup>2</sup> shall be constructed according to the requirements specified in 430-DD of this standard.

Plastic pipe pressure rating normally is based on a water temperature of 73.4 degrees F. Factors for adjusting allowable working pressure for higher water temperature given in table 1.

Table 1. — Pressure rating factors for PVC and PE pipe for water at elevated temperatures

Temperature <i>deg F</i>	PVC	PE
73.4	1.00	1.00
80	.88	.92
90	.75	.81
100	.62	.70
110	.50	—
120	.40	—
130	.30	—
140	.22	—

Note: To obtain the pipe's reduced pressure rating because of a water temperature greater than 73.4 deg F, multiply the normal pressure rating by the appropriate factor from table.

**Friction losses.** For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient, *c*, equal to 150.

**Flow velocity.** The full-pipe design water velocity in the pipeline when operating at system capacity should not exceed 5 ft/s.

**Capacity.** The design capacity of the pipeline shall be based on whichever of the following criteria requires the larger amount of water.

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.

2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

**Outlets.** Appurtenances to deliver water from the pipe system to the land, to a ditch or a reservoir, or to any surface pipe system shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow to (1) the hydraulic gradeline of a pipe or ditch, (2) a point at least 6 in. above the field surface, or (3) the design in surface elevation in a reservoir.

**Check valves.** A check valve shall be installed between the pump discharge and the pipeline if backflow may occur.

**Stands open to the atmosphere.** Stands shall be used wherever water enters the pipeline system to avoid entrapment of air, to prevent surge pressures, to avoid collapse because of negative pressures, and to prevent the pressure from exceeding the maximum allowable working pressure of the pipe. Open stands may be required at other locations in low-head systems to perform other functions. Stands shall be constructed of steel pipe or other approved material and be supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline. Open stands shall be designed to meet or exceed the following criteria:

1. Each stand shall allow at least 1 ft of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that neither the static head nor the design working head plus freeboard exceeds the allowable working pressure of the pipe.
2. The top of each stand shall extend at least 4 ft above the ground surface except for surface gravity inlets or where visibility is not a factor. Gravity inlets shall be equipped with a trash guard.
3. The downward water velocity in stands shall not exceed 2 ft/s. The inside diameter of the stand shall not be less than the inside diameter of the pipeline. This downward velocity criterion applies only to stands having vertical offset inlets and outlets.
4. If the water velocity in the inlet (from the pump or other water source) equals or exceeds three times the velocity in the outlet pipeline, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.
5. The cross-sectional area of stands may be reduced above a point 1 ft above the top of the upper inlet or outlet pipe, but the reduced cross section shall not be such that it would produce an average velocity of more than 10 ft/s if the entire flow were discharging through it.
6. Vibration-control measures, such as special couplers or flexible pipe, shall be provided as needed to insure that vibration from pump discharge pipes is not transmitted to stands.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 in. and shall be constructed so that the bottom is at least 24 in. below the invert of the outlet of the pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 ft/s.

Gate stands shall be of sufficient dimension to accommodate the gate or gates and shall be large enough to make the gates accessible for repair.

Float valve stands shall be large enough to provide accessibility for maintenance and to dampen surge.

**Stands closed to the atmosphere.** If pressure-relief valves and air-vacuum, valves are used instead of open stands, all requirements under "Stands Open to the Atmosphere" shall apply except as modified below.

The inside diameter of the closed stand shall be equal to or greater than that of the pipeline for at least 1 ft. above the top of the uppermost inlet or outlet pipe,. To facilitate attaching the pressure-relief valve and the air-and-vacuum valve, the stand may be capped at this point or, if additional height is required, the stand may be extended to the desired elevation by using the same inside diameter or a reduced cross section. If a reduced section is used, the cross-sectional area shall be such that it would produce an average velocity of no more than 10 ft/s if the entire flow were discharge through it. If no vertical offset is required between the pump discharge pipe and the outlet pipeline and the discharge pipe is “doglegged” below ground, the stand shall extend to a least 1 ft. above the highest part of the pump discharge pipe.

An acceptable alternative design for stands requiring no vertical inlet (when inlet velocity is less than three times that of the outletting pipeline) shall be:

1. Construct the dogleg section of the pump discharge pipe with the same nominal diameters as that of the pipeline.
2. Install the pressure-relief valve and the air-and vacuum valve on top the upper horizontal section of the dogleg.

Pressure relief and air-and vacuum valves shall be installed on stands with nominal size pipe required to fit the valves’ threaded inlets.

**Vents.** Vents must be designed into systems open to the atmosphere to provide for the removal and entry of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 ft above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum allowable working pressure of the pipe.
2. Have a cross-sectional area at least one half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least one pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2 in. in diameter.

These cross-sectional requirements shall apply when an air-and-vacuum valve is used instead of a vent, but the reduced section shall be increased to the nominal size pipe required to fit the valve’s threaded inlet. An acceptable alternative is to install this valve in the side of a service outlet, provided that the riser is properly located and adequately sized. If both an air-and-vacuum valve and a pressure-relief valve are required at the location, the 10-ft/s velocity criterion given under “Stands Open to the Atmosphere” shall apply to the reduced section.

3. Be located at the downstream end of each lateral, at summits in the line, and at points where there are changes in grade in a downward direction of flow of more than 10 degrees.

**Air-and-vacuum valves.** An air-and-vacuum valve, which has a large venting orifice, exhausts large quantities of air from the pipeline during filling operations and allows air to reenter the line and prevents a vacuum from forming during emptying operations. This type of valve is sometimes called air-vacuum valve or air vent and vacuum-relief valve. It is not continuous acting because it does not allow further escape of air at working pressure once the valve closes.

Air-and-vacuum valves installed according to the standards for “Vents” can be used instead of open vents at any or all the locations listed in (3) under “Vents.”

Air-and-vacuum valves installed according to the standards for “Stands Closed to the Atmosphere” can be used in conjunction with pressure-relief valves as an alternative to open pump stands. A pipeline is considered open to the atmosphere if at least one stand, vent, or

service outlet is unclosed and located so that it cannot be isolated from the system by line gates or valves.

The diameter of the orifice (opening that controls air flow during filling and emptying operations) of an air-and-vacuum valve shall equal or exceed that specified below for the appropriate diameter of pipeline.

Diameter of orifice	Diameter of pipeline
<i>(in)</i>	<i>(in)</i>
3/4	4
1 1/4	6
1 3/4	8
2 1/4	10
2 3/4	12
3 1/4	14
3 1/2	15
3 3/4	16
4	18

Manufacturers of air-and-vacuum valves marketed for use under this standard shall provide dimensional data, which shall be the basis for selecting and accepting these valves.

**Pressure-relief valves.** Pressure-relief valves can be used on low-pressure plastic pipelines as an alternative to stands open to the atmosphere. A pressure-relief valve shall serve the pressure-relief function of the open stand or vent for which it is an alternative.

Pressure-relief valves do not function as air-release valves and shall not be used as substitutes for such valves if release of entrapped air is required. Pressure-relief valves shall be used in conjunction with air-and-vacuum valves at all pump stands and at the end of pipelines if needed to relieve surge at the end of the lines.

The flow capacity of pressure-release valves shall be the pipeline design flow rate with a pipeline pressure no greater than 50 percent more than the permissible working pressure for the pipe.

The pressure at which the valve starts to open shall be marked on each pressure-relief valve. Adjustable pressure-relief valves shall be sealed or otherwise altered to insure that the adjustment marked on the valve is not changed.

Manufacturers of pressure-relief valves marketed for use under this standard shall provide capacity tables, based on performance tests, that give the discharge capacity of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be the basis for design of pressure setting and of acceptance of these valves.

**Drainage.** Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures, drainage is recommended by the manufacture of the pipe or drainage of the line is specified for the job. If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets can drain into dry wells or to points of lower elevation. If drainage cannot be thus provided by gravity, provisions shall be made for emptying the line by pumping or by other means.

**Flushing.** If provisions are needed for flushing the line free of sediment or other foreign material, a suitable valve shall be installed at the distal end of the pipeline.

**Thrust control.** Anchors or thrust blocks shall be provided on pipelines having a working pressure of 25 lb/in.2 or greater at abrupt changes in pipeline grade, changes in horizontal

alignment, or reduction in pipe size to absorb any axial thrust of the pipeline. Thrust blocks may also be needed at the end of the pipeline and at inline control valves.

The pipe manufacturer's recommendations for thrust control shall be followed. In absence of such recommendations, the following formula should be used to design thrust blocks:

$$A = ((98 HD^2)/B)\sin(a/2)$$

Where:

- A = Area of thrust block required
- H = Maximum working pressure in ft
- D = Inside diameter of pipe in ft
- B = Allowable passive pressure of the soil in lb/ft<sup>2</sup>
- a = Deflection angle of pipe bend

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90° deflection angle of pipe bend.

If adequate soil tests are not available, the allowable bearing soil pressure can be estimated from table 2.

Table 2.—Allowable soil bearing pressure

Natural soil material	Depth of cover to center of thrust block			
	2 ft	3 ft	4 ft	5 ft
Sound bedrock	8,000	10,000	10,000	10,000
Dense sand and gravel mixture (assumed Ø = 40°)	1,200	1,800	2,400	3,000
Dense fine to coarse sand (assumed Ø = 35°)	800	1,200	1,650	2,100
Silt and clay mixture (assumed Ø = 25°)	500	700	950	1,200
Soft clay and organic soils (assumed Ø = 10°)	200	300	400	500

**Materials.** All materials described and required in this standard shall meet or exceed the minimum requirements listed for materials under "Specifications."

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing low-pressure, underground, plastic irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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**IRRIGATION WATER CONVEYANCE**  
**NONREINFORCED CONCRETE PIPELINE**  
(ft)  
**CODE 430CC**

**DEFINITION**

A pipeline and appurtenances installed in an irrigation system.

**SCOPE**

This standard applies to low or intermediate pressure, nonreinforced concrete irrigation pipelines with rubber gasket joints, mortar joints, or cast-in-place without joints.

The standard includes the design criteria and minimum installation requirements for nonreinforced concrete irrigation pipelines and the specifications for the concrete pipe to be used.

**PURPOSE**

To prevent erosion, degradation of water quality, or damage to the land; to make possible the proper management of irrigation water; and to reduce water conveyance losses.

**CONDITIONS WHERE PRACTICE APPLIES**

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Concrete pipelines shall not be installed on sites where the sulfate-salt concentration in the soil or soil water exceeds 1.0 percent. On sites where the sulfate concentration is more than 0.1 percent but not more than 1.0 percent, concrete pipe may be used only if the pipe is made with Type V cement or Type II cement whose tricalcium aluminate content does not exceed 5.5 percent.

Cast-in-place pipe shall be used as the outside soils that are capable of being used as the outside form for approximately the bottom half of the conduit.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effect on the water budget, especially on infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may be located next to the original conveyance.

## Water Quality

1. Effects of installing the pipeline, replacing other types of conveyances, on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil, and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that might cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

## DESIGN CRITERIA.

**Working pressure.** The pipelines shall be designed to meet all service requirements without a static working pressure, including surge, at any point greater than the minimum allowable working pressure of the pipe used at that point. The static or working pressure of pipelines open to the atmosphere shall include freeboard.

The maximum working pressure for rubber gasket joints shall not be more than one-third of the certified hydrostatic test pressure determined by the test procedure in ASTM-C-505 and shall not exceed 50 ft of head for sized 6 through 12 in. in diameter, 40 ft for sizes 15 through 18 in., 30 ft for sizes 21 and 24 in., and 25 ft for sizes 26 through 30

The maximum working pressure for mortar joints shall not be more than one-fourth the certified hydrostatic test pressure as determined by the hydrostatic test pressure prescribed in ASTM-C-118 and shall not exceed 40 ft of head for sizes 6 and 8 in., 35 ft for sizes 10 and 12 in., 30 ft for sizes 14 through 24 in., and 25 ft for sizes 26 through 30 in.

The maximum working pressure for cast-in-place pipe shall not exceed 15 ft of head above the centerline of the pipe.

**External load limit.** A safety factor of at least 1.25 shall be applied to the three-edge bearing test in computing allowable heights of fill over the precast pipe.

**Friction losses.** For design purposes, friction head losses shall be no less than those computed by Manning's formula, using a coefficient of roughness "n" of 0.011 for rubber-gasket-jointed pipe, 0.012 for mortar-jointed pipe, and 0.014 for cast-in-place pipe.

**Capacity.** The design capacity of the pipelines shall be based on whichever of the following criteria required the larger amount of water:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.
2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods of irrigation planned.

**Outlets.** Appurtenances to deliver water from the pipe system to the land, to a ditch or reservoir, or to any surface pipe system shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow to: (1) the hydraulic gradeline of a pipe or ditch, (2) a point at least 6 in. above the field surface, or (3) the design surface elevation in a reservoir.

**Stands open to the atmospheres.** Stands shall be placed at each inlet to the irrigation pipe system and at such other points as required. All stand shall serve as vents in addition to their other functions. Stands shall be constructed of steel pipe or other approved material and shall be

supported on a base adequate to support the stand and prevent movement or undue stress on the pipeline. Open stands shall be designed to meet or exceed the following criteria:

1. Each stand shall allow at least 1 ft of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that neither the static head nor the design plus freeboard shall exceed the allowable working pressure of the pipe.
2. The top of each stand shall extend at least 4 ft above the ground surface except for surface gravity inlets or where visibility is not a factor. Gravity inlets or stands shall be equipped with a trash guard.
3. Downward water velocities in stands shall not exceed 2 ft/s. The inside diameter of the stand shall not be less than the inside diameter of the pipeline. This downward velocity criterion applied only to stands having vertical offset inlets and outlets.
4. If the water velocity in the inlet (from the pump or other water source) equals or exceeds three times the velocity in the outlet pipeline, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.
5. The cross-sectional area of stands may be reduced above a point 1 ft above the top of the upper inlet or outlet pipe, but the reduced cross section shall not be such that it would produce an average velocity of more than 10 ft/s if the entire flow were discharging through it.
6. Vibration-control measures, such as special couplers or flexible pipe, shall be provided as needed to insure that vibration from pump discharge is not transmitted to stands.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 in. and shall be constructed so that the bottom is at least 24 in. below the invert of the outlet to the pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 ft/s.

Gate stands shall be of sufficient dimensions to accommodate the gate or gates and shall be large enough to make the gates accessible for repair.

Float valves stands shall be large enough to provide accessibility for maintenance and to dampen surge.

**Stands closed to the atmosphere.** If pressure-relief valves and air-and-vacuum valves are used instead of open stands, all requirements detailed in "Stands Open to the Atmosphere" shall apply except as modified below.

The inside diameter of the closed stand shall be equal to or greater than that of the pipeline for at least 1 ft above the top of the uppermost inlet of outlet pipe. To facilitate attaching the pressure-relief valve and the air-and-vacuum valve, the stand may be capped at this point, or if additional height is required, the stand may be extended to the desired elevation by using the same inside diameter or a reduced cross section. If a reduced section is used, the cross-sectional area shall be such that it would produce an average velocity of no more than 10 ft/s if the entire flow were discharged through it. If vertical offset is required between the pump discharge pipe and the outlet pipeline and the discharge pipe is "doglegged" below ground, the stand shall extend at least 1 ft above the highest part of the pump discharge pipe.

An acceptable alternative design for stands requiring no vertical inlet offset (when inlet velocity is less than three times that of the outletting pipeline shall be to:

1. Construct the dogleg section of the pump discharge pipe with the same nominal diameter as that of the pipeline.
2. Install the pressure-relief valve and the air-and-vacuum valve on top of the upper horizontal section of the dogleg.

Pressure-relief and air-and-vacuum valves shall be installed on stands with the nominal size pipe required to fit the valves' threaded inlets.

**Vents.** Vents may be designed into systems open to provide for the removal and entry of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 ft above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum allowable working pressure of the pipe.
2. Have a cross-sectional area at least one-half the cross-sectional areas of the pipeline (both inside measurements) for a distance of at least one pipe-line diameter up from the centerline of the pipeline.

Above this elevation the vent may be reduced to 2 in. in a diameter.

These cross-sectional requirements shall apply when an air-and-vacuum valve is used instead of a vent, but the reduced section shall be increased to the nominal size pipe required to fit the valve's threaded inlet. An acceptable alternative is to install this valve in the side of a service outlet, provided that the riser is properly located and adequately sized. If both an air-and-vacuum valve and a pressure-relief valve are required at the location, the 10-ft/s velocity criterion given under "Stands" shall apply to the reduced section.

3. Be located at the downstream end of each lateral, at summits in the line, and at points where there are changes in grade in a downward direction of flow of more than 10 degrees.

**Air-and-vacuum valve.** An air-vacuum valve, which has a large venting orifice, exhausts large quantities of air from the pipeline during filling operations and allows air to reenter the line to prevent a vacuum from forming during emptying operations. This type of valve is sometimes called air-vacuum or air-vent-and-vacuum relief valve. It is not continuous acting because it does not allow further escape of air at working pressure once the valve closes.

An air-and-vacuum valves may be used instead of vents at any or allocations listed under "Vents," conjunction with a pressure-relief valve as an alternative to open pump stands. A pipeline is considered open to the atmosphere is at least one stand, vent, or service outlet is unclosed and located so that it cannot be isolated from the system by line gated or valves.

On concrete pipelines not open to the atmosphere, air-and-vacuum valves shall be installed at all locations specified under "Vents," on all pump stands, and at inline control devices where there is a need for air removal and entry during filling and emptying.

The diameter of the orifice (opening that controls air-flow during filling and emptying operations) of and air-and-vacuum valve shall equal or exceed that specified in figure 1 for the appropriate diameter of the pipeline.

Manufacturers of air-and-vacuum valves marketed for use under this standard shall provide dimensional data, which shall be the basis for selection and acceptance these valves.

**Pressure-relief valves.** Pressure-relief valves may be used on concrete pipelines as an alternative to stands open to the atmosphere. A pressure-relief valve shall serve the pressure-relief function of the open stand or vent for which it is an alternative. Pressure-relief valves do not function as air-release valves and shall not be used as substitute for such valves if release or entry of air is required. Pressure-relief valves shall be used in conjunction with air-and-vacuum valves at all pump stands and at the ends of pipelines if needed to relieve surge at the ends of the lines.

The flow capacity of pressure-release valves shall be pipeline design flow rate with a pipeline pressure not greater than 50 percent more than the permissible working pressure for the pipe.

The pressure at which the valve starts to open shall be marked on pressure-relief valves. Adjustable pressure-relief valves shall be sealed or otherwise altered to prevent changing the adjustment from the marked on the valve.

Manufacturers of pressure-relief valves marketed for use under this standard shall provide capacity tables, based on performance tests, that give the discharge capacity of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be basis for design of pressure setting and of acceptance of these valves.

**Check valves.** A check valve shall be installed between the pump discharge and the pipeline if detrimental backflow may occur.

**Drainage.** Provisions shall be made for completely drainage the pipeline if a hazard is imposed by freezing temperatures or drainage of the line is specified for the job. If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain into dry wells or to points of lower elevation. If drainage cannot be thus provided by gravity, provisions shall be made to empty the line by pumping or by other means.

**Flushing.** If provisions are needed for flushing the line free of sediment or other foreign material, a suitable valve shall be installed at the distal end of the pipeline.

**Thrust control.** Abrupt changes in pipeline grade or alinement, require either:

1. A stand having a diameter greater than that of the pipeline,
2. An anchor or thrust block to absorb any axial thrust of the pipeline, or
3. A larger diameter pipe placed horizontally or placed vertically and capped below ground or an in place structure capped below ground.

An abrupt change shall be considered to be (a) an angle of 45 degrees or greater than the maximum working head is under 10 ft; (b) an angle of 30 degrees or greater when the maximum working head is between 10 and 20 ft; and (c) an angle of 15 degrees or greater when the maximum working head is greater than 20 ft.

Suitable thrust control shall be provided to resist end thrust of rubber gasket pipelines.

$$A = ((98 HD^2)/B)\sin(a/2)$$

Where:

A = Area of thrust block required

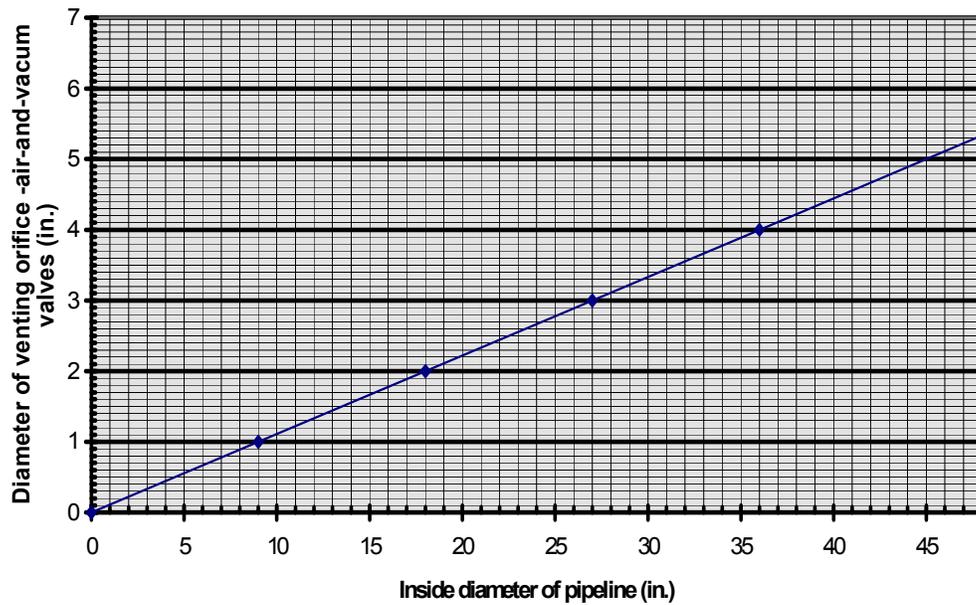
H = Maximum working pressure in ft

D = Inside diameter of pipe in ft

B = Allowable passive pressure of the soil            in lb/ft<sup>2</sup>

a = Deflection angle of pipe bend

Figure 1. Sizing of air-and-vacuum valves



Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90° deflection angle of pipe bend.

If adequate soil tests are not available, the passive soil pressure may be estimated from table 1.

**Materials.** All materials desired and required in this standard shall meet or exceed the minimum requirements indicated in "Specifications of Materials."

Table 1.—Allowable soil bearing pressure

Natural soil material	Depth of cover to center of thrust block			
	2 ft	3 ft	4 ft	5 ft
Sound bedrock	8,000	10,000	10,000	10,000
Dense sand and gravel mixture (assumed $\phi = 40^\circ$ )	1,200	1,800	2,400	3,000
Dense fine to coarse sand (assumed $\phi = 35^\circ$ )	800	1,200	1,650	2,100
Silt and clay mixture (assumed $\phi = 25^\circ$ )	500	700	950	1,200
Soft clay and organic soils (assumed $\phi = 10^\circ$ )	200	300	400	500

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**IRRIGATION WATER CONVEYANCE**  
**REINFORCED PLASTIC MORTAR PIPELINE**  
(ft)  
**CODE 430GG**

**DEFINITION**

A pipeline and appurtenances installed in an irrigation system.

**SCOPE**

This standard applies to underground reinforced plastic mortar pipelines 8 to 54 in. in diameter. Pipelines more than 54 in. in diameter shall be installed under special design and specification requirements.

The standard includes the design criteria for irrigation pipelines, the minimum installation requirements, and the specifications for the reinforced plastic mortar pipe to be used. It applies to pipelines with stands and vents open to the atmosphere and to pipelines not open to the atmosphere but provided with pressure-relief valves and air-and vacuum valves.

**PURPOSE**

To prevent erosion or loss of water quality or damage to the land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

**CONDITIONS WHERE PRACTICE APPLIES**

All pipelines shall be planned and located to serve an integral part of an irrigation water distribution or conveyance system designed to facilitate the conservation use and management of the soil and water resources on a farm or group of farms.

Water supplies, quality, and rates of irrigation delivery for the area served by the pipelines shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Reinforced plastic mortar pipelines installed under this standard shall be placed only in suitable soils where the bedding and backfill requirements can be fully met.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects on the components of the water budget, especially on infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

## Water Quality

1. Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil, and on any percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

## DESIGN CRITERIA

**Working pressure.** The pipeline shall be designed to meet all service requirements without a static or working pressure at any point greater than the maximum allowable working pressure of the pipe used at that point. The static or working pressure of pipelines open to the atmosphere shall include free board.

The minimum acceptable work pressure class shall be pipe having a rated operating head of 50 ft of water.

**Friction losses.** For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient,  $c$ , equal to 145.

**Flow velocity.** The design water velocity in the pipeline when operating at system capacity shall not exceed 5 ft/s. If this limit is exceeded, special considerations must be given to the flow conditions and measures to adequately protect the pipelines against surge.

**Capacity.** The design capacity of the pipeline shall be based on whichever of the following criteria requires the larger amount of water:

1. The capacity shall be sufficient to deliver the volume of water required to meet the peak-period consumptive use of the crop or crops to be irrigated.
2. The capacity shall be sufficient to provide an adequate irrigation stream for all methods or irrigation planned.

**Outlets.** Appurtenances to deliver water from the pipe system to the land, to a ditch or reservoir, or to any surface pipe system shall be known as outlets. Outlets shall have adequate capacity at design working pressure to deliver the required flow to (1) the hydraulic gradeline of a pipe or ditch; (2) a point at least 6 in. above the field surface; (3) the design surface elevation in a reservoir; or (4) and individual sprinkler, lateral line, or other sprinkler line.

**Check valves.** A check valve shall be installed between the pump discharge and the pipeline if detrimental backflow occurs.

**Stands open to the atmosphere.** Stands shall be used wherever water enters the pipeline system to avoid entrapment of air, to prevent surge pressures, to avoid collapse due to negative pressures, and to prevent pressure from exceeding the maximum allowable working pressure of the pipe. Open stands may be required at other locations in low-head systems to perform other functions. Stands shall be constructed of steel pipe or other approved materials and shall be supported on a base adequate to support the stand and to prevent movement or undue stress on the pipeline. Open stands shall be designed to meet or exceed the following criteria:

1. Each stand shall allow at least 1 ft of freeboard above design working head. The stand height above the centerline of the pipeline shall be such that neither the static head nor

the design working head plus freeboard will exceed the allowable working pressure of the pipe.

2. The top of each stand shall extend at least 4 ft above the ground surface except for surface gravity inlets, which shall be equipped with trash racks and covers.
3. Downward water velocities in stands shall not exceed 2 ft/s. The inside diameter of the stand shall not be less than the inside diameter of the pipeline. This downward velocity criterion applies only to stands having vertical offset inlets and outlets.
4. If the water velocity in the inlet (from the pump or other water sources) equals or exceeds three times the velocity in the outlet pipeline, the centerline of the inlet shall have a minimum vertical offset from the centerline of the outlet at least equal to the sum of the diameters of the inlet and outlet pipes.
5. The cross-sectional area of stands may be reduced above a point 1 ft above the top of the upper inlet or outlet pipe, but the reduction shall not be such that it would produce an average velocity of more than 10 ft/s if the entire flow were discharging through it.
6. Vibration-control measures, such as special couplers of flexible pipe, shall be provided, as needed, to insure that vibration from pump discharge pipes is not transmitted to stands.

Sand traps, when combined with a stand, shall have a minimum inside dimension of 30 in. and shall be constructed so that the bottom is at least 24 in. below the invert of the outlet to the pipeline. The downward velocity of flow of the water in a sand trap shall not exceed 0.25 ft/s. Suitable provisions for cleaning sand traps shall be provided.

Gate stands shall be of sufficient dimensions to accommodate the gate or gates and shall be large enough to make the gates accessible for repair.

Float valve stands shall be large enough to provide accessibility for maintenance and to dampen surge.

**Stands closed to the atmosphere.** If pressure-relief valves and air-and-vacuum valves are used instead of open stands, all requirements detailed under "Stands Open to the Atmosphere" shall apply except as modified below.

The inside diameter of the closed stand shall be equal to or greater than that of the pipeline for at least 1 ft above the top of the uppermost inlet or outlet pipe. To facilitate attaching the pressure-relief valve and the air-and-vacuum valve, the stand may be capped at this point, or if additional height is required, the stand may be extended to the desired elevation by using the same inside diameter or a reduced cross section. If a reduced section is used, the cross-sectional area shall be such that it would produce an average velocity of no more than 10 ft/s if the entire flow were discharge through it. If no vertical offset is required between the pump discharge pipe and the outlet pipeline and the discharge pipe is "doglegged" below ground, the stand shall extend at least 1 ft above the highest part of the pump discharge pipe.

An acceptable alternative design for stands requiring no vertical inlet offset (when inlet velocity is less than three times that of the outletting pipeline) shall be:

1. Construct the dogleg section of the pump discharge pipe with the same nominal diameter as that of the pipeline.
2. Install the pressure-relief valve and the air-and-vacuum valve on top of the upper horizontal section of the dogleg.

Pressure-relief and air-and-vacuum valves shall be installed on stands with the nominal size pipe required to fit the valves threaded inlets.

**Vents.** Vents must be designed into systems open to the atmosphere to provide for the removal and entry of air and protection from surge. They shall:

1. Have a minimum freeboard of 1 ft above the hydraulic gradeline. The maximum height of the vent above the centerline of the pipeline must not exceed the maximum allowable working pressure of the pipe.
2. Have a cross-sectional area at least one-half the cross-sectional area of the pipeline (both inside measurements) for a distance of at least one pipeline diameter up from the centerline of the pipeline. Above this elevation the vent may be reduced to 2 in. in diameter.

These cross-sectional requirements shall apply when an air-and-vacuum valve is used instead of a vent, but the reduced section shall be increased to the nominal size pipe required to fit the valve's threaded inlet. An acceptable alternative is to install this valve in the side of a service outlet riser, provided that the riser is properly located and adequately sized. If an air-and-vacuum valve and a pressure-relief valve are required at the location, the 10-ft/s velocity criterion given under "Stands" shall apply to the reduced section.

3. Be located at the downstream end of each lateral, at summits in the line, and at points where there are changes in grade in downward direction of flow of more than 10 degrees.

**Air-and-vacuum valves.** An air-and-vacuum valve, which has a large venting orifice, exhausts large quantities of air from the pipeline during filling operations and allows air to reenter the line and prevents a vacuum from forming during emptying operations. This type of valve is sometimes called air-vacuum-release valve or air-vent-and-vacuum-relief-valve. It is not continuous acting because it does not allow further escape of air at working pressure once the valve closes.

Air-and-vacuum valves may be used instead of vents at any or all the locations listed under "Vents". An air-and-vacuum valve also may be used in conjunction with a pressure-relief valve as an alternative to open pump stands. A pipeline is considered open to the atmosphere if at least one stand, vent, or service outlet is unclosed and located so that it can not be isolated from the system by line gates or valves.

On low-pressure pipelines not open to the atmosphere, air-and-vacuum valves shall be installed at all locations specified under "Vents", on all pump stands, and at inline control devices where there is a need for air removal and entry during filling and emptying operations.

Air-release and vacuum-release valve outlets shall be at least 1 in. in diameter when specified for lines 5 to 8 in. in diameter, at least 2-in. for lines 10 to 16 in. in diameter, at least 4 in. for lines 18 to 28 in. in diameter, at least 6-in. for lines 30 to 36 in. in diameter, and least 8-in. for lines 38 to 48 in. in diameter.

For pipelines larger than 16 in. in diameter, 2-in. air-release valves may be used instead of the sizes indicated if they are supplemented with vacuum-release valves that provide a vacuum-release capacity equal to the sizes shown.

Manufacturers of air-and-vacuum valves marketed for use under this standard shall provide dimensional data, which shall be basis for the selection and acceptance of these valves.

**Pressure-relief valves.** Pressure-relief valves may be used on low-pressure pipelines as an alternative to stands open to the atmosphere.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressures are likely to build up, a surge chamber or pressure-relief valve shall be installed close to the check valve on the side away from the pump.

Pressure-relief valves shall be no smaller than  $\frac{1}{4}$ -in. nominal size for each diameter inch of the pipeline and shall be set a maximum of 5 lb/in.<sup>2</sup> above the pressure rating of the pipe.

A pressure-relief valve or surge chamber shall be installed at the end of the pipeline if needed to relieve surge.

The flow capacity of pressure-release valves shall be the pipeline design flow rate within a pipeline pressure no greater than 50 percent above the permissible working pressure for the pipe.

The pressure at which the valve starts to open shall be marked on pressure-relief valves. Adjustable pressure-relief valves shall be sealed or otherwise altered to prevent changing the adjustment from the marked on the valve.

Manufacturers of pressure-relief valves marketed for use under this standard shall provide capacity tables, based on performance tests, that give the discharge capacities of the valves at the maximum permissible pressure and differential pressure settings. Such tables shall be the basis for design of pressure setting and of acceptance of these valves.

**Drainage.** Provisions shall be made for completely draining the pipeline if freezing temperatures are a hazard, the pipe manufacturer recommends it, or it is specified for the job. If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets can drain into dry wells or to points of lower elevation. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping or other means.

**Flushing.** If provisions are needed for flushing the line free of sediment or other foreign material, a suitable valve shall be installed at the distal end of the pipeline.

**Thrust control.** Anchors or thrust blocks shall be provided on pipelines at abrupt changes in pipeline grade, changes in horizontal alignment, or reduction in pipe size to absorb any axial thrust of the pipeline. Thrust blocks may also be needed at the end of the pipeline and at inline control valves.

The pipe manufacturer's recommendations for thrust control shall be followed. In the absence of such recommendations, the following formula shall be used in designing thrust blocks:

$$A = ((98 HD^2)/B)\sin(a/2)$$

Where:

- A = Area of thrust block required
- H = Maximum working pressure in ft
- D = Inside diameter of pipe in ft
- B = Allowable passive pressure of the soil in lb/ft<sup>2</sup>
- a = Deflection angle of pipe bend

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90° deflection angle of pipe bend.

Area of thrust blocks for dead ends and tees shall be 0.7 times the area of block required for a 90-degree deflection angle of pipe bend.

If adequate soil tests are not available, the allowable bearing soil pressure may be estimated from Table 1.

Table 1.—Allowable soil bearing pressure

Natural soil material	Depth of cover to center of thrust block			
	2 ft	3 ft	4 ft	5 ft
Sound bedrock	8,000	10,000	10,000	10,000
Dense sand and gravel mixture (assumed $\phi = 40^\circ$ )	1,200	1,800	2,400	3,000
Dense fine to coarse sand (assumed $\phi = 35^\circ$ )	800	1,200	1,650	2,100
Silt and clay mixture (assumed $\phi = 25^\circ$ )	500	700	950	1,200
Soft clay and organic soils (assumed $\phi = 10^\circ$ )	200	300	400	500

**Maximum depth of cover.** If the pipe is installed in a trench, the earth cover over the top of the pipe shall not exceed that given in table 2.

Table 2. —Maximum cover for pipes installed in trenches

Pipe diameter	Type 4 bedding	Type 7 bedding	Type 10 bedding
<i>in.</i>	<i>ft</i>	<i>ft</i>	<i>ft</i>
8	35	35	35
10	23	35	35
12	18	35	35
14	15	35	35
15-16	13	35	35
18-20	12	35	35
21	11	35	35
24	11	28	35
27	10	25	35
30	10	24	35
33	10	23	35
36	10	22	35
39	10	21	35
42	9	20	35
45-54	9	19	35

If the pipe is installed in an embankment, the external load shall not exceed a load equivalent to the height of earth cover over the top of the pipe given in table 3.

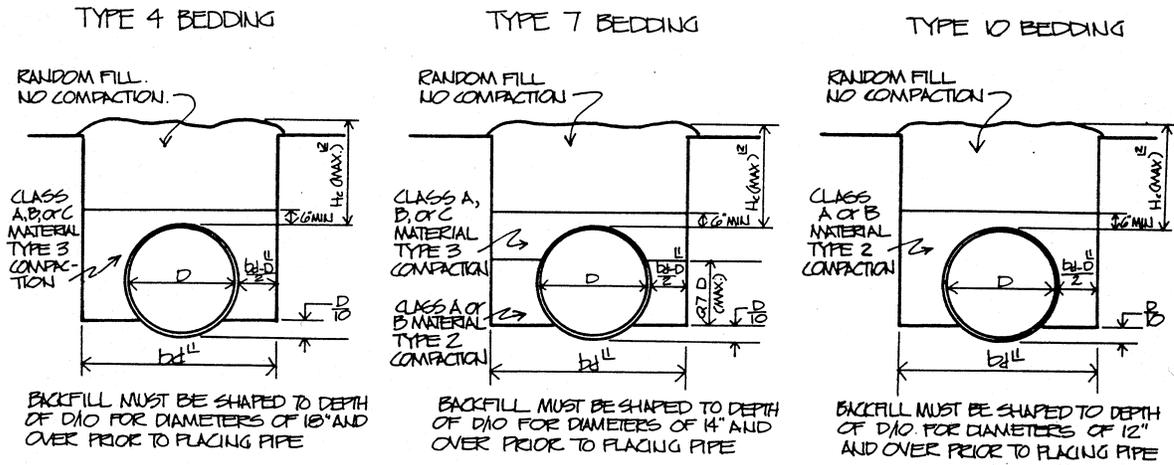
Table 3. —Maximum cover for pipes installed in embankments

Pipe diameter	Type 4 bedding	Type 7 bedding	Type 10 bedding
<i>in.</i>	<i>ft</i>	<i>ft</i>	<i>ft</i>
8	12	18	24
10	10	15	21
12	9	14	20
14	9	13	19
15-39	8	13	19
45-54	7	13	19

**Materials.** All materials described and required in this standard shall meet or exceed the minimum requirements indicated in “Specifications for Materials.”

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing reinforced plastic mortar irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.



Shape natural subgrade to fit the pipe to depth of  $D/10$  by using a template or properly shaped excavating equipment. At the contractor's option, the subgrade may be excavated to 4 in. below the bottom of the pipe and backfilled with Class A material, Type 3 compaction. If the subgrade is rock, contains rocks larger than 1 in. in diameter, or is unstable, excavate to a depth of 6 in. below the bottom of the pipe, backfill with Class A material, Type 3 compaction, and shape backfill as instructed above. Pipe must be in contact with the subgrade at all locations along the pipe (no high or low spots except as needed for bell ends, rings, or fittings).

NOTES—Show appropriate value on drawings:

1.  $bd = D + 18$  in. for compaction by water saturation;  $bd = D + 36$  in. for mechanical compaction.
2.  $H_c$  = Height of fill used in design calculations.

Figure 1.—Bedding conditions for pipe.

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**IRRIGATION WATER CONVEYANCE**  
**RIGID GATED PIPELINE**  
(ft)  
**CODE 430HH**

**DEFINITION**

A rigid pipeline, with closely spaced gated, installed as part of a surface irrigation system.

**SCOPE**

This standard applies to the design and installation of rigid gated pipe. It includes material specifications for aluminum and polyvinyl chloride (PVC) plastic gated pipe.

**PURPOSE**

To efficiently convey and distribute water to the land surface for better water management, without causing excessive erosion, water losses, or reduction in water quality.

**CONDITIONS WHERE PRACTICE APPLIES**

The rigid gated pipeline shall be planned and located to serve as an integral part of an irrigation distribution system that has been designed to help conserve soil and water resources on a farm. This practice shall not be used in lieu of buried pipelines for conveyance systems; however, reaches of ungated pipe may be used to obtain necessary working pressure for the system or to convey the water to various points.

Water supplies and rated of irrigation delivery for the area shall be sufficient to make irrigation practical for the crop to be grown and for border, furrow, corrugation, or contour water application methods.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effect on the components of the water budget, especially on volumes and rates of infiltration, evaporation, transpiration, deep percolation and ground water recharge.
2. Effects on downstream flow or aquifers that would affect other water uses or users.
3. Potential use for irrigation water management.

**Water Quality**

1. Effects on erosion along furrows and the movement of sediment and soluble and sediment-attached substances carried from the field.
2. Effects on the movement of dissolved substances into the soil, and on percolation below the root zone or to ground water recharge.
3. Potential effect of water level control on soil nutrient processes such as plant nitrogen use or denitrification.
4. Effects on the salinity of soils, soil water, or downstream flows.
5. Effects of controlled water delivery on the water temperatures that could cause undesirable effects on aquatic and wildlife communities.

6. Effects on the visual quality of water resources.

## **DESIGN CRITERIA.**

**Working pressure.** The maximum working pressure shall be 10 psi or 23 ft of head. Design working heads in excess of 23 feet shall be controlled by installing orifice plate head reducers, butterfly valves, stand pipes, or other appurtenances for head control.

**Friction losses.** For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation, using a roughness coefficient of C=130 for aluminum pipe and C=150 for plastic pipe. A multiple outlet factor shall be used in computing losses only when it affects the design pipe size.

**Flow velocity.** The design velocity in the pipeline when operating at system capacity shall not exceed 7 ft/s.

**Capacity.** The design capacity of the pipelines shall be sufficient to deliver an adequate irrigation stream to the design area for the planned irrigation method.

**Outlet gates.** Individual outlet gates shall have the capacity at design working pressure to deliver the required flow to a point at least 0.3 ft above the field surface.

**Head requirement.** The working head shall not be less than 0.5 ft above the outlet gates, unless a detailed design is complete to indicate that a lower head requirement is adequate. Where streamflows are erosive, a "sock" shall be installed on each gate or some other means of erosion control shall be provided.

**Flushing.** A surface outlet shall be installed at the terminal end of the pipeline if needed for flushing the line free of sediment or other foreign material.

**Quality of water.** Water quality shall be evaluated for all aluminum pipeline installations. A copper content in excess of 0.02 ppm produced nodular pitting and rapid deterioration of pipe if water is allowed to become stagnant. The pipeline should be drained after use. Provisions shall be made to prevent trash inflow into the gated pipeline.

**Materials.** Pipe materials shall equal or exceed the physical requirements specified under "Materials."

## **RELATED STRUCTURES**

On farm irrigation delivery systems shall meet or have a plan for improving the system to meet the appropriate irrigation water conveyance standard.

Appurtenances used to join the gated pipeline to the delivery system outlet must have adequate capacity at design working head to deliver the required flow.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing gated pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

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**IRRIGATION WATER CONVEYANCE**  
**STEEL PIPELINE**  
(ft)  
**CODE 430FF**

**DEFINITION**

A pipeline and appurtenances installed in an irrigation system.

**SCOPE**

This standard applies to the design and installation of buried steel irrigation pipelines and steel irrigation pipelines permanently installed above ground. If soil conditions do not permit below ground installation, onground installation is restricted to pipelines not greater than 6 in. in diameter. Pipelines greater than 6 in. installed under those conditions shall be placed on aboveground supports. This standard is restricted to pipelines not greater than 48 in. in diameter and does not apply to short pipes used in structures such as siphons, outlets from canals, and culverts under roadways.

**PURPOSE**

To prevent erosion or loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

**CONDITIONS WHERE PRACTICE APPLIES**

The pipeline shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All areas served by the pipeline shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects on the water budget, especially on infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

**Water Quality**

1. Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.

2. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.
5. Effects on the visual quality of water resources.

## DESIGN CRITERIA

Working pressure. The pipeline shall be designed to meet all service requirements without the use of a working pressure that will produce tensile stresses in the pipe greater than a design stress equal to 50 percent of yield-point stress. Design stresses for commonly used steel and steel pipe classes are shown in column two below:

Specification and grade of steel	Design stress 50 pct yield point <i>lb/in.<sup>2</sup></i>
ASTM-A-283	
Grade B	13,500
Grade C	15,000
Grade D	16,500
ASTM-A-570	
Grade A	12,500
Grade B	15,000
Grade C	16,500
Grade D	20,000
Grade E	21,000
AWWA-C-200	
Furnace butt weld	12,500
Grade A	15,000
Grade B	17,500
Grade X42	21,000

In computing tensile stresses in steel pipe, the following items must be considered:

1. The pressure to be delivered at the end of the pipeline.
2. The friction head loss,
3. The elevation differential between the outlet and the inlet of the pipe, and
4. Any pressure due to water hammer or surge that may be created by the closure of a valve in the pipeline.

**Flow capacity.** The design capacity shall be based on whichever of the following is greater:

1. Capacity to deliver sufficient water to meet the weighted peak consumptive use rate of the crops to be grown, or
2. Capacity sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

**Minimum wall thickness.** Minimum pipe wall thickness shall be as follows:

Nominal diameter	Wall thickness
<i>in.</i>	
4 - 12	14 gage less 12.5 %
14 - 18	12 gage less 12.5 %
20 - 24	10 gage less 12.5 %
26 - 36	3/16 in. less 12.5 %
38 - 48	1/4 in. less 12.5 %

**Friction loss.** For design purposes, the pipeline friction loss shall be based on that computed with Manning's Formula with n equal to no less than 0.012 for unlined and no less than 0.010 for lined pipe.

**Check, pressure-relief, vacuum-release, and air-release valves.** If detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, in closed systems where the line is protected from reversal of flow by a check valve and excessive surge pressure can build up, a surge chamber or a pressure-relief valve shall be installed close to the check valve on the side from the pump.

Pressure-relief valves shall be no smaller than ¼ in. nominal size for each diameter inch of the pipeline and shall be set at a maximum of 5 lb/in.<sup>2</sup> above the safe working pressure of the pipeline. A pressure-relief valve or surge chamber shall be installed at the end of the pipeline if needed to relieve surge.

Air-release and vacuum-release valves or combination air-release and vacuum-release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve if needed to provide a positive means of air entrance or escape.

Air-release and vacuum-release valve outlets shall be at least ½ in. in nominal diameter when specified for lines 4 in. or less in diameter, at least 1 in. outlets for lines 5 to 8 in. diameter, at least 2 in. outlets for lines 10 to 16 in. diameter, at least in. outlets for lines 18 to 28 in. in diameter, at least 6 in. outlets for lines 30 to 36 in. in diameter, and at least 8 inches outlets for lines 38 to 48 in. in diameter.

For pipelines larger than 16 in. in diameter, e in. air-release valves may be used in place of the sizes indicated if they are supplemented with vacuum-release valves that provide a vacuum-release capacity equal to the sizes shown.

**Drainage and flushing.** Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures or if drainage is specified for the job.

If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain at all low places in the line. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping

**Outlets.** Appurtenances for delivering water from a pipe system to the land, to a ditch, or to a surface pipe system shall be known, as outlets. Outlets shall have capacity to deliver the required flow:

1. To a point at least 6 in. above the field surface,
2. To the hydraulic gradeline of a pipe or ditch,
3. To an individual sprinkler, lateral line, or other sprinkler line at the design operating pressure of the sprinkler or line.

**Pipe supports.** Irrigation pipelines placed above ground shall be supported by suitably built concrete, steel, or timber saddles shaped to support the pipe throughout the arc of contact, which shall be not less than 90 degrees nor more than 120 degrees as measured at the central angle of the pipe. If needed to prevent overstressing, ring girder-type supports shall be used. Support spacing shall insure that neither the maximum beam stresses in the pipe span or the maximum stress at the saddle exceed the design stress values.

**Thrust control.** For aboveground pipelines with welded joints, anchor blocks and expansion joints shall be installed at spacings that limit pipe movement due to expansion or contraction to a maximum of 40 percent of the sleeve length of the expansion coupling to be used. The maximum length of pipeline without expansion joints shall be 500 ft. Aboveground pipelines with rubber gasket-type joints shall have the movement of each pipe length restrained by steel hold-down straps at the pipe supports or by anchor blocks instead of normal pipe supports.

Anchor blocks usually are not required on buried pipelines. Expansion joints shall be installed, as needed, to limit stresses in the pipeline to the design values.

Thrust blocks shall be required on both buried and aboveground pipelines at all points of abrupt changes in grade, horizontal alignment, or reduction in size. The blocks must be of sufficient size to withstand the forces tending to move the pipe, including those of momentum and pressure, as well as forces due to expansion and contraction.

**Joints and connections.** All connections shall be designed and constructed to withstand the working pressure of the line without leakage and to leave the inside of the pipeline free of any obstruction that would reduce the line capacity below design requirements. On sloping lines, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks. If cathodic protection is required, high resistance joints shall be bridged to insure continuous flow of current.

A dielectric connection shall be placed between the pump and the pipeline and between pipes with different coatings.

**Corrosion protection.** Interior protective coatings shall be provided if the pH of the water to be conveyed is 6.5 or lower. Cement mortar coatings may be used if the water to be conveyed has a pH of 5.5 or higher and a sulfate content of 150 ppm or less.

All pipe exteriors for underground lines must be fully protected against corrosion. To meet protection requirements, all pipe must be coated and must be provided with supplementary cathodic protection as specified in item 2 below:

1. A Class A protection coating shall be provided if the soil-resistivity survey shows that either (a) 20 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 1,500 ohm-cm or less or (b) 10 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 750 ohm-cm or less. A Class B coating shall be provided for pipe to be installed in soil having a resistivity greater than 1,500 ohm-cm.
2. Supplementary cathodic protection shall be provided if the soil-resistivity survey shows that any part of the pipeline will be in soil whose resistivity is less than 10,000 ohm-cm unless galvanized pipe is used. Pipe to soil potential shall be not less than is used. Pipe to soil potential shall be not less than 0.85 V negative, referred to as a copper/copper-sulfate reference electrode, with the cathodic protection installed. The initial anode installation shall be sufficient to provide protection for a minimum of 15 years.

Cathodic protection shall be provided for galvanized pipe if the soil-resistivity survey shows that any part of the galvanized pipe will be in soil whose resistivity is less than

4,000 ohm-cm. Galvanized pipe requiring cathodic protection shall have a Class B coating.  
 The total current required, the kind and number of anodes needed, and the expected life of the protection may be estimated as shown below:

The total cathode current required may be estimated from the formula.

$$I_t = C [ A_1 / R_{e1} + A_2 / R_{e2} + . . . A_n / R_{en} ]$$

Where:

- $I_t$  = total current requirement in mA
- $A$  = surface area pipe in ft<sup>2</sup>
- $R_e$  = soil resistivity in ohm-cm
- $C$  = a constant for a given pipe coating

For design purposes, this constant shall be considered to be not less than 32 for Class A coatings and not less than 60 for class B coatings.

The kind of galvanic anode to be used depends on the resistivity of the soils in the anode bed location. If the resistivity of the anode bed is:

- a. Less than 2,000 ohm-cm, zinc anodes shall be used;
- b. Between 2,000 and 3,000 ohm-cm, either zinc or magnesium anodes shall be used; and
- c. Between 3,000 and 10,000 ohm-cm, magnesium anodes shall be used.

Anodes shall not be required on pipelines if soil resistivity is greater than 10,000 ohm-cm.

The number of anodes needed to protect the pipeline may be estimated by dividing the total cathode current requirement of the pipeline by the current output per anode.

Thus:

$$N = I_t / I_m \text{ and } I_m = k / R$$

Where:

- $N$  = number of anodes needed
- $I_t$  = total current requirement in mA
- $I_m$  = maximum anode current output in mA
- $k$  = constant for a given anode
- $R$  = soil resistivity of the anode bed in ohm-cm.

The expected life of an anode, based on the use of 17 lb / ampere year for magnesium and 26 lb per ampere year for zinc and a utilization factor of 0.80, shall be computed as follows:

$$\begin{aligned} \text{Magnesium . . . . . } Y &= 47W / I_o \\ \text{Zinc . . . . . } Y &= 31W / I_o \end{aligned}$$

Where:

- $Y$  = expected life in years
- $W$  = weight of anode in lb
- $I_o$  = design anode current in mA =  $I_m$  unless resistors are used in anode circuit to reduce output

If resistors are used to reduce anode current output to increase service life, the number of anodes required shall be based on the regulated output of the anode rather than on the maximum output,  $I_m$ .

3. Preliminary soil-resistivity measurements to determine coating requirements and the approximate amount of cathodic protection needed may be made before the trench is excavated.

For this purpose, field resistivity measurements shall be made, or samples for laboratory analysis shall be taken at least every 400 ft. long the proposed pipeline and at points where there is a visible change in soil characteristics. If a reading differs markedly from a preceding one, additional measurements shall be taken to locate the point of change. Resistivity determinations shall be made at two or more depths in the soil profile at each sampling station; the lowest depth shall be the strata in which the pipe will be laid. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station.

After the pipe trench is excavated, a detailed soil resistivity survey shall be made as a basis for final design of the coating and the required cathodic protection. At this time, resistivity measurements shall be made in each exposed soil horizon at intervals not exceeding 200 ft. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station. If design values for adjacent stations differ significantly, additional intermediate measurements shall be made.

Steel pipelines placed on the ground shall be limited to sites where the soil resistivity along any part of the pipeline is greater than 4,000 ohm-cm. Pipe at anchor or thrust blocks shall be embedded or attached rigidly with a holddown strap.

All pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and two or more final coating.

**Materials.** All materials shall meet or exceed the minimum requirements of this standard.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for steel irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

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# IRRIGATION WATER MANAGEMENT

(Acre)  
CODE 449

## DEFINITION

Irrigation water management is the process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner.

## PURPOSE

Irrigation water management is applied as part of a conservation management system to support one or more of the following:

- Manage soil moisture to promote desired crop response
- Optimize use of available water supplies
- Minimize irrigation induced soil erosion
- Decrease non-point source pollution of surface and groundwater resources
- Manage salts in the crop root zone
- Manage air, soil, or plant micro-climate.

## CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable to all irrigated lands.

An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, etc.) must be available and capable of applying water to meet the intended purpose(s).

## CRITERIA

### General Criteria Applicable To All Purposes

All work shall comply with Federal, State, and local laws and regulations. Water shall not be applied in excess of the needs to meet the intended purpose.

### Additional Criteria to Manage Soil Moisture to Promote desired Crop Response

The following principles shall be applied for various crop growth stages:

- The volume of water needed for each irrigation shall be based on plant available water holding capacity of the soil for the crop rooting depth, management allowed soil water depletion, irrigation efficiency, and water table contribution.
- The irrigation frequency shall be based on the volume of irrigation water needed and/or available, the rate of crop evapotranspiration, and effective precipitation.
- The application rate shall be based on the volume of water to be applied, the frequency of irrigation applications, soil infiltration and permeability characteristics, and the capacity of the irrigation system.

### Additional Criteria To Optimize Use Of Water Supplies

Limited irrigation water supplies shall be managed to meet critical crop growth stages.

### **Additional Criteria to Minimize Irrigation Induced Soil Erosion**

Application rates shall be consistent with local field conditions for long term productivity of the soil.

### **Additional Criteria to Decrease Non-Point Source Pollution of Surface and Groundwater Resources**

Water application shall be at rates that minimize transport of sediment, nutrients, and chemicals to surface waters and that minimize transport of nutrients and chemicals to groundwater.

### **Additional Criteria to Manage Salts in the Crop Root Zone**

The irrigation application volume shall be increased by the amount required to maintain an appropriate salt balance in the soil profile.

The requirement shall be based on the leaching procedure contained in the National Engineering Handbook (NEH) Part 623, Chapter 2.

### **Additional Criteria to Manage Air, Soil, or Plant Micro-Climate**

The irrigation system shall have the capacity to apply the required rate of water for cold or heat protection as determined by the methodology contained in NEH Part 623, Chapter 2.

## **CONSIDERATIONS**

The following items should be considered when planning irrigation water management:

- Consideration should be given to managing precipitation effectiveness, crop residues, and reducing system losses.
- Modify plant populations, crop and variety selection, and irrigated acres to match available or anticipated water supplies.
- Consider potential for spray drift and odors when applying agricultural and municipal waste waters.
- Equipment modifications and/or soil amendments such as polyacrylamides and mulches should be considered to decrease erosion.
- Consider the quality of water and the potential impact to crop quality and plant development.
- Quality of irrigation water should be considered relative to its potential effect on the soil's physical and chemical properties, such as soil crusting, pH, permeability, salinity, and structure.
- Avoid traffic on wet soils to minimize soil compaction.
- Consider the effects that irrigation water has on wetlands, water related wildlife habitats, riparian areas, cultural resources, and recreation opportunities.
- Management of nutrients and pesticides.
- Schedule salt leaching events to coincide with low residual soil nutrients and pesticides.
- Water should be managed in such a manner as to not drift or come in direct contact with surrounding electrical lines, supplies, devices, controls, or components that would cause shorts in the same or the creation of an electrical safety hazard to humans or animals.
- Consideration should be given to electrical load control/interruptible power schedules, repair and maintenance downtime, and harvest downtime.
- Consider improving the irrigation system to increase distribution uniformity of irrigation water application.

## **PLANS AND SPECIFICATIONS**

Application of this standard may include job sheets or similar documents that specify the applicable requirements, system operations, and components necessary for applying and maintaining the practice to achieve its intended purpose(s).

## **OPERATION AND MAINTENANCE**

There are no operation and maintenance (O&M) aspects applicable to this standard. Necessary O&M items are addressed in the physical component standards considered companions to this standard.

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# **LAND CLEARING**

(acre)  
**CODE 460**

## **DEFINITION**

Removing trees, stumps, and other vegetation from wooded areas.

## **PURPOSE**

To achieve needed land use adjustments and improvements in the interest of soil and water conservation and in keeping with the capabilities of the land.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to wooded areas where the removal of trees, stumps, brush, and other vegetation is needed in carrying out a soil and water conservation plan, and the land to be cleared will be used according to its capabilities.

## **PLANNING CONSIDERATIONS**

The plan shall specify the kinds of timber to be salvaged, lengths of logs, and place of stacking. Method of disposal shall be specified for all material not be salvaged. Clearing and disposal methods shall be according to applicable state laws and with due regard to the safety of persons and property.

The cleared area shall be left in a neat and sightly condition that will facilitate the planned use and treatment of the land.

The plan shall provide for the measures necessary to protect the cleared area from erosion.

Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable. Consideration of such things as strip clearing, windowing debris, and maintaining den and food trees shall be explored.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for land clearing shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, evaporation, and transpiration.
2. The impact of soil settling on the variation in rates of runoff immediately after clearing.

## Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.

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**LAND RECLAMATION**  
**FIRE CONTROL**  
(No.)  
**CODE 451**

**DEFINITION**

Controlling or extinguishing fires in coal refuse.

**SCOPE**

This standard applies to the coal fires in spoil and refuse from surface or underground coal mining activities, generally associated with abandoned mine lands.

**PURPOSE**

To control or extinguish coal spoil or refuse fires to eliminate harmful fumes and gases, improve public safety, conserve coal resources, prevent ignition of additional coal or refuse, protect surface lands and vegetation, remove the threat of forest fires, improve water quality, and restore areas to a beneficial use.

**CONDITIONS WHERE PRACTICE APPLIES**

Locations where coal refuse is burning and degrading the environment. Land reconstructing will normally be associated with this practice.

**PLANNING CONSIDERATIONS**

1. Area of burning material.
2. Geologic sections of the strata where coal is burning.
3. Hazardous fumes and gases being released.
4. Ignition potential for other combustible materials.
5. Materials available for extinguishing the fire and stabilizing the area.

**DESIGN CRITERIA**

SCS fire control will normally be limited to small fires that are a part of a larger land reconstruction project. Major fires should be controlled by other agencies. Many mine reclamation jobs have the potential to burn and the principles in this standard should be used for fire prevention on all abandoned mine reclamation work. Coal refuse must never be left on the surface.

There are four primary methods for controlling mine fires, depending on the condition. They are (1) loading out, (2) fire barriers (trench and plug), (3) flushing (grouting), and (4) surface sealing.

**Loading out.** This involves digging out the burning and heated material, and cooling it with water or by spreading it on the ground. The excavation should start between the fire and the unburned coal material. The burning materials must be cooled by water to allay dust and reduce the probability of explosions and to prevent damage to machinery. The cooled material can then be disposed of in a safe manner either on the site or at a disposal area. The area containing all the

combustible material must then be protected from ignition by surface sealing with soil material or a method that provides equivalent results.

**Fire barriers.** A trench barrier is made by excavating a trench, usually from an outcrop on one side of the fire to an outcrop on the other side, between the burning material and the unburned material. The trench is backfilled with incombustible materials such as earth, fly ash, or granulated slag. The sides of the trench excavation must be stable. The minimum thickness of the incombustible backfill barrier is 4.6 m (15 ft)

A plug barrier is used where excessive overburden prevents use of a trench barrier. The plug is installed similar to a trench barrier except that the trenches are started at an outcrop and stopped when the overburden exceeds 18 m (60 ft). Two plugs will normally be required, one on each side of the fire. The surface over the fire between the two plugs must be sealed where the overburden exceeds 18 m(60 ft).

**Flushing.** This method is designed to fill the voids around an underground fire area with finely divided incombustible solids to prevent airflow to the burning material. This method is applicable where excessive overburden or improvements preclude the use of other methods.

To construct the barrier, 15-cm (6-in) holes are bored in the mine void on 3-m (10-ft) centers. Holes on adjacent lines are to be staggered. Sand, water-cooled slag, crushed limestone, and crushed and screened earth or shale can be slurried into the mine through the holes. Another alternative is to use air flushing injection of dry fly ash material. Barriers constructed by this method may consist of one row of 15-cm (6-in) boreholes on 7.6-m (25-ft) centers. In each case the installation must be monitored to ensure that enough fine incombustible material is installed to make the barrier effective. Angle drilling around improvements and other obstructions may be necessary.

**Surface sealing.** Surface sealing is used on fires that have extended for a great distance, or it is used in conjunction with other control measures. Sealing is obtained by covering the affected area with not less than 1.2 m (4 ft) of incombustible fine-grained earth material or other suitable material. Materials that will not crack upon drying out should be used. The seal should extend from 3 m (10 ft) below the burning material to 18 m (60 ft) above. All openings and drains must be sealed to cut off the flow of oxygen. Drainage pipes with traps to prevent air and gas passage may be used if continuous water drainage is necessary. Erosion must be controlled to prevent braking the seal. Intensive water disposal systems are required to ensure an effective seal.

## MONITORING

Treated mine fire areas are to be monitored to ensure that the fire is out. Fires extinguished by loading out may be monitored by surface inspection. Other fire areas shall have monitoring holes installed into the burning zone. The monitoring holes shall not exceed a 61-m (200-ft) spacing in any direction. The monitoring holes shall be sealed and the temperature monitors. A weighted thermocouple is lowered into the hole and the temperature read on the surface with a potentiometer. Thermometers may be used for shallow holes. Temperatures should be read at least every 60 days. Monitoring may be stopped when the maximum temperature in all wells reaches 48.8 °C (120 °F) or less and the trend is down.

## MAINTENANCE

A maintenance plan will be developed, including mandatory temperature monitoring. Regular periodic inspections must be carried out until the fire is extinguished and the area is stabilized. Needed maintenance must be carried out promptly to ensure a successful operation.

## **PROTECTION**

All disturbed areas shall be reshaped and regraded to blend with surrounding features. Visual resources must be considered in the planning, design, and installation. Exposed toxic material and rock shall be covered with soil material and established with vegetation or protected by other means. Access roads must be maintained and foot and vehicular traffic controlled to protect the work.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for controlling mine and refuse fires shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **LAND RECLAMATION, FIRE CONTROL SPECIFICATIONS**

### **FOUNDATION PREPARATION**

The foundation area shall be cleared of trees, brush, debris, and rubbish to conduct fire control operations. Waste materials shall be disposed of at designated locations by burning or burying as specified on the plans.

### **EXCAVATION OF BURNING MATERIALS**

Hot materials shall be excavated and cooled by quenching with water or mixing with incombustible soil materials as specified on the plans. Cooled material shall be stockpiled for use as backfill area is ready. Cooled material shall be placed and compacted in layers. The surface shall be placed to the approximate final grade in readiness for the seal, top-soil, and vegetation.

### **BARRIERS**

Barriers of earth or fly ash shall be placed to line and grade as shown on the plans, or as specified during installation, to provide a positive barrier to the fire.

### **INSPECTION HOLES**

Holes for inspection will be drilled at the locations and to the depths specified on the plans. Casings and caps of the size, thickness, and materials specified shall be installed to line and grade. Marker posts shall be installed as necessary. All holes not cased and capped shall be sealed with nonflammable material.

### **SEALS**

Seals of incombustible soil materials shall be installed to the thickness specified. The seal shall be placed in layers not exceeding 300 mm (1 ft) thick and compacted by normal traffic or by a compacting roller as necessary to achieve the required density. Topsoil shall be added to the specified thickness after the seal is compacted.

## **PROTECTION**

A protective cover of vegetation shall be established on all exposed surfaces if soil and climatic conditions permit. Nonvegetative protective measures may be used if soil and climatic conditions preclude the use of vegetation.

Appropriate safety measures, warning signs, rescue facilities, fencing, and other measures shall be provided.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **QUANTITY**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge.
2. Effects of vegetation on soil moisture.

### **QUALITY**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects of nutrients and pesticides and their effect on surface and ground water quality.
3. Effect on the visual quality of downstream and local water resources.
4. Short-term and construction-related effects of this practice on the quality of the surface and ground water.
5. Long-term effects of the management and maintenance of this practice on surface and ground water quality.
6. The potential for uncovering toxic materials and spreading them in areas that might cause undesirable effects.
7. The effects on wetlands and water-related wildlife habitats.

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**LAND RECLAMATION**  
**HIGHWALL TREATMENT**  
(No. and m, ft)  
CODE 456

**DEFINITION**

Reducing harmful effects of highwalls in abandoned mined areas.

**SCOPE**

This standard applies to the treatment of highwalls resulting from past mining activities and is usually associated with reclamation and reconstruction of abandoned mined areas.

**PURPOSE**

To reduce highwall heights or slopes to satisfactory levels to eliminate the hazard to human health and safety, control erosion and sediment, improve or maintain water quality, improve landscape resource quality, create conditions conducive to the establishment of protective cover, and return the area to a beneficial land use.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to areas where highwalls resulting from past mining are: (1) a hazard to human health and safety; (2) unstable and contributing excessive sediment to adjacent land and waters; and (3) degrading water quality, the environment, or landscape resources.

**PLANNING CONSIDERATIONS**

1. Geology and the associated subsurface conditions of the highwall area.
2. Surface and subsurface hydrologic conditions.
3. Land use, land ownership, dwellings, and other improvements in the adjacent area.
4. Slide or failure potential.
5. Contribution of sediment to offsite areas.
6. Availability of backfill material.
7. Landscape (visual) resources.
8. The extent and quality of associated wetland areas.
9. Water quality.
10. Surface water disposal.

The existence of a highwall does not necessarily mean that treatment is required. Three basic types of problems should be considered for treatment. One of these types exists when the highwall is near roads, schools, parks, dwellings, or other populated areas and presents a substantial hazard to human health and safety. The potential for occasional exposure by humans to the unsafe condition does not qualify as a substantial hazard. Another type to consider is when the site is unstable with actual or potential failure, is contributing excessive sediment to adjacent land or waters, or is otherwise degrading the environment. The third type of problem exists when the highwall is determined to be a significant visual degrader. A highwall may have positive, negative, or even neutral effects on visual quality. Its existence may add a desirable

element of variety to the landscape or may otherwise fit into a planned and pleasing landscape. Its location may also be so remote or obscure that it does not present a visual problem. Visibility is an important consideration in making a determination about treatment.

Full consideration should be given to fencing and using vegetative barriers to reduce the probability of human injury; however, it should be recognized that barriers do not solve the problem. Major earthwork to reduce or eliminate the highwall will usually be required to remedy stability problems. Screening with trees may be effective in solving visual problems.

The elimination of water areas or wetlands as a result of highwall reduction may have adverse environmental effects. The quality of the water for fish, wildlife, and vegetative growth is a key factor in determining wetland classification. All significant wetlands and water areas must be properly classified and protected or losses mitigated in accordance with SCS policies (see SCS policy, 7 CFR 650). Acid or other toxic aqueous discharges should be treated according to the standard for Toxic Discharge Control (455).

The principles stated in this standard are also applicable to the treatment of highwalls not associated with mining.

## **DESIGN CONSIDERATIONS AND CRITERIA**

**Landscape (visual) resources.** The appearance of the reclaimed site must be in accordance with standards for maintaining and improving the visual quality of the landscape and must be comparable with adjacent undisturbed areas. Areas of high public visibility or those offering direct or indirect human benefits shall be evaluated and considered in a landscape resource management plan and design. Borrow areas are to be reshaped and vegetated as a part of the landscape plan and design.

**Barriers to human access.** Fencing and vegetative barriers may be used singularly or in combination. The type of fencing shall be “anti-intruder” chain link, barbed wire, or a net wire and barbed wire combination. If reduced visibility is desired, fencing such as black vinyl-coated wire should be considered.

Vegetative barriers shall consist of vigorous, durable plant species adapted to the site, with growth habits that provide a barrier to human access. Barriers are to be part of the landscape management plan.

**Reduction (height or slope).** Consideration should be given to a combination of cut and fill or to partial reduction for meeting the objectives with the least cost.

**Slope stability.** Highwalls in rock formations may be stable on steep slopes. In these cases, treatment needs may be limited to the control of rolling or falling rocks. Fences or dikes at the base of the slope may be used as control measures.

Highwalls in earth, fractured rock, or other weak materials are to be evaluated to determine if an analysis of the failure potential is needed. Measures developed to prevent or stabilize failures associated with highwalls shall be based on engineering judgment and an analysis made by an engineer trained and experienced in soil mechanics.

Slope stability analysis shall account for all critical soil and loading conditions. The strength parameters of natural soil and rock or of waste materials shall be based on the appropriate conditions for each site. Long-term strength parameters ( $c = 0$  and internal friction based on residual shear) are often required. The methods of slope stability analysis are to be appropriate for the loading conditions and for the location and shape of the potential failure surfaces.

Appropriate safety factors shall be provided based on the degree of uncertainty in the soil strength values used, the soil and water conditions assumed, and the details of the analysis used. If there is a potential for loss of life or damage to farmsteads, residential areas, frequently traveled roads, or other occupied facilities, the measures shall include removal of the highwall or use of other control measures that ensure safety.

Earthquake or seismic forces are to be considered in the appropriate locations. The criteria for geologic investigations, seismic assessments, and minimum seismic coefficients associated with earthquakes shall apply as contained in Technical Release No. 60 for earth dams.

**Water disposal.** The need for drainage, erosion control, and water disposal systems shall be carefully analyzed and needed systems included in the design. Acid water discharges must be treated as necessary to meet the environmental requirements of the receiving waters as prescribed by the state regulatory agency.

**Other practices.** All individual practice components shall be designed and installed in accordance with appropriate SCS standards and specifications. Where standards do not exist, applicable current technology shall be used.

## **MAINTENANCE**

Maintenance activities are to be outlined in a maintenance plan. Water management systems, erosion control systems, vegetative cover, and barriers are to be maintained to accomplish their intended purposes. Regular periodic inspections must be carried out and needed repairs made promptly.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for highwall treatment shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve the intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the components of the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, macropore and borehole flow, and ground water recharge.
2. Variability of the practice's effects caused by seasonal and climatic changes.
3. Effects of vegetation on soil moisture.
4. The effects of snowcatch and melt on water budget components.
5. Effects on downstream flow and aquifers that would affect other water uses or users.
6. Effects on the volume of downstream flow that might cause undesirable environmental, social or economic effects.
7. Potential for water use control, and management.

### **Quality**

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff or seepage.
2. Effects on the visual quality of onsite downstream water resources.
3. Short-term and construction-related effects on the quality of downstream surface and ground water.
4. Potential for uncovering and redistributing toxic material.

5. Effects on the movement of dissolved substances below the root zone and toward the ground water.
6. Effects on wetlands and water-related wildlife habitats.

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**LAND RECLAMATION**  
**LANDSLIDE TREATMENT**  
(No. and ha, acre)  
**CODE 453**

**DEFINITION**

Treating inplace materials, mine spoil (excavated over-burden), mine waste or overburden to reduce downslope movement.

**SCOPE**

This practice applies to landslides or potential landslides.

**PURPOSE**

To prevent or stabilize landslides to: protect life and property; prevent excessive erosion and sedimentation; improve water quality and landscape resource quality; and to create a condition conducive to establishing surface protection and beneficial land use.

**CONDITIONS WHERE PRACTICE APPLIES**

To areas where inplace material, mine spoil, waste, or overburden is unstable, moving, or judged to have potential of moving downslope in a manner that will cause damage to life, property, or the environment and produce excessive sediment and debris. Land reconstruction is normally associated with this practice.

**PLANNING CONSIDERATIONS**

1. Geology of the area and associated subsurface conditions.
2. Type and amount of spoil or waste.
3. Topography of the slide and adjacent areas, including known or estimated pre-mine, preconstruction, or pre-slide conditions.
4. Surface drainage and runoff patterns.
5. Groundwater profiles, seepage patterns, and sources of subsurface water.
6. Land use, dwellings, roads, structures, and water disposal system.
7. Procedures used during mining operations or construction.
8. Slide potential during investigation and construction.
9. Rainfall and runoff.

Landslides result from a combination of several factors, the most important being static load, slope of the surface and slip zone, the soil characteristics in the slip zone, and the presence of water. The key to control is to bring about a favorable balance between the load that created the tendency to move and the resisting forces that restrain movement. This can be done by reducing the load, reducing the slope, increasing internal strength, and providing external restraining forces. A good reference on landslides is the publication "Landslides: Analysis and Control," 1978. Transportation Research Board, National Academy of Sciences, Special Report 176, 234 p.

**Investigations.** Investigations are to be made to determine:

1. Surface profiles, cross sections, and topographic features.
2. Geologic profiles and cross sections showing attitude and conditions of strata and details of the slip zone.
3. Soil properties, including gradation, density, strength, and physical and chemical characteristics.
4. Ground-water conditions
5. Depth and volume of material involved.
6. Extent of problem or potential problem area.
7. Estimated pre-slide profile and subsurface conditions.
8. Conditions where slopes are stable in similar materials.

Extreme caution must be exercised and careful planning is required before permitting any drilling equipment, construction machinery, or personnel in the slide area. A slide is often active only during wet periods and may be comparatively stable during dry periods. With this in mind, heavy drilling and machinery work should be scheduled during dry periods.

## **DESIGN CONSIDERATIONS AND CRITERIA**

In most cases the unstable or potentially unstable conditions cannot be attributed to one cause. Therefore, the solution is usually a combination of treatment measures, each either increasing the internal strength or decreasing the external load to the point where required stability is obtained.

**Slope stability.** Measures developed to prevent or stabilize slides shall be based on engineering analysis and judgment made by an engineer trained and experienced in soil mechanics. Slides are the most complex of geotechnical problems requiring analysis. The best available expertise in soil engineering is needed and expert consultants should be hired, if necessary.

Slope stability analysis shall account for all critical soil and loading conditions. The strength parameters of natural soil and rock or of waste materials shall be based on the appropriate conditions for each slide. Long-term strength parameters ( $c=0$  and internal friction based on residual shear) are often required. The methods of slope stability analysis are to be appropriate for the loading conditions and for the location and shape of sliding or potential failure surfaces. Appropriate safety factors shall be provided based on the degree of uncertainty in the soil strength values used, the soil and water conditions assumed, and the detail of the analysis used. When there is a potential for loss of life or damage to farmsteads, residential areas, frequently traveled roads, and occupied facilities, or important public utilities, the measures shall include removal of the material subject to sliding or any other control to ensure safety.

Earthquake or seismic forces are to be considered on major high hazard sites. The criteria as contained in Technical Release No. 60 for earth dams shall apply for geologic investigations, seismic assessments, and minimum seismic coefficients associated with earthquakes.

**Water control.** Water creates problems in two ways. The addition of water to the material above the slope zone increases the load. It also acts as a lubricant, or increases pore pressure within the slide material and in the slope area, thereby reducing internal strength. In both cases water increases the potential for sliding.

There are three major sources of water within the slide area—surface runoff that finds its way onto the slide area, precipitation directly on the surface, and subsurface water from known or unknown sources. A combination of these sources usually contributes to the excessive water problem.

**Surface runoff water.** Runoff water from outside areas is to be controlled by using diversions, associated structures, and conveyance systems.

**Water from direct precipitation.** Infiltration can be limited and controlled by providing positive surface drainage, sealing the surface cracks and breaks on the slide and adjacent areas, and establishing vegetation. Grading and shaping may be required to provide positive surface drainage. Terraces structures, and waterways are to be installed as needed to provide safe water disposal without erosion and with positive grade to reduce seepage. Cut and fill to a depth of 0.9 to 1.2 m (3 to 4 ft) may be required to reduce surface infiltration and seal cracks and breaks. Compaction of the material will further reduce infiltration, but care must be taken to prevent excessive compaction which would restrict vegetative establishment. Establishing a vigorous vegetative cover will increase evapotranspiration and control erosion.

**Ground water.** Ground water that contribute to instability is to be controlled. Many slides remain active during reconstruction periods and further movement can be expected. Therefore, drainage systems are to be designed to remain operative after limited movement. Pipes must be used with caution because of the potential of breaking and/or misalignment with further movement. Flat or nearly flat gradients should not be used for the same reasons. A properly designed filter shall be used to prevent clogging of the drains.

**Earth material control.** Earth material in internal water are the load factors that contribute to the unstable conditions that cause slides. Treatment consists of removing earth material to reduce the load and slope, increasing the internal strength of the earth material and providing external restraints to movement.

**Loading control.** In most cases loading control consists of removing excess material to a safe location. However, in some instances the solution may be adding material to the toe of the slide area to increase the load, resisting further movement. Removal of slide debris from the toe (downhill side) of the slide usually will increase the instability and cause further slide movement.

**Slope reduction.** Slopes can sometimes be reduced by grading and shaping to eliminate critical slopes within the slide area. It can also be reduced as a result of loading control measures.

**Increasing internal strength.** Reducing the internal water of the slide material, removing or replacing the slide material, incorporating any admixture needed into it, and compacting it can increase the internal strength to resist a tendency to slide.

**External restraints.** In some cases, buttresses, bulkheads retaining walls, pilings, tieback anchors, and gabions can be used to restrain further slide movement. These structures may provide the only practicable solution where high-valued improvements are involved and movement must be contained in a short distance. The structures are normally very expensive and are usually not practicable otherwise. They also require complex design analyses, using the expertise of geologists, soil mechanics engineers, and structural engineers.

**Component practices.** All individual practices installed as a component of landslide treatment are to be designed and installed in accordance with applicable SCS standards and specifications. If SCS standards are not available, the practice is to be designed and installed using current engineering technology.

**Environmental.** All disturbed areas are to be provided with adequate water disposal systems and established to vegetative cover, or otherwise protected, to control erosion and sediment as soon as practicable. Temporary protective measures will be necessary if a long delay is anticipated in establishing permanent cover. Foot and vehicular traffic is to be controlled to protect the area.

Visual resources are to be given the same consideration as other design features during planning, design, and installation. All disturbed areas shall be reshaped and regraded to blend in with the surrounding land features.

## **MAINTENANCE**

The maintenance plan is to include periodic inspections because of the potential for additional movement, failure of water disposal systems, failure of vegetation, and other problems. The water disposal system, subsurface drainage system, access roads, and vegetative cover are to be maintained to accomplish their intended purposes. Necessary maintenance and repair activities are to be initiated promptly.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for slide treatment shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effect on and discharge capacity of water courses affected by the landslide.
2. Water budget effect on volumes and rates of runoff, evaporation, deep percolation, and ground water recharge.
3. Potential for a change in plant growth and transpiration because of changes in the amount of soil moisture in the vicinity of the structure.

### **Quality**

1. Potential to reduce erosion and related movement of sediment or sediment-attached substances.
2. Short-term and construction-related effects on downstream water courses.
3. Potential to alter the discharge of toxic materials to ground or surface waters.
4. Effects on the visual quality of water resources.

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# LAND RECLAMATION

## SUBSIDENCE TREATMENT

(ha, acre)  
CODE 454

### DEFINITION

Treating subsidence areas to reduce the harmful effects and provide for beneficial use.

### SCOPE

This standard applies to surface subsidence associated with abandoned underground mines in rural areas that are being treated as part of surface reclamation. Open sinkholes caused by mine collapse are covered by the shaft and adit closing standard (452).

### PURPOSE

Subsidence is treated to minimize damages where high-valued improvements are involved or where there is high hazard to human life. It is also treated to reduce pollution of surface and ground water, prevent soil degradation, improve landscape resource quality, and restore or maintain a beneficial use.

### CONDITIONS WHERE PRACTICE APPLIES

This standard applies to locations where surface subsidence from the collapse of underground mining is threatening rural buildings and structures, roads, dams, and ponds; decreasing land values; interfering with surface drainage or water supplies; creating a hazard to human life; damaging landscape values; and creating a nuisance or preventing beneficial use.

### PLANNING CONSIDERATIONS

1. Geologic environment of the immediate area, including characteristics of overburden such as lithology, faults, joints, and attitude.
2. Surface and subsurface hydrologic conditions
3. Mining history.
4. Postmining history and conditions.
5. Land use.
6. Vertical and horizontal dimension of voids.
7. Depth of voids below land surface.
8. Size, type, and distribution of pillars.
9. Surface topography and drainage pattern.
10. Availability and quality of backfill material.
11. Availability of slurry water.

#### General

If high-valued improvements or danger to human life are involved, the hazard can be reduced by backfilling the mined-out areas under and adjacent to the improvements with hydraulic or blind backfilling. If the mined-out voids are not too deep, a stripping operation can be used to eliminate present and further subsidence problems. Surface treatment may be used to reduce the harmful effects, recognizing that future subsidence may occur and additional treatment will be necessary.

## DESIGN CRITERIA

**Controlled backfilling.** Controlled backfilling methods can be used where the mine is accessible and can be traversed to key areas for the filling operation. Bulkheads are built in mine passage around the periphery of the work area for containment of the fill. Drains may be incorporated in the bulkheads to facilitate rapid water removal. Bulkheads are built of wood or other suitable material. Vertical injection boreholes should be minimum of 30 cm (12 in) in diameter. At the base of each hole, a 90° long radius pipe elbow is placed whereby the slurry can be diverted to horizontal pipes and distributed into the mine workings. Boreholes through bulkheads may also be utilized.

**Blind backfilling-gravity method.** If abandoned mine openings are inaccessible because of flooding or caving, blind backfilling must be used. Pipes are installed from the surface into the mine openings through drill holes and granular material is flushed in with water under the force of gravity. In the gravity feed method, the injected granular material builds a cone under the injection pipe. When the cone builds up to the mine roof, no more fill will enter the mine and a new hole must be drilled.

**Blind flushing pumped-slurry injection.** In the pumped-slurry method, durable granular material is blended with water, and the suspension (slurry) is pumped to the point of injection. Energy provided by the pump and the static head in the borehole give the velocity required to keep the solid particles in suspension and to transport them. As the slurry firsts enters the open space, its velocity drops rapidly, and the sold particles settle out in a mound. As the mound approaches the mine roof, the velocity of the slurry increases through the narrowing channels, and the solid particles are transported to the outer limits of the mound. Here the velocity again decreases abruptly, the solids are deposited, and the mound is built outwards until resistance to flow reduces the velocity below that required to transport the solids. This may be several hundred feet, depending on particle size and concentration and other factors. Exploratory drill hoes may be needed to determine the extent and effectiveness of backfilling.

**Daylighting.** Stripping, replacement of the overburden and complete reclamation are the most effective methods of subsidence treatments. The hazard to personnel and equipment caused by the subsurface voids is a major consideration in planning equipment movement and mining operations; therefore, the plan must include procedures to establish firm support. It may be necessary to excavate and backfill the anticipated travel paths ahead of the complete stripping operation. If the remaining coal is not to be removed, care must be taken to open all rooms and travelways and ascertain that they are completely backfilled with overburden material before initiating other backfill operations.

**Surface treatment.** Surface filling of subsidence areas is usually applicable when drainage cannot be obtained or other important factors make filling a practical alternative. Some areas of subsidence may be considered low hazard and sufficiently stable to permit land use operations after surface filling. Drainage systems can be used to eliminate excess water. Diversions can be used to keep runoff water from entering the treatment areas, and land smoothing and grading can be used to ensure positive drainage. Pumped drainage may be necessary if a gravity outlet is not available.

**Borrow areas.** Any areas used for borrow for backfill operations should be reestablished to their proper uses in accordance with appropriate SCS standards.

**Environmental.** All disturbed areas shall be reshaped and regraded to blend with surrounding land features. Visual resources must be given the same consideration as other design features in planning, design, and installation. Exposed areas of earth shall be covered with soil materials and established with vegetation or protected by other means as soon as practicable. Access roads must be maintained and foot and vehicular traffic controlled to protect the work.

## **MAINTENANCE**

Sites must be monitored to determine the effectiveness of the backfilling. Surface treatment may be required to reduce the harmful effects of subsidence.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for subsidence treatment shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **LAND RECLAMATION, SUBSIDENCE TREATMENT SPECIFICATIONS**

### **FOUNDATION PREPARATION**

Access shall be carefully controlled to preclude accidents to machinery, equipment, and personnel. Mechanical impact devices shall be used to locate safe routes for machinery and hauling equipment if shown on the plans or if required in the contract documents.

The foundation shall be cleared of trees, brush, and other debris as necessary for construction operations. Wastes shall be disposed of at designated locations. All subsidence holes or other subsided areas shall be shaped to sizes and grades as specified.

### **EXCAVATION (DAYLIGHTING)**

This operation consists of removing the overburden to the mine tunnels and shafts and filling the mine voids with overburden excavation. The approximate extent of the mine voids area is shown in the plans. The actual extent will be determined during the excavation. All abandoned mining equipment found in the mine shall be disposed of as specified. The backfill shall be placed in lifts and compacted as specified. The surface area shall be left in a smooth condition suitable for placement of topsoil.

### **FILLING UNDERGROUND VOIDS**

Fill material shall be mine tailings, soil, fly ash, or other approved material. Materials shall be placed by pneumatic stowing. The system must be capable of placing materials 75 mm (3 in.) or smaller. The materials shall be placed to 80 percent of standard Proctor density. Water shall be added to control dust. If a soil cement seal is required, enough water shall be added to provide for proper soil cement sealing.

### **SURFACE TREATMENT**

Diversions, precision land forming, surface drains, and subsurface drains shall be installed according to the requirements shown in the plans.

### **PROTECTION**

Bare soil areas not to be farmed are to be protected by vegetation. Other materials may be used if soil and climatic conditions preclude the use of vegetation.

Appropriate safety measures shall be taken during and after construction. Such measures include warning signs, rescue facilities, gas-warning meters, fences, and mechanical impact testing.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff and ground water recharge.

### **Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff to surface and ground water.
2. Effects on the movement of dissolved substances to ground water.
3. Potential for uncovering or redistributing toxic materials that might cause undesirable effects on water or plants.
4. Short-term, construction, and maintenance effects on the quality of water resources.
5. Effects on wetlands or water-related wildlife habitats.
6. Effects on the visual quality of water resources.

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**LAND RECLAMATION**  
**TOXIC DISCHARGE CONTROL**  
(No.)  
**CODE 455**

**DEFINITION**

Control of acid or otherwise toxic aqueous discharge from abandoned mines or mine waste.

**SCOPE**

This standard applies to toxic discharges from areas that have been mined, either surface or subsurface, and is usually associated with land reconstruction (543).

**PURPOSE**

To improve water quality, eliminate unsightly residues and odors, reduce erosion, and restore areas to beneficial use.

**CONDITIONS WHERE PRACTICE APPLIES**

This standard applies to locations where acid or toxic drainage is degrading water quality and the environment in and adjacent to streams, lakes, reservoirs, or wetlands.

**PLANNING CONSIDERATIONS**

1. Geologic environment of the immediate area, including characteristics of overburden such as lithology, faults, joints, and attitude.
2. Surface and subsurface hydrologic conditions.
3. Mining history.
4. Land use.
5. Postmining history and conditions.
6. Topography.
7. Spatial and stratigraphic location of pyrites and other sulfides
8. Availability of limestone or other alkaline material.
9. Availability of blanketing materials.
10. Use of water.

**DESIGN CRITERIA**

There are four primary methods for controlling toxic mine drainage: (1) mine sealing, (2) infiltration control, (3) "daylighting," and (4) neutralization.

**Mine sealing.** This method is usually used to reduce the amount of water entering or to promote inundation by water of underground mine workings to reduce or prevent oxidation of pyritic materials.

In the locations where air and surface water enter underground mines, the measures used for Shaft and Adit Closing (452) or Subsidence Treatment (454) can be used. Other practices such as diversions or drains can be used to keep water from entrances. Reducing the amount of water entering the mine may solve the problem.

In the inundation process, physical barriers are constructed in a mine opening to prevent the escape of water. These seals must be designed to withstand maximum expected hydrostatic heads and be constructed of suitable materials such as masonry, concrete, grouted limestone, or clay. The double bulkhead grouted aggregate seal has been the most successful and appears capable of withstanding large amounts of water pressure—up to 10.7 m (35 ft) of head. Sealing mines to reduce acid mine drainage by constructing wet seals at the mouths of mine portal drainways, which provides air locks while allowing water to discharge, has been tried in the past with little success.

**Infiltration control.** This method is designed to reduce the amount of water entering toxic surface materials. Gob piles and cast overburden can be reshaped for better surface drainage and blanketed with compacted, slowly permeable soil materials to deter infiltration. An intensive water disposal system is required to prevent soil materials to deter infiltration. An intensive water disposal system is required to prevent erosion into the toxic material. Terraces, underground outlets, lined waterways, and grade stabilization structures are typically used. All surfaces should be left with positive grades to the water disposal system. Diversions may be used to reduce outside overflow. Blanketing with pulverized limestone before topsoiling and revegetating may increase the pH of the infiltrate, which inhibits the growth of *Ferrobacillus-Thiobacillus* organisms, thereby greatly reducing acid formation. Surface soils should be treated as necessary to promote a healthy root environment for planned vegetation.

**Daylighting.** This practice is surface mining the existing underground coal, selectively placing toxic materials, regrading and vegetating the area, and diverting water to natural drainageways. Daylighting has proved to be the most successful method of abating toxic mine drainage from abandoned underground mines to receiving streams. This method may work on surface mines if deeper coal seams are present that can be economically mined.

**Neutralization.** Acid or other toxic mine drainage water can be treated and neutralized by adding alkaline material to the mine drainage. By selecting the proper alkaline agent, many metal cations can be removed during neutralization as insoluble hydroxides. Several alkaline materials are available, such as hydrated lime (CaOH), caustic soda (NaOH), and limestone.

Alkaline mine drainage having relatively high pH—in excess of 6.5—and containing predominantly iron cations can be successfully treated by aeration or adding hydrogen peroxide.

Although most of the undesirable metal cations are removed during neutralization, the water still is considered hard and requires additional treatment for beneficial use. If a proper sludge-settling basin is provided after neutralization, the product water would not be detrimental to most fish and wildlife. Chemical treatment is the least desirable measure because of the long-term nature of the action and the excessive operation and maintenance costs involved.

SCS projects will normally involve only one-time treatment to permit discharge of ponded water where this will prevent the formation of more toxic water.

## **PROTECTION AND MAINTENANCE**

All disturbed areas shall be reshaped and regraded to blend with surrounding features. Visual resources must be considered in the planning, design, and installation of land reclamation projects. Exposed earth shall be covered with soil materials and established to vegetation or protected by other means. Access roads must be maintained and foot vehicular traffic controlled.

Sites must be monitored to determine the effectiveness of the work. Water sampling and pH readings should be taken at regular intervals until a steady state is established.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for toxic discharge control shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volume and rates of runoff, infiltration, evaporation, transpiration, deep percolation, flow through soil openings, and ground water recharge.
2. Variability of effects caused by seasonal and climatic conditions.
3. Effects of vegetation on soil moisture.
4. Effects on downstream flows or aquifers that would affect other water uses or users.
5. The effects of the potential changes on the established water regime on and near the site.
6. The effect on the water table of the area that could increase the hydraulic head sufficiently to force underground water to the surface in some less suitable site.

### **Quality**

1. Effects on erosion and the movement of sediment, pathogens, soluble and sediment attached substances, and other deleterious materials carried by runoff or translocated by seepage water.
2. Effects on the visual quality of onsite and downstream water resources.
3. Short-term and construction-related effects of this practice on the quality of downstream water.
4. Potential for uncovering or redistributing toxic and low productive soil material.
5. Effects on the movement of dissolved substances below the root zone toward ground water.
6. The effects on wetlands or water-related wildlife habitats.

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# **LAND RECONSTRUCTION, ABANDONED MINED LAND**

(ha, acre)  
**CODE 543**

## **DEFINITION**

Restoring land and water areas that are adversely affected by past mining practices and increasing the productivity of the areas for a beneficial use.

## **SCOPE**

The standard applies to the construction, grading, and reshaping of land that has been disturbed or adversely affected by past mining of all minerals and commodities.

## **PURPOSE**

To stabilize mined areas so that they can be used to support desirable vegetation; reduce erosion and sedimentation; enhance water quality or quantity; maintain and improve the visual quality of the landscape; and protect public health, safety, and general welfare.

## **CONDITIONS WHERE PRACTICE APPLIES**

Abandoned mined land that degrades the quality of the environment, prevents or interferes with the beneficial use of land or water resources, or endangers the health or safety of individuals.

## **PLANNING CONSIDERATIONS**

Evaluate the properties of the soils, including geologic and hydrogeologic values; the quantity and quality of water; and the potential of related resources to determine their suitability for use in reconstruction operations. Consider measures for placement of soils or spoil materials; location of access roads; potential for water disposal and impoundments; measures to enhance visual resources; provisions for controlling erosion and sedimentation; practices for eliminating public health or safety hazards; and suitability of the reclaimed land for its intended use.

Land reconstruction on abandoned mined lands shall include the components necessary to reclaim and stabilize the area and prevent further degradation of air, water, soil, and plant resources. The system may consist of one or two components or several. The land reclamation standards shall be used for those components such as fire control (451) and toxic discharge control (455). Traditional practices such as terraces, grade stabilization structures, and critical area treatment components shall be used also as appropriate.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

This practice is a management system that may combine practices to most conservation goals. Consult the planning considerations for water quantity and quality for the practices used in this system.

A special concern is the potential for uncovering or redistributing toxic materials from earth moving activities.

## DESIGN CRITERIA

**Site preparation.** Unsuitable soil material must be removed and buried so that it does not adversely affect water quality or plant growth. Boulders, other rocks, and similar materials shall be buried or otherwise placed where they do not interfere with water disposal practices, stabilization operations, and the planned use of the land. These materials must be disposed of in a manner that minimizes the potential for seepage which can pollute surface and ground water. Materials containing heavy metals must be buried to a depth below the root zone, or suitable kinds and amounts of soil amendments must be added.

**Removal and placement of material for final cover.** An effort should be made to reconstruct the soil with material available on site. If feasible, soil material suited to plant growth shall be salvaged, stockpiled, and protected for use as final cover material.

The reconstructed soil must meet the requirements for the specified land use on at least 80 percent of the area. The rest of the area must be in such a condition that it can be stabilized.

The salvaged material and other suitable materials must be spread over the graded areas to the depth specified in the reclamation plan. The final slope must permit application of needed conservation and management practices to keep soil losses at permissible levels. If settlement is likely to interfere with the planned use of the land, surface drainage, or water disposal, allowances must be made for the expected settlement during final grading.

**Protective measures in areas with highwalls and landslides.** Provisions must be made to reduce potential safety hazards and erosion and water pollution problems in areas that have highwalls and landslides. Treatment shall meet or exceed the requirements of SCS standards for landslide treatment (453) and highwall treatment (456) as appropriate.

**Water disposal.** The need for a water disposal system shall be carefully analyzed, and if needed, it shall be included in the design. The system must be intensive enough to control erosion during stabilization and after. If any practices are to be removed after vegetation is established, provisions must be made to promptly stabilize all disturbed areas. Water disposal systems suitable for erosion control on intensively farmed cropland are usually required for mine reclamation and may be used as a guide in the absence of local experience.

**Landscape resources.** The appearance of the reclaimed site must be in accordance with standards for maintaining and improving the visual quality of the landscape and must be compatible with the adjacent landscape. Areas of high public visibility or those offering direct or indirect human benefits shall be evaluated and considered in landscape resource management planning and design. Soil piles and borrow areas should be shaped to blend with the adjacent landscape.

**Establishment.** Due to the nature of mine reclamation work, it is not always possible to achieve complete stabilization with the first effort. Provisions should be made to promptly fill and vegetate areas of excessive settlement, repair and revegetate bare spots and eroded areas, add soil amendments or replace with suitable soil materials, add plant nutrients to achieve acceptable plant development, and install any additional structural measures needed, such as terraces, lined waterways, and grade stabilization structures.

**Restoration of borrow area.** If cover material is taken from an area outside the site, the borrow area must be graded and reshaped to insure proper drainage and must be revegetated to control erosion.

If the cover material is taken from adjacent farmland, the topsoil from the area must be stockpiled separately and then replaced after the land is restored for its intended purpose.

If the borrow area is prime farmland, the A and B horizons (or the B and C horizons if applicable) must be removed and stockpiled separately by horizon and then replaced on the borrow area in natural sequence. The combined thickness of the replaced horizons should be adequate to restore the original soil productivity.

**Maintenance.** A plan shall be prepared that provides specific details concerning maintenance and operation of conservation practices identified in the reclamation plan. The maintenance and operation plan should specify procedures for filling areas where settlement may adversely affect drainage and land use; promptly repairing and revegetating bare spots and eroded areas; adding soil amendments to soils that cannot support adequate vegetation or replacing them with suitable soil material; maintaining access roads; keeping drainage structures and channels clean and functional; applying fertilizer and lime; controlling weeds; using proper grazing practices; and controlling vehicular traffic.

## **SPECIFICATIONS GUIDE**

Areas to be graded shall be cleared of trees, logs, brush, rubbish, and other undesirable materials that can prevent proper application of the practice. These materials shall be disposed of in a manner that precludes interference with water disposal practices or the operations associated with the planned use of the land.

Materials suited to growing vegetation shall be stockpiled and protected for use as final cover. Vegetation that can be saved should be properly identified and protected. Temporary seeding, mulching, water disposal, and similar measures to help control erosion should be used as necessary.

Overhanging rocks and walls that are to be covered shall be sloped  $\frac{1}{2}$  to 1 before the soil is placed against the wall, unless a flatter slope is needed for stability. The area shall be shaped to the line and grade shown in the plans or as staked in the field. Unless otherwise specified, fill material shall be spread in successive layers not more than 0.6 m (2 ft) thick.

Boulders and other rocks shall be covered to the depth specified for the planned land use.

After major earthmoving is completed, the cover material should be spread over the surface. The work shall be finished according to the design and to the tolerances specified in the plans.

If borrow material from areas outside the reclamation site is used, these areas must be graded, reshaped, and left as specified or shown in the plans.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for reconstructing abandoned mined land shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# **LAND RECONSTRUCTION, CURRENTLY MINED LAND**

(ha, acre)  
**CODE 544**

## **DEFINITION**

Restoring currently mined land to an acceptable form and for a planned use.

## **SCOPE**

This standard applies to the identification, removal, stockpiling, and replacement of soil materials on currently mined land. It also applies to nearby areas that can be affected by the mining of various minerals or commodities.

## **PURPOSE**

To prevent permanent damage to soil and water resources in and near mined areas. To restore the productivity of soils to permit their premining use or a more intensive use. To control erosion, preserve the environment, maintain the visual quality of the landscape, and provide an economic use of the land.

## **CONDITIONS WHERE PRACTICE APPLIES**

Currently mined areas that will be adversely affected by mining practices.

## **PLANNING CONSIDERATIONS**

1. With use of a soil survey, evaluate soils significant to reconstruction operations and identify prime farmland.
2. Evaluate water and other related resources.
3. Consider locations for storage of soil material, access roads, and possible permanent impoundments.
4. Consider measures for placement of spoil, water disposal, replacement of soil material, restoration of soil productivity, and revegetation of disturbed areas.
5. Consider measures to maintain or enhance landscape resources.
6. Prepare a reclamation plan specifying required procedures for conducting reconstruction operations.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

This practice is a management system that may combine practices to most conservation goals. Consult the planning considerations for water quantity and quality for the practices used in this system.

A special concern is the potential for uncovering or redistributing toxic materials from earth moving activities.

## SPECIFICATIONS GUIDE

**Site preparation.** Areas shall be cleared of trees, logs, brush, rubbish, and other undesirable materials. Areas to be preserved, including those containing vegetation, stream corridors, natural springs, or other important features, shall be properly identified.

**Removal of material for soil reconstruction.** All upper soil horizons to be used in reconstructing the soil shall be removed from the immediate area before blasting, mining, or any surface disturbance other than removal of woody plants.

All of the A horizon shall be removed for use as surface soil on disturbed areas. If the A horizon is less than 15 cm (6 in) thick, material, other than bedrock, immediately below the A horizon can be removed and used to obtain this thickness. If the total thickness of the available material is less than 15 cm (6 in), all unconsolidated material can be used.

If the area is prime farmland or soil productivity consistent with that needed for postmining use is required, the B horizon or part of the C horizon or other underlying layers suitable for root development shall be removed and segregated for use as subsoil. The minimum depth of the soil and the soil material to be reconstructed shall be 122 cm (48 in) or equal to the depth of the subsurface horizon in the natural soil, whichever is less. If the natural soil is underlain by root-inhibiting layers, such as bedrock or a fragipan, depth can be the same as the original soil.

**Removal of overburden material for use as topsoil.** Selected overburden material can be substituted for or added to the material in the A and B horizons if it is demonstrated by field observations and chemical and physical laboratory analyses that the overburden material or the overburden and topsoil mixture is better suited to use in restoring the capability and productivity of the land than the material originally in the A and B horizons. Analyses can include determination of pH value; sulfide content; percentage of organic material; nitrogen, phosphorus, and potassium contents; texture; and available water capacity. Field-site trials or greenhouse tests may be needed to ascertain the feasibility of using overburden material.

If it is determined that the overburden material is suitable, it must be removed, segregated, and replaced according to the requirements specified in this standard.

**Storage of soil material.** If it is impractical to spread the material immediately after the land is regraded, it must be stockpiled. Stockpiles shall be selectively located and protected against wind and water erosion, unnecessary compaction, and contamination by undesirable materials. Planting an effective vegetative cover or using other suitable practices can provide adequate protection.

**Replacement of soil material.** Before spreading topsoil, the regraded areas must be scarified or otherwise treated to eliminate slippage surfaces and to promote root penetration. Topsoil shall be spread in a manner that:

1. Insures that the position and thickness of each horizon is equivalent to those in the undisturbed soil.
2. Prevents excess compaction. The bulk density of the reconstructed soil when moist must permit the soil to support plant growth at a level equivalent to that of a similar layer in undisturbed soil.
3. Protects the topsoil against wind and water erosion before it is seeded and planted.

Nutrients and soil amendments. After the topsoil has been spread on the disturbed areas, nutrients and soil amendments shall be applied according to the needs determined by soil tests.

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# **LAND SMOOTHING**

(Acre)  
CODE 466

## **DEFINITION**

Removing irregularities on the land surface by use of special equipment.

## **SCOPE**

This practice applies to operations classed as rough grading. Ordinarily, this does not require a complete grid survey. It does not apply to the "floating" done as a regular maintenance practice on irrigated land or the "planning" done as the final step in Precision Land Forming (462) or in Irrigation Land Leveling (464).

## **PURPOSE**

Improve surface drainage, provide for more effective use of precipitation, obtain more uniform planting depths, provide for more uniform cultivation, improve equipment operation and efficiency, improve terrace alinement, and facilitate contour cultivation.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies on areas where depressions, mounds, old terraces, turn rows, and other surface irregularities interfere with the application of needed soil and water conservation and management practices.

It is limited to areas having adequate soil depth or where topsoil can be salvaged and replaced.

## **DESIGN CRITERIA**

The extent of rough grading required and tolerances of the finished smoothing job shall be in keeping with the requirements of the planned cropping system.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for land smoothing shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **LAND SMOOTHING SPECIFICATIONS**

Construction operations shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.

The land to be smoothed shall be cleared of vegetative matter and trash.

Irregularities shall be smoothed to the degree required for the planned use and the requirements of subsequent tillage, floating, or planing to be performed.

Where possible, the ground surface should be plowed or disked prior to smoothing.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, and evaporation.
2. Potential for changes in plant growth and transpiration because of changes in the volume of soil water.

### **Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects on the use and management of nutrients and pesticides.
3. Effects on downstream water quality.
4. Potential for earth moving to uncover or redistribute toxic materials, such as saline soils.
5. Effects on the visual quality of downstream water resources.

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# LINED WATERWAY OR OUTLET

(ft)  
CODE 468

## DEFINITION

A waterway or outlet having an erosion-resistant lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

## SCOPE

This standard applies to waterways or outlets having linings of nonreinforced, cast in-place concrete; flagstone mortared in place; rock riprap; or similar permanent linings. It does not apply to irrigation water conveyance, grassed waterways with stone centers or small lined sections to carry prolonged low flows. The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft<sup>3</sup>/s.

## PURPOSE

To provide for safe disposal of runoff from other conservation structures or from natural concentrations of flow, without damage by erosion or flooding, where unlined or grassed waterways would be inadequate. Properly designed linings may also control seepage, piping, and sloughing or slides.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies if the following or similar conditions exist:

1. Concentrated runoff is of such that a lining is needed to control erosion.
2. Steep grades, wetness, prolonged base flow, seepage, or piping would cause erosion.
3. The location is of such that use by people or animals preclude use of vegetated waterways or outlets.
4. High-value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.
5. Soils are highly erosive or other soil or climatic conditions preclude using vegetation.
6. Installation of nonreinforced concrete or mortared flagstone linings, shall be made only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

## DESIGN CRITERIA

**Capacity.** The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year frequency storm. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish.....	0.012 -.014
Float finish.....	.013 -.017
Gunit.....	.016 -.022
Flagstone.....	.020 -.025
Riprap.....	Determine from figure 1

**Velocity.** Maximum design velocity shall be as shown in figure 2. Except for short transition sections, flow in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical shall be restricted to straight reaches.

Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical.

**Cross section.** The cross section shall be triangular, parabolic, or trapezoidal. Cross section made of monolithic concrete may be rectangular.

**Freeboard.** The minimum freeboard for lined waterways or outlets shall be 0.25 ft above design high water in areas where erosion-resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required if vegetation can be grown and maintained.

**Side slope.** The steepest permissible side slopes, horizontal to vertical, shall be:  
Nonreinforced concrete:

Hand-placed, formed concrete

- Height of lining, 1.5 ft or less .....Vertical

Hand-placed screened concrete or mortared in place flagstone

- Height of lining, less than 2 ft .....1 to 1
- Height of lining, more than 2 ft .....2 to 1

Slip form concrete:

- Height of lining, less than 3 ft .....1 to 1

Rock riprap .....2 to 1

**Lining thickness.** Minimum lining thickness shall be:

Concrete.....4 in. (In most problem areas, minimum thickness shall be 5 in. with welded wire fabric reinforcing.)

Rock riprap.....Maximum stone size plus thickness of filter or bedding

Flagstone.....4 in., including mortar bed

**Related structures.** Side inlets, drop structures, and energy dissipators shall meet the hydraulic and structural requirements for the site.

**Filters or bedding.** Filters or bedding shall be used to prevent piping. Drains shall be used to reduce uplift pressure and to collect water, as required. Filters, bedding, and drains shall be designed according to SCS standards. Weep holes may be used with drains if needed.

**Concrete.** Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required. Specify a mix that can be certified as suitable to produce a minimum strength of at least 3,000 lb/in.<sup>2</sup>. Cement used shall be Portland cement, Types I, II, or if required, Types IV or V. Aggregate used shall have a maximum size of 1-1/2 in.

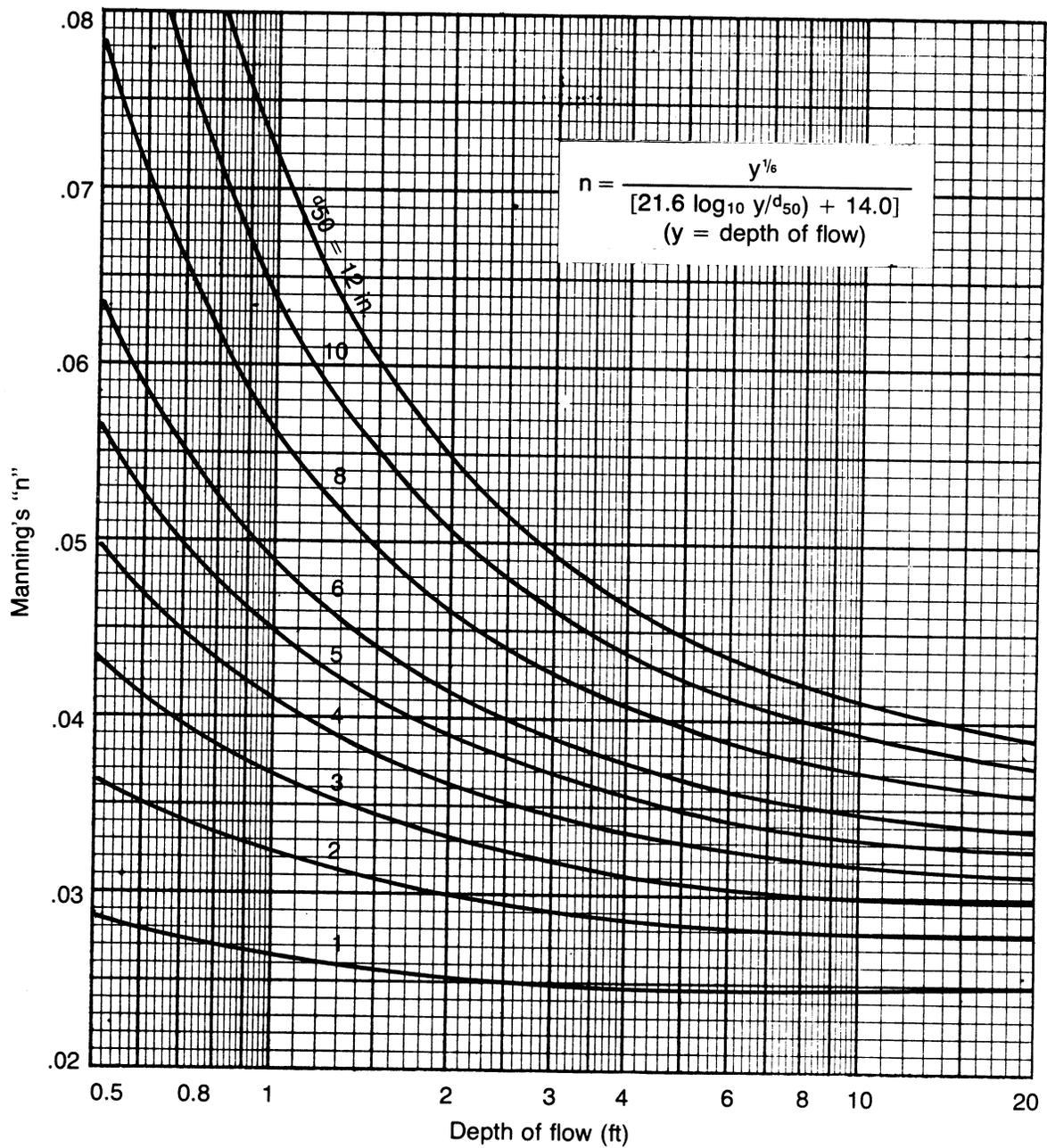


Figure 1.—Values of  $n$  for riprap-lined channels,  $d_{50}$  size vs depth of flow.

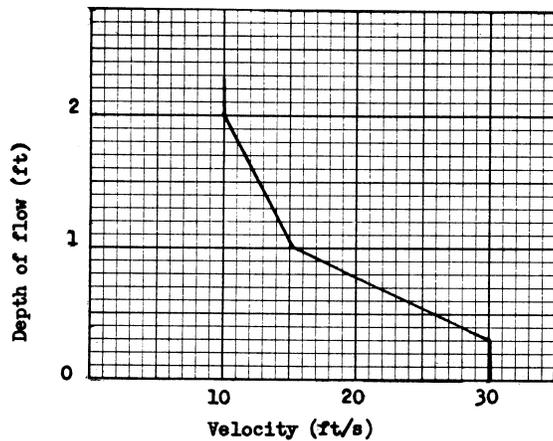


Figure 2.—Maximum velocity vs depth of flow.

**Mortar.** Mortar used for mortared in-place flagstone shall consist of a workable mix of cement, sand, and water with a water-cement ratio of not more than 6 gallons of water per bag of cement.

**Contraction joints.** Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 ft. Provide for uniform support to the joint to prevent unequal settlement.

**Rock riprap or flagstone.** Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking.

## MAINTENANCE.

Provisions must be made for timely maintenance to insure lined waterways function properly.

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing lined waterways or outlets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

## LINED WATERWAY OR OUTLET SPECIFICATIONS

The foundation area shall be cleared of trees, stumps, roots, sod, loose rock, or other objectionable material.

The cross section shall be excavated to the neat lines and grades as shown on the plans. Over excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alinement shall be permitted. Concrete linings shall be placed to the thickness shown on the plans and shall be finished in a workmanlike manner. Provisions shall be made to protect freshly placed concrete and to insure proper curing.

Filter, bedding, and rock riprap shall be placed to line and grade and in the manner specified. Riprap shall be placed so that it does not reduce the design section more than 10 percent.

Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within reasonable and legal limits. The completed job shall be workmanlike and present a good appearance. All disturbed areas shall be vegetated or otherwise provided with a cover to protect the areas against soil erosion.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of the practice's effect caused by seasonal and climatic changes.

### **Quality**

1. Filtering effects of vegetation on the movement of sediment and dissolved and sediment attached substances will be evaluated.
2. Effects on the visual quality of the water resources.
3. Short-term and construction-related effects on the quality of water resources.

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# MANURE TRANSFER

(No.)

## CODE 634DEFINITION

A manure conveyance system using structures, conduits, or equipment.

### PURPOSE

To transfer animal manure (bedding material, spilled feed, process and wash water, and other residues associated with animal production may be included) through a hopper or reception pit, a pump (if applicable), and a conduit to;  
a manure storage/treatment facility,

- A loading area, and
- To agricultural land for final utilization. This includes application of manure to the utilization area.

### CONDITIONS WHERE PRACTICE APPLIES

The manure transfer component is a part of a planned agricultural manure management system. Where manure is generated by livestock production or processing; and a conveyance system is necessary to transfer manure from the source to a storage/treatment facility and/or a loading area, and/or from storage/treatment to an area for utilization.

### CRITERIA

#### Criteria for all purposes

Manure transfer components shall comply with all federal, state, and local laws, rules and regulations.

Structures - All structures, including those which provide a work area around pumps, will be designed to withstand the anticipated static and dynamic loading. The structure shall withstand earth and hydrostatic loading in accordance with Practice Standard 313, Waste Storage Facility. The minimum thickness of component elements of concrete structures shall also be in accordance with Practice Standard 313. When needed, covers shall be designed to support the anticipated dead and live loads.

Reception pits shall be sized to contain one full days manure production. Openings to structures to receive manure from alley scrape collection shall be a minimum of 9 square feet with one dimension no smaller than 4 feet. The opening shall be equipped with a grate designed to support the anticipated loads.

When curbs are needed in conjunction with structures, they shall be constructed of either concrete or wood. Curbs shall be of sufficient height to insure total manure flow into the structure and be adequately anchored.

Pipelines - Design of pipelines shall be in accordance with Practice Standard 430, Irrigation Water Conveyance. The minimum pipeline capacity from collection facilities to storage/treatment facilities shall be the maximum flow anticipated on a daily basis. The minimum pipeline capacity from storage/treatment facilities to utilization areas shall insure the storage/treatment facilities can

be emptied within the time limits stated in the management plan for manure utilization. Pipelines shall be designed to have a minimum of 2 feet per second and a maximum of 6 feet per second velocity except where ruminant manure is transferred in a gravity system; in which case velocities can be reduced if a minimum of 5 feet of head is provided on the pipe system.

Clean-out access shall be provided for gravity pipelines at a maximum interval of 200 feet for lines carrying non-bedded manure. For pipelines carrying bedded manure the maximum interval shall be 150 feet. Gravity pipelines shall not have horizontal curves or bends except minor deflections (less than 10 degrees) in the pipe joints unless special design considerations are used.

Other Conduits - Concrete lined ditches shall be designed in accordance with Practice Standard 428A, Irrigation Water Conveyance-Non-reinforced Concrete Ditch and Canal Lining. A minimum design velocity of 1.5 feet per second shall be used.

Pumps - Pumps installed for manure transfer shall meet the requirements of Practice Standard 533, Pumping Plant for Water Control. Pumps shall be sized to transfer manure at required system head and volume. Type of pump shall be based on the consistency of manure. Consideration for pump installations shall be based on manufacturer's recommendations.

Safety - The system design shall consider the safety of humans and animals during construction and operation.

Open structures shall be provided with covers or barriers such as gates, fences, etc. Ventilation and warning signs shall be provided for manure transfer systems as necessary to warn of the danger of entry and to reduce the risk of explosion, poisoning, or asphyxiation.

Pipelines from enclosed buildings shall be provided with a water-sealed trap and vent or similar devices where necessary to control gas entry into buildings.

Gravity discharge pipes used for emptying a storage/treatment facility shall have a minimum of two gates or valves, one of which shall be manually operated.

Tractors or other vehicles used to tow manure spreaders or tank wagons shall be sized to reduce the danger of roll-over.

#### Criteria in support of the purpose of land application

Manure shall be applied to the utilization area in amounts and at a time consistent with the manure management plan and Practice Standard 633, Waste Utilization. Sprinklers or sprinkler systems shall be designed in accordance with Practice Standard 442, Irrigation System, Sprinkler. Sprinkler system design capacity shall be adequate to apply the required volume of manure at a rate and uniformity that shall prevent runoff and meet the nutrient needs of the plants. Nozzle size shall be appropriate for the consistency of the manure applied. Sprinkler applied, manure contaminated water, shall normally contain less than two percent solids unless provisions are made for straining or filtering before application. Manure spreaders and/or tank wagons shall have adequate capacity to insure the emptying of storage/treatment facilities within appropriate time periods as stated in the system operation and maintenance plan.

Gated pipe and other appurtenances used in conjunction with gravity application shall be designed to insure uniform application amounts.

## **CONSIDERATIONS**

Utilization of topography to generate head to reduce pumping requirements;

Economics (including design life), overall manure management system plans, and health and safety factors;

Possible contamination of domestic water systems and ground water;

Loading and unloading of equipment in the vicinity of the manure transfer components;

Subsurface conditions, i.e., depth to bedrock, water table, etc.;

When applicable, compatibility to joint use of manure transfer with irrigation system design requirements;

System for flushing pipelines with clean water;

Provisions for cleaning out solids deposition in ditches;

Pipe pressure rating adjustments required based on manure temperature.

Corrosion resistance and water tightness in the selection of pipe material and joints;

Need for appropriate check valves, anti-siphon protection and open air breaks;

Sanitation needs of all conveyance equipment that leaves the farm in order to prevent the spread of disease;

Potential for salt (struvite) deposits in smaller diameter pipe.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing manure transfer systems shall be in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **OPERATION AND MAINTENANCE**

Operation and maintenance shall be in accordance with the requirements specified in the overall operation and maintenance plan required by the applicable Practice Standard 313, Waste Storage Facility, or 359, Waste Treatment Lagoon.

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# MINE SHAFT AND ADIT CLOSING

(no.)  
CODE 457

## DEFINITION

Filling underground mines or closing exposed openings.

## PURPOSES

- To fill or seal mine shafts and other openings to reduce subsidence problems, hazards to humans and animals, the emission of hazardous gases, and the pollution of surface and ground water
- To close openings for human safety while maintaining access for wildlife species
- To close openings for the protection of cultural resources

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to locations where shafts, sinkholes, or adits of underground mines have been left open.

This practice may be associated with surface treatment to reclaim the area surrounding the mine opening.

## CRITERIA

### General criteria applicable to all purposes:

Gates or other closure techniques that optimize bat and other wildlife habitat must be considered where habitat or potential habitat exists. Enclosures, gates, and caps shall be used only where periodic inspection and maintenance is ensured through a maintenance agreement with a responsible government entity, landowner, or organization.

Closure of openings for protection of cultural resources shall meet the requirements of Enclosures and Gates or Designed Filling or Sealing, as appropriate.

Stockpiled soil or rock materials shall be protected from erosion until used.

### Design References:

Agricultural Engineering Note 1, January 1981, contains guidance on investigation, safety, design, and construction and is to be used as a procedural guide with this standard. Agricultural Engineering Note 1 was developed specifically for coal mines and all information does not apply to other types of mines

Guidance for enclosures and gates for bat conservation purposes is found in Bats and Mines by Merlin D. Tuttle and Daniel A.R. Taylor of Bat Conservation International, Inc., 12/94.

### Safety:

Teams consisting of a minimum two persons each are required to conduct searches for concealed shafts and adits, leaving their specific schedule with others. Safety barriers, ropes,

safety belts, gas detectors, and other equipment must be used as necessary during site reconnaissance, surveying, and foundation investigation activities.

If hazardous gas is present, safety precautions are to be taken as necessary for the site investigation and practice installation. Only persons experienced and trained in this activity are to provide guidance on measures to be taken.

During construction, a collapse zone shall be established, clearly marked with fencing and warning notices, and no person shall enter this zone without wearing proper safety equipment. Bumper blocks or other devices must be used to keep machinery and trucks from falling into shafts and subsidence pits. If possible, equipment blades and buckets shall be larger than the opening being filled.

At the completion of the closing, the shaft or adit location shall be marked and recorded to reduce the risk of future development over the shaft or adit.

**Additional Criteria for Enclosures and Gates:**

Enclosures or gates shall be used for the protection of wildlife habitat, such as bat roosting sites or where it is essential to occasionally enter or gain access to shafts or adits.

Enclosures or gates shall be made of steel, concrete, masonry, or "anti intruder" chain link and barbed wire fences or a combination of these materials. Enclosures or gates shall be constructed to keep unauthorized persons out and shall be located where subsidence or caving will not break their integrity.

**Additional Criteria for Designed Filling or Sealing:**

Shafts and adits shall be cleaned of all trash, debris, metal, timber, wire, and other materials that could hinder an effective design filling or sealing.

All materials removed shall be disposed of by burning or burying at approved sites or transported to approved landfills.

**a. Designed filling:**

Shafts or adits shall be filled to about 1.5 m (5 ft) from the surface with a properly designed filter consisting of nonacid-forming, free-draining materials.

The remainder of the shaft or adit shall be filled with random fill materials interspersed with layers of clay, approximately 0.6 m (2 ft) thick, or other impervious materials that would retard the passage of water or gas. Shaft openings shall be overfilled 10 percent of the depth of the shaft, or 1.5 m (5 ft), whichever is less to allow for settlement.

The finished surface of the filled shaft or adit shall be graded to provide free drainage away from the opening and vegetation established in accordance with NRCS standards.

Sinkholes that are the result of a mining process and are open, active, and/or passing a significant quantity of water require a properly designed filter of nonacid-forming, free-draining material. Sufficient soil covering shall be placed to sustain planned vegetation.

Sinkholes that are closed, inactive, and not passing a significant quantity of water shall require only backfilling with suitable soil material. The allowance made for settlement shall be 10 percent of the fill depth, and the area shall be overfilled accordingly.

**b. Sealing with Caps:**

Caps are constructed of reinforced concrete or steel beams and grates or solid steel plates to completely close shaft or adit openings.

Caps shall be designed with sufficient strength to support anticipated loads. The cap and fittings, access holes, and vent pipe shall be reasonably vandal proof. The surface of a cap over a shaft must be raised not less than 0.3 m (1 ft) above the surrounding terrain to provide good visibility and positive drainage away from the cap installation.

**c. Sealing with Plugs:**

Shafts shall be closed with plugs only if another practical solution is not available. Installed at substantial distances below the ground surface, plugs are used where the shaft is to be filled to the surface (see "Designed Filling"), but the shaft below is to remain open.

Plugs shall be constructed of reinforced concrete designed to support anticipated loads and shall be placed on firm bedrock. They may be designed to be watertight and gastight or to allow drainage and venting of gasses.

**d. Sealing with Barriers:**

Barriers are constructed to restrict humans and animals from entering adits, and may be used to prevent lateral spreading of backfill material and to support fill used to cover adit openings.

Barriers are constructed of stones, crushed rock, quarry run rock, gravel, shale, or similar nonacid-forming, free-draining materials.

The minimum length of the barrier shall be three times the maximum adit height or width within the barrier section, whichever is greatest.

Concrete or masonry wall may be used to support the barrier. Barriers not supported by concrete or masonry walls shall have 3 horizontal to 1 vertical or flatter slopes.

Barriers at the ground surface shall be covered with soil materials to a minimum vertical thickness of 1.2 m (4 ft) and vegetation established in accordance with NRCS standards.

If needed, a permanent drainage system using pipe or rock toes shall be installed through this covering. Traps to prevent air or gas passage may be necessary.

**e. Sealing with Dams:**

Dams are constructed to prevent water flow into or out of adits.

Dimensional requirements are those stated for barriers in the previous paragraph.

The fill shall be essentially watertight and designed to support anticipated structural and hydraulic loads.

**CONSIDERATIONS**

No special considerations have been identified for this practice.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for closing shafts and adits shall be in keeping with this standard and shall describe the requirements for applying the practice to the specific site to achieve its intended purpose or purposes.

## **OPERATION AND MAINTENANCE**

Restrictive barriers, fences, enclosures and caps are to be maintained to accomplish their purpose.

Maintenance is essential because of the strong likelihood of additional subsidence, water drainage, failure of vegetation, vandalism, and other problems associated with mine closures.

Regular inspections must take place and prompt repair and follow-up be carried out. Additional maintenance activities must be outlined in the maintenance plan.

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# **MOLE DRAIN**

(ft)  
**CODE 482**

## **DEFINITION**

An underground conduit constructed by pulling a bullet-shaped cylinder through the soil.

## **SCOPE**

This standard covers the requirements for the planning and the installation of a system of subsurface earthen channels and its facilitating and protective appurtenances.

## **PURPOSE**

To establish a system of subsurface channels for removal of trapped surface and subsurface water from land where the use of buried drains is physically or economically impractical to complete the drainage required.

## **CONDITIONS WHERE PRACTICE APPLIES**

Mole drains may be used in hayland and cropland in highly cohesive or fibrous soils that are free of stones, gravel, or sand lenses if the area served is small and if an outlet is available or can be constructed to provide continuously free outfall from the drains. They may also be used as a supplement to other drains.

## **DESIGN CRITERIA**

Mole drains shall be installed according to an approved plan, or as modified by an authorized technician at the site.

The location, grade, length of line, depth, spacing and size of drains, and the outlet protection for such drains shall meet requirements of Section 16, Soil Conservation Service National Engineering Handbook, or as modified by approved local drainage guides.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing mole drains shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on runoff, infiltration, deep percolation, and potential ground water recharge.
2. Effects of increased drainage waters on downstream baseflow.

### **Quality**

1. Effects of increase in dissolved substances that may be discharged to streams.
2. Effects on aquifer recharge water quality.

3. Reduction in the yields of sediment or sediment-attached substances, and effects on downstream water quality and water use.
4. Downstream temperature changes.
5. Effects on the visual quality of downstream waters.

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# MULCHING

(acre)  
CODE 484

## DEFINITION

Applying plant residues or other suitable materials not produced on the site to the soil surface.

## PURPOSE

To conserve moisture; prevent surface compaction or crusting; reduce runoff and erosion; control weeds; and help establish plant cover.

## CONDITIONS WHERE PRACTICE APPLIES

On soils subject to erosion on which low-residue-producing crops, such as grapes and small fruits, are grown; on critical areas; and on soils that have a low infiltration rate.

## SPECIFICATIONS GUIDE

Amount of mulch and the type of management needed under different conditions.

## PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

### Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, and transpiration.
2. Variability of the practice's effects caused by seasonal weather variations.
3. Effects of increased cover on soil moisture.
4. Potential for changes in plant growth and transpiration because of changes in the soil water volume.

### Quality

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects on the visual quality of downstream water resources.

## EFFICIENCIES

Use of vegetative and mulching measures has shown a high reduction of sedimentary soil erosion. An average sediment reduction of about 80 to 90% in a review of over 20 field test plot studies of hydroseeding and various mulches on construction site soils in 1990 (Brown and Caraco, 1997). A 99% reduction in suspended solids load was reported with establishing a grass cover (Lee and Skogergboe, 1985). The grass cover increased the biomass of the test area from 0 to 2464 lb/ac (Lee and Skogergboe, 1985).

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# **NUTRIENT MANAGEMENT**

(Acre)  
CODE 590

## **DEFINITION**

Managing the amount, source, placement, form and timing of the application of nutrients and soil amendments.

## **PURPOSES**

- To budget and supply nutrients for plant production.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To minimize agricultural nonpoint source pollution of surface and ground water resources.
- To maintain or improve the physical, chemical and biological condition of soil.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all lands where plant nutrients and soil amendments are applied.

## **CRITERIA**

### **General Criteria Applicable to All Purposes**

Plans for nutrient management shall comply with all applicable Federal, state, and local laws and regulations.

Plans for nutrient management shall be developed in accordance with policy requirements of the NRCS General Manual Title 450, Part 401.03 (Technical Guides, Policy and Responsibilities) and Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy); technical requirements of the NRCS Field Office Technical Guide (FOTG); procedures contained in the National Planning Procedures Handbook (NPPH), and the NRCS National Agronomy Manual (NAM) Section 503.

Persons who review or approve plans for nutrient management shall be certified through any certification program acceptable to NRCS within the state.

Plans for nutrient management that are elements of a more comprehensive conservation plan shall recognize other requirements of the conservation plan and be compatible with its other requirements.

A nutrient budget for nitrogen, phosphorus, and potassium shall be developed that considers all potential sources of nutrients including, but not limited to animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water.

Realistic yield goals shall be established based on soil productivity information, historical yield data, climatic conditions, level of management and/or local research on similar soil, cropping systems, and soil and manure/organic by-products tests. For new crops or varieties, industry yield recommendations may be used until documented yield information is available.

Plans for nutrient management shall specify the form, source, amount, timing and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and/or phosphorus movement to surface and/or ground waters.

Erosion, runoff, and water management controls shall be installed, as needed, on fields that receive nutrients.

### **Soil Sampling and Laboratory Analysis (Testing)**

Nutrient planning shall be based on current soil test results developed in accordance with Land Grant University guidance or industry practice if recognized by the Land Grant University. Current soil tests are those that are no older than five years.

Soil samples shall be collected and prepared according to the Land Grant University guidance or standard industry practice. Soil test analyses shall be performed by laboratories that are accepted in one or more of the following programs:

- State Certified Programs,
- The North American Proficiency Testing Program (Soil Science Society of America), or
- Laboratories whose tests are accepted by the Land Grant University in the state in which the tests will be used.

Soil testing shall include analysis for any nutrients for which specific information is needed to develop the nutrient plan. Request analyses pertinent to monitoring or amending the annual nutrient budget, e.g. pH, electrical conductivity (EC), soil organic matter, nitrogen, phosphorus, and potassium.

### **Plant Tissue Testing**

Tissue sampling and testing, where used, shall be done in accordance with Land Grant University standards or recommendations.

### **Nutrient Application Rates**

Soil amendments shall be applied, as needed, to adjust soil pH to the specific range of the crop for optimum availability and utilization of nutrients.

Recommended nutrient application rates shall be based on Land Grant University recommendations (and/or industry practice when recognized by the university) that consider current soil test results, realistic yield goals and management capabilities. If the Land Grant University does not provide specific recommendations, application shall be based on realistic yield goals and associated plant nutrient uptake rates.

The planned rates of nutrient application, as documented in the nutrient budget, shall be determined based on the following guidance:

- **Nitrogen Application** - Planned nitrogen application rates shall match the recommended rates as closely as possible, except when manure or other organic by-products are a source of nutrients. When manure or other organic by-products are a source of nutrients, see "Additional Criteria" below.
- **Phosphorus Application** - Planned phosphorus application rates shall match the recommended rates as closely as possible, except when manure or other organic by-products are a source of nutrients. When manure or other organic by-products are a source of nutrients, see "Additional Criteria" below.
- **Potassium Application** - Excess potassium shall not be applied in situations in which it causes unacceptable nutrient imbalances in crops or forages. When forage quality is an

- issue associated with excess potassium application, state standards shall be used to set forage quality guidelines.
- **Other Plant Nutrients** - The planned rates of application of other nutrients shall be consistent with Land Grant University guidance or industry practice if recognized by the Land Grant University in the state.
  - **Starter Fertilizers** - Starter fertilizers containing nitrogen, phosphorus and potassium may be applied in accordance with Land Grant University recommendations, or industry practice if recognized by the Land Grant University within the state. When starter fertilizers are used, they shall be included in the nutrient budget.

### **Nutrient Application Timing**

Timing and method of nutrient application shall correspond as closely as possible with plant nutrient uptake characteristics, while considering cropping system limitations, weather and climatic conditions, and field accessibility.

### **Nutrient Application Methods**

Nutrients shall not be applied to frozen, snow-covered, or saturated soil if the potential risk for runoff exists.

Nutrient applications associated with irrigation systems shall be applied in accordance with the requirements of Irrigation Water Management (Code 449).

### **Additional Criteria Applicable to Manure or Organic By-Products Applied as a Plant Nutrient Source**

Nutrient values of manure and organic by-products (excluding sewage sludge) shall be determined prior to land application based on laboratory analysis, acceptable "book values" recognized by the NRCS and/or the Land Grant University, or historic records for the operation, if they accurately estimate the nutrient content of the material. Book values recognized by NRCS may be found in the Agricultural Waste Management Field Handbook, Chapter 4 - Agricultural Waste Characteristics.

### **Nutrient Application Rates**

The application rate (in/hr) for material applied through irrigation shall not exceed the soil intake/infiltration rate. The total application shall not exceed the field capacity of the soil.

The planned rates of nitrogen and phosphorus application recorded in the plan shall be determined based on the following guidance:

- **Nitrogen Application** - When the plan is being implemented on a phosphorus standard, manure or other organic by-products shall be applied at rates consistent with the phosphorus standard. In such situations, an additional nitrogen application, from non-organic sources, may be required to supply the recommended amounts of nitrogen.

Manure or other organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass.

- **Phosphorus Application** - When manure or other organic by-products are used, the planned rates of phosphorus application shall be consistent with any one of the following options:

- **Phosphorus Index (PI) Rating.** Nitrogen based manure application on Low or Medium Risk Sites, phosphorus based or no manure application on High and Very High Risk Sites.\*\*
- **Soil Phosphorus Threshold Values.** Nitrogen based manure application on sites on which the soil test phosphorus levels are below the threshold values. Phosphorus based or no manure application on sites on which soil phosphorus levels equal or exceed threshold values.\*\*
- **Soil Test.** Nitrogen based manure application on sites on which there is a soil test recommendation to apply phosphorus. Phosphorus based or no manure application on sites on which there is no soil test recommendation to apply phosphorus.\*\*

\*\* Acceptable phosphorus based manure application rates shall be determined as a function of soil test recommendation or estimated phosphorus removal in harvested plant biomass. Guidance for developing these acceptable rates is found in the NRCS General Manual, Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy), and the National Agronomy Manual, Section 503.

A single application of phosphorus applied as manure may be made at a rate equal to the recommended phosphorus application or estimated phosphorus removal in harvested plant biomass for the crop rotation or multiple years in the crop sequence.

When such applications are made, the application rate shall:

- not exceed the recommended nitrogen application rate during the year of application, or
- not exceed the estimated nitrogen removal in harvested plant biomass during the year of application when there is no recommended nitrogen application.
- not be made on sites considered vulnerable to off-site phosphorus transport unless appropriate conservation practices, best management practices, or management activities are used to reduce the vulnerability.

### **Field Risk Assessment**

When animal manures or other organic by-products are applied, a field-specific assessment of the potential for phosphorus transport from the field shall be completed. This assessment may be done using the Phosphorus Index or other recognized assessment tool. In such cases, plans shall include:

- a record of the assessment rating for each field or sub-field, and
- information about conservation practices and management activities that can reduce the potential for phosphorus movement from the site.

When such assessments are done, the results of the assessment and recommendations shall be discussed with the producer during the development of the plan.

### **Heavy Metals Monitoring**

When sewage sludge is applied, the accumulation of potential pollutants (including arsenic, cadmium, copper, lead, mercury, selenium, and zinc) in the soil shall be monitored in accordance with the US Code, Reference 40 CFR, Parts 403 and 503, and/or any applicable state and local laws or regulations.

### **Additional Criteria to Minimize Agricultural Non-point Source Pollution of Surface and Ground Water Resources**

In areas with an identified or designated nutrient-related water quality impairment, an assessment shall be completed of the potential for nitrogen and/or phosphorus transport from the field. The Leaching Index (LI) and/or Phosphorus Index (PI), or other recognized assessment tools, may be used to make these assessments. The results of these assessments and recommendations shall be discussed with the producer and included in the plan.

Plans developed to minimize agricultural nonpoint source pollution of surface or ground water resources shall include practices and/or management activities that can reduce the risk of nitrogen or phosphorus movement from the field.

### **Additional Criteria to Improve the Physical, Chemical, and Biological Condition of the Soil.**

Nutrients shall be applied in such a manner as not to degrade the soil's structure, chemical properties, or biological condition. Use of nutrient sources with high salt content will be minimized unless provisions are used to leach salts below the crop root zone.

Nutrients shall not be applied to flooded or saturated soils when the potential for soil compaction and creation of ruts is high.

## **CONSIDERATIONS**

Consider induced deficiencies of nutrients due to excessive levels of other nutrients.

Consider additional practices such as Conservation Cover (327), Grassed Waterway (412), Contour Buffer Strips (332), Filter Strips (393), Irrigation Water Management (449), Riparian Forest Buffer (391A), Conservation Crop Rotation (328), Cover and Green Manure (340), and Residue Management (329A, 329B, or 329C, and 344) to improve soil nutrient and water storage, infiltration, aeration, tillage, diversity of soil organisms and to protect or improve water quality.

Consider cover crops whenever possible to utilize and recycle residual nitrogen.

Consider application methods and timing that reduce the risk of nutrients being transported to ground and surface waters, or into the atmosphere. Suggestions include:

- split applications of nitrogen to provide nutrients at the times of maximum crop utilization,
- avoiding winter nutrient application for spring seeded crops,
- band applications of phosphorus near the seed row,
- applying nutrient materials uniformly to application areas or as prescribed by precision agricultural techniques, and/or
- immediate incorporation of land applied manures or organic by-products,
- delaying field application of animal manures or other organic by-products if precipitation capable of producing runoff and erosion is forecast within 24 hours of the time of the planned application.

Consider minimum application setback distances from environmentally sensitive areas, such as sinkholes, wells, gullies, ditches, surface inlets or rapidly permeable soil areas.

Consider the potential problems from odors associated with the land application of animal manures, especially when applied near or upwind of residences.

Consider nitrogen volatilization losses associated with the land application of animal manures. Volatilization losses can become significant, if manure is not immediately incorporated into the soil after application.

Consider the potential to affect National Register listed or eligible cultural resources.

Consider using soil test information no older than one year when developing new plans, particularly if animal manures are to be a nutrient source.

Consider annual reviews to determine if changes in the nutrient budget are desirable (or needed) for the next planned crop.

On sites on which there are special environmental concerns, consider other sampling techniques. (For example: Soil profile sampling for nitrogen, Pre-Sidedress Nitrogen Test (PSNT), Pre-Plant Soil Nitrate Test (PPSN) or soil surface sampling for phosphorus accumulation or pH changes.)

Consider ways to modify the chemistry of animal manure, including modification of the animal's diet to reduce the manure nutrient content, to enhance the producer's ability to manage manure effectively.

## **PLANS AND SPECIFICATIONS**

Plans and specifications shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s), using nutrients to achieve production goals and to prevent or minimize water quality impairment.

The following components shall be included in the nutrient management plan:

- aerial photograph or map and a soil map of the site,
- current and/or planned plant production sequence or crop rotation,
- results of soil, plant, water, manure or organic by-product sample analyses,
- realistic yield goals for the crops in the rotation,
- quantification of all nutrient sources,
- recommended nutrient rates, timing, form, and method of application and incorporation,
- location of designated sensitive areas or resources and the associated, nutrient management restriction,
- guidance for implementation, operation, maintenance, recordkeeping, and
- complete nutrient budget for nitrogen, phosphorus, and potassium for the rotation or crop sequence.

If increases in soil phosphorus levels are expected, plans shall document:the soil

- phosphorus levels at which it may be desirable to convert to phosphorus based implementation,
- the relationship between soil phosphorus levels and potential for phosphorus transport from the field, and
- the potential for soil phosphorus drawdown from the production and harvesting of crops.

When applicable, plans shall include other practices or management activities as determined by specific regulation, program requirements, or producer goals.

In addition to the requirements described above, plans for nutrient management shall also include:

- discussion about the relationship between nitrogen and phosphorus transport and water quality impairment. The discussion about nitrogen should include information about nitrogen leaching into shallow ground water and potential health impacts. The discussion about phosphorus should include information about phosphorus accumulation in the soil, the increased potential for phosphorus transport in soluble form, and the types of water

- quality impairment that could result from phosphorus movement into surface water bodies.
- discussion about how the plan is intended to prevent the nutrients (nitrogen and phosphorus) supplied for production purposes from contributing to water quality impairment.
  - a statement that the plan was developed based on the requirements of the current standard and any applicable Federal, state, or local regulations or policies; and that changes in any of these requirements may necessitate a revision of the plan.

## **OPERATION AND MAINTENANCE**

The owner/client is responsible for safe operation and maintenance of this practice including all equipment. Operation and maintenance addresses the following:

- periodic plan review to determine if adjustments or modifications to the plan are needed. As a minimum, plans will be reviewed and revised with each soil test cycle.
- protection of fertilizer and organic by-product storage facilities from weather and accidental leakage or spillage.
- calibration of application equipment to ensure uniform distribution of material at planned rates.
- documentation of the actual rate at which nutrients were applied. When the actual rates used differ from or exceed the recommended and planned rates, records will indicate the reasons for the differences.
- Maintaining records to document plan implementation. As applicable, records include:
  - soil test results and recommendations for nutrient application,
  - quantities, analyses and sources of nutrients applied,
  - dates and method of nutrient applications,
  - crops planted, planting and harvest dates, yields, and crop residues removed,
  - results of water, plant, and organic by-product analyses, and
  - dates of review and person performing the review, and recommendations that resulted from the review.

Records should be maintained for five years; or for a period longer than five years if required by other Federal, state, or local ordinances, or program or contract requirements.

Workers should be protected from and avoid unnecessary contact with chemical fertilizers and organic by-products. Protection should include the use of protective clothing when working with plant nutrients. Extra caution must be taken when handling ammonia sources of nutrients, or when dealing with organic wastes stored in unventilated enclosures.

The disposal of material generated by the cleaning nutrient application equipment should be accomplished properly. Excess material should be collected and stored or field applied in an appropriate manner. Excess material should not be applied on areas of high potential risk for runoff and leaching.

The disposal or recycling of nutrient containers should be done according to state and local guidelines or regulations.

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# **OBSTRUCTION REMOVAL**

(acre)  
**CODE 500**

## **DEFINITION**

Removal and disposal of unwanted, unsightly or hazardous buildings, structures, vegetation, landscape features, trash, and other materials.

## **PURPOSE**

To safely remove and dispose of unwanted obstructions and materials in order to apply conservation practices or facilitate planned use of abandoned mine lands, farms, ranches, construction sites, and recreation areas.

## **SCOPE**

This standard applies to removal and disposal of all types of obstructions and materials that prevent or hinder installation of conservation practices or present a hazard to their use and enjoyment.

## **CONDITIONS WHERE PRACTICE APPLIES**

On land where existing obstructions interfere with planned use and development.

## **DESIGN CRITERIA**

Rock piles, boulders, stones, fences, hedge rows, abandoned buildings and structures, trash, and similar obstruction that would interfere with planned use and development shall be removed. All debris such as broken concrete and masonry, structural steel and wood, stones, stumps, slash, and sterile or toxic soil material shall be disposed of so that they will not impede subsequent work or cause damage to offsite or other areas. Disposal shall be by burning, burying, or removing to an approved land fill in an environmentally acceptable manner. All required gully shaping shall be performed to specified dimensions and grades. Gully fills shall be compacted to the required density. The cover over buried materials shall be designed to be adequate for the planned use, treatment, and vegetation. Historical or archaeological significant and scenic values shall be identified and preserved as appropriate.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for obstructions removal shall be in keeping with this standard and shall describe the requirements for applying and achieving the practice purpose.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects upon components of the water budget, especially effects on volume and rate of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

### **Quality**

1. Effects on the visual quality or downstream water resources.
2. Short-term and construction-related effects on the quality of water resources.
3. Potential uncovering or redistributing toxic materials such as saline soils.

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# OPEN CHANNEL

(ft)  
CODE 582

## DEFINITION

Constructing or improving a channel either natural or artificial, in which water flows with a free surface.

## SCOPE

This standard applies to construction of open channels or modifications of existing streams or ditches. Design criteria for channel stability and maintenance of Floodwater Diversions (400), Floodways (404), or Surface Drainage, Main or Lateral (608), having a drainage area in excess of 1 mi<sup>2</sup> (1.6 km<sup>2</sup>) shall be in accord with this standard for open channels. It does not apply to Diversions (362), Grassed Waterways (412), Irrigation Field Ditches (388), Surface Drainage, Field Ditches (607), or Irrigation Canals or Laterals (320).

## PURPOSE

To provide discharge capacity required for flood prevention, drainage, other authorized water management purposes, or any combination of these purposes.

## CONDITIONS WHERE PRACTICE APPLIES

This standard applies to all earth channel construction or modification except as noted under "Scope."

It also applies where stability requirements can be met, where the impact of the proposed construction on water quality, fish and wildlife habitat, forest resources, and quality of the landscape is evaluated and the techniques and measures necessary to overcome the undesirable effects are made part of any planned work, where an adequate outlet for the modified channel reach is available for discharge by gravity flow or pumping, and where excavation or other channel work does not cause significant erosion, flooding, or sedimentation.

## DESIGN CRITERIA

**Plan.** Channel construction or modification shall be according to an approved plan prepared for the site. TR-25 shall be used in surveys, planning, and site investigations for channel work. Design criteria in TR-25 shall be followed, using the procedure best adapted to site conditions. In selecting the location and design of channels, careful consideration shall be given to minimizing water pollution, damage to fish and wildlife habitat, and to protecting forest resources and the quality of the landscape. In considering requirements for construction and operation and maintenance, selected woody plants must be preserved. The overall landscape character, prominent views, and fish and wildlife habitat requirements must be considered.

Planned measures necessary to mitigate unavoidable losses to fish or wildlife habitat shall be included in the project. The quality of the landscape shall be maintained by both the location of channel works and plantings, as appropriate.

The alignment of channels undergoing modifications shall not be changed to the extent that the stability of the channel or laterals thereto is endangered.

**Capacity.** The capacity for open channels shall be determined according to procedures applicable to the purposes to be served and according to related engineering standards and guidelines in handbooks. The water surface profile or hydraulic gradeline for design flow shall be determined according to guidelines for hydraulic design in TR-25. The n value for aged channels shall be based on the expected vegetation, along with other retardance factors, considering the level of maintenance prescribed in the operation and maintenance plan prepared with the owners or sponsors. The required capacity may be established by considering volume-duration removal rates, peak flow, or a combination of the two, as determined by the topography, purpose of the channel, desired level of protection, and economic feasibility.

**Cross section.** The required channel cross section and grade shall be determined by the plan objectives, the design capacity, the materials in which the channel is to be constructed, the vegetative establishment program, and the requirements for operation and maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. Urban and other high-value developments through which the channel is to be constructed must be considered in the design of the channel section.

**Channel stability.** Characteristics of a stable channel are:

1. The channel neither aggrades nor degrades beyond tolerable limits.
2. The channel banks do not erode to the extent that the channel cross section is changed appreciably.
3. Excessive sediment bars do not develop.
4. Gullies do not form or enlarge because of the entry of uncontrolled surface flow to the channel.

All channel construction and modification (including clearing and snagging) shall be according to a design that can be expected to result in a stable channel that can be maintained at reasonable cost. Vegetation, riprap, revetments, linings, structures, or other measures shall be used if necessary to insure stability.

The method applicable to site channel in TR-25 shall be used in determining the stability of proposed channel improvements.

Bankfull flow is the flow in a channel that creates a water surface at or near the normal ground elevation, or the tops of dikes or continuous spoil banks that confine the flow for a significant length of a channel reach.

Channels must be stable under conditions existing immediately after construction (as-built condition) and under conditions existing during effective design life (aged condition). Channel stability shall be determined for discharges under these conditions as follows:

1. As-built condition – Bankfull flow, design discharge, or 10-year frequency flow, whichever is smallest, but not less than 50 percent of design discharge.

The allowable as-built velocity (regardless of type of stability analysis) in the newly constructed channel may be increased by a maximum of 20 percent if:

- a. The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion-controlling vegetation,
- b. Species of erosion-controlling vegetation adapted to the area and proven methods of establishment are known, and
- c. The channel design includes detailed plans for establishing vegetation on the channel side slopes.

2. Aged condition – Bankfull flow or design discharge, whichever is larger, except that it is not necessary to check stability for discharge greater than the 100-year frequency.

Stability checks that are flow related are not required if the velocity is 2 ft/s (0.6 m/s) or less. For newly constructed channels in fine-grained soils and sands, the *n* values shall be determined according to procedures in chapter 6 of TR-25, and shall not exceed 0.025. The *n* value for channels to be modified by clearing and snagging only shall be determined by reaches according to the expected channel condition upon completion of the work.

**Appurtenant structures.** The channel design shall include all structures required for proper functioning of the channel and its laterals, as well as travelways for operation and maintenance. Inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the channel design. The design also shall provide for necessary flood gates, water-level-control devices, bays used in connection with pumping plants, and any other appurtenances essential to the functioning of channels and contributing to attainment of the purposes for which they are built. If needed, protective structures or treatment shall be used at junctions between channels to insure stability at these critical locations.

The effect of channel work on existing culverts, bridges, buried cables, pipelines, irrigation flumes, and inlet structures for surface and subsurface drainage on the channel and laterals thereto shall be evaluated to determine the need for modification or replacement.

Culverts and bridges that are modified or added as part of channel projects shall meet reasonable standards for the type of structure and shall have a minimum capacity equal to the design discharge of state agency design requirements, whichever is greater. Capacity of some culverts and bridges may need to be increased above the design discharge.

**Disposition of spoil.** Spoil material from clearing, grubbing, and channel excavation shall be disposed of in a manner that will:

1. Not confine or direct flows so as to cause instability when the discharge is greater than the bankfull flow.
2. Provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed.
3. Not hinder the development of travelways for maintenance.
4. Leave the right-of-way in the best condition feasible, consistent with the project purposes and adjacent land uses.
5. Direct water accumulating on or behind spoil areas to protected outlets.
6. Maintain or improve the visual quality of the site to the extent feasible.

**Vegetation of channel.** Vegetation shall be established on all channel slopes, berms, spoil, and other disturbed areas according to the SCS standard for Channel Vegetation (322).

## OPERATION AND MAINTENANCE

**Plan.** An operation and maintenance plan must be prepared for each channel system. Minimum requirements for operation, maintenance, and replacement shall be consistent with the design objectives. This includes consideration of fish and wildlife habitat, quality of the landscape, water quality, mitigation features, methods, equipment, costs, stability, function for design life, frequency, and time of year for accomplishing the work. Detailed provisions for operation and maintenance must be made if complex features, such as water-level-control structures and pumping plants, are required.

**Maintenance access.** Travelways for maintenance generally shall be provided as part of all channel work. This requirement may be met by providing reading access points to sections of the

channel if this will permit adequate maintenance in conformance with the operation and maintenance plan.

A travelway shall be provided on each side of large channels if necessary for use of maintenance equipment. Travelways must be adequate for movement and operation of equipment required for maintenance of the channel. The travelway may be located adjacent to the channel on a berm or on the spread spoil. In some places the channel itself may be used as the travelway. The travelway, including access points, must blend into the topography, the landscape, and adjacent land uses.

**Safety.** Open channels can create a safety hazard. Appropriate safety features and devices should be installed to protect people and animals from accidents such as falling or drowning.

## **PLANS AND SPECIFICATIONS**

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

## **PLANNING CONSIDERATIONS FOR QUANTITY AND QUALITY**

### **Quantity**

1. Effects on components of the water budget, especially on volumes and rates of runoff and infiltration.

### **Quality**

1. Effects of erosion and the movement of sediment and soluble and sediment-attached substances in runoff during and immediately after construction.
2. Effects of the use of chemicals during vegetation control.
3. Effects of changes in channel vegetation on downstream water temperature.
4. Potential for temporary and long-term effects on the visual quality of downstream waters.

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# PASTURE AND HAY PLANTING

(Acre)  
CODE 512

## DEFINITION

Establishing native or introduced forage species.

## PURPOSES

This practice may be applied as part of a conservation management system to accomplish one or more of the following purposes:

- Establish adapted and compatible species, varieties, or cultivars.
- Improve or maintain livestock nutrition and/or health.
- Extend the length of the grazing season.
- Provide emergency forage production.
- Reduce soil erosion by wind and/or water.

## CONDITIONS WHERE PRACTICE APPLIES

This practice may be applied on cropland, hayland, pastureland, and other agricultural lands where forage production is feasible and desired.

## CRITERIA

**General criteria applicable to all the purposes stated above.**

Plant species and their cultivars shall be selected based upon:

- Climatic conditions, such as annual rainfall, seasonal rainfall patterns, growing season length, humidity levels, temperature extremes and the USDA Plant Hardiness Zones.
- Soil condition and position attributes such as pH, available water holding capacity, aspect, drainage class, inherent fertility, salinity and alkalinity, flooding and ponding, and levels of toxic elements that may be present such as selenium and aluminum.
- Plant resistance to disease and insects common to the site or location.
- Plant compatibility with other forage species and their selected cultivar(s) in rate of establishment, maturity, and growth habit when seeded together as a forage mixture.

Specified seeding/plant material rates, methods of planting and date of planting shall be consistent with documented guidance cited by research institutions or agency demonstration trials for achieving satisfactory establishment.

Seeding rates will be calculated on a pure live seed (PLS) basis or percent germination. Provide a firm, weed-free seedbed that ensures seed will contact soil moisture uniformly, facilitates seedling emergence, and provides a medium that does not restrict or allow roots to become dry.

All seed and planting materials shall be labeled and meet state seed quality law standards. Legume seed shall be inoculated with the proper, viable rhizobia before planting.

**Additional criteria for improving or maintaining livestock nutrition and/or health.**

Forage species must be capable of meeting the desired level of nutrition for the kind and class of the livestock to be fed.

**Additional criteria for extending the grazing season.**

Forage species selected for establishment shall fulfill a recognized dietary deficiency within the year long forage management program.

**Criteria for providing emergency forage production.**

Select plants that will produce forage for use during periods when other on-farm/ranch forage is unavailable to meet livestock needs.

**Criteria for reducing erosion by wind and/or water.**

Plants shall have the ability to provide adequate ground cover, canopy cover, root mass, and vegetal retardance to wind forces and water flows either alone or in combination with other forage species when site conditions require erosion protection.

**CONSIDERATIONS**

Prescribed Burning, Prescribed Grazing, Brush Management, and Grazing Land Mechanical Treatment practices may be used in combination with Pasture and Hay Planting.

Where wildlife management is an objective, the food and cover value of the planting can be enhanced by using an approved habitat evaluation procedure to aid in selecting plant species and providing for other habitat requirements necessary to achieve the objective.

Forage species planted in mixture should exhibit similar palatability to one another to avoid spot or selective grazing.

**PLANS AND SPECIFICATIONS**

Specifications for the establishment of pasture and hay plantings shall be prepared for each site or management unit according to the Criteria, Considerations, and Operations and Maintenance described in this standard, and shall be recorded on specification sheets, job sheets, in narrative statements in the conservation plan, or other acceptable documentation.

**OPERATION AND MAINTENANCE**

Growth of seedlings or sprigs shall be monitored for water stress. Water stress may require reducing weeds, early harvest of any companion crops, irrigating when possible, or replanting failed stands, depending on the severity of drought.

Invasion by undesirable plants shall be controlled by cutting, using a selective herbicide, or by grazing management by manipulating livestock stocking rates, density, and duration of stay.

Insects and diseases shall be controlled when an infestation threatens stand survival.

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# **PEST MANAGEMENT**

(Acre)  
CODE 595A

## **DEFINITION**

Managing agricultural pest infestations (including weeds, insects, and diseases) to reduce adverse effects on plant growth, crop production, and environmental resources.

## **SCOPE**

This standard establishes the minimum acceptable elements of a pest management program. It includes appropriate cultural, biological, and chemical controls, and combinations thereof.

## **PURPOSE**

To develop a pest management program that is both consistent with selected crop production goals and environmentally acceptable.

## **CONDITIONS WHERE PRACTICE APPLIES**

On cropland and other land where pest control is needed.

## **PLANNING CONSIDERATIONS**

1. Use integrated pest management principles, some major features of which are incorporated in subsequent items.
2. Consider the use of crop rotations, crop varieties resistant to the target pest(s), and adjusting planting dates to help control weed, insect, and disease problems.
3. Consider mechanical cultivation and biological controls, where appropriate, to control pests.
4. Consider the effect of adequate plant nutrients and soil moisture, favorable pH, and good soil condition to reduce plant stress and improve plant vigor.
5. Consider use of hand weeding for small, isolated areas, or on larger areas where labor costs are not prohibitive. Spot spraying rather than full-coverage spraying is another alternative.
6. Consider pesticide characteristics such as solubility, toxicity, degradation products, mobility, persistence, adsorption, and efficacy, and relationships to site characteristics such as soil, geology, depth to water table, proximity to surface water, topography, climate, and sensitive environmental elements to determine the potential impact on water quality.
7. Practice timing of pesticide application in relation to present soil moisture, anticipated weather conditions, and irrigation to achieve greatest efficiency and reduce potential for offsite transport. The method of pesticide application, such as ground or aerial spraying, wicking, granules, etc., is important since the degree of drift and volatilization can vary considerably.
8. Consider the effects of erosion control practices, including subsurface water management, used to reduce soil loss and runoff on transport of adsorbed and dissolved pesticides.
9. Consider the effects of repetitive use of the same or similar pesticides on pest resistance and shifts in the pest types.

10. Consider effects of pest control measures on non-target soil organisms, and on aquatic and terrestrial life. Special care should be afforded to threatened and endangered species of plants and animals.
11. Consider effects of the seasonal water budget on potential pesticide loss from the plant environment to surface or ground water.

## **OPERATION, SAFETY, AND MAINTENANCE**

1. Prepare a chemical management plan.
2. Maintain mechanical equipment in good working condition and calibrate application equipment to ensure recommended rates are applied. Replace worn components of pesticide application equipment as well as other pest management implements.
3. Operators of equipment must be alert at all times to avoid bodily injury and unnecessary exposure to chemicals.
4. Pesticide users must read and follow label directions, maintain appropriate Material Safety Data Sheets (MSDS), and become certified to apply restricted use pesticides.
5. Apply chemicals during periods of minimum potential for drift.
6. Minimize exposure to chemicals, wear protective clothing, and use safety equipment as appropriate.
7. Ensure that the pesticide applicator knows the exact field location to be treated. Post signs according to label directions or state and Federal laws around fields that have been treated. Follow the established re-entry time as stated on the MSDS.
8. Properly locate chemical mixing and equipment rinsing stations relative to potential for contamination of ground or surface water. Extreme care must be taken to follow loading and mixing procedures. Provide for managing accidental spills.
9. Properly rinse equipment and re-use rinsate for subsequent batches of the same pesticide, where possible.
10. Store pesticides in original containers in a locked, well ventilated weather resistant building. Post warning signs on or around the building. Locate the building so that accidental spills will create minimal environmental effects. Dispose of pesticide containers according to label directions and adhere to local or state regulations.
11. Provide emergency wash stations for personnel who might be accidentally exposed to chemicals, and formulate a safety plan complete with information about locations of emergency treatment centers for personnel exposed to chemicals.
12. Ensure that backflow prevention devices are installed and operating properly on irrigation systems used for applying pesticides.
13. Recognize the dangers from excessive exposure to the take appropriate precautionary measures. This is especially important for farm workers who spend long hours in the field.

## **SPECIFICATION GUIDE**

1. Identify the target pest(s), the life cycle periods when it is most vulnerable to control, and the best mechanical, biological, or chemical control method or combinations of control and list limitations on use.
2. Develop and use a water budget when planning the use of this practice that will show the seasonal distribution of water resources under the appropriate soil-crop-management system.
3. Describe specifications for any pest management measure consistent with state and local regulations. Appropriate land grant university publications concerning pesticide use will be maintained and updated as part of the field office technical guide, and all recommendations for specific pesticides, rates of pesticides, level of crop tolerance, and effectiveness ratings for the target pest(s) shall be in accordance with these publications.
4. Determine potential pesticide loss to surface runoff and leaching using "Soil Ratings for Pesticide Leaching and Surface Loss Potentials" or other appropriate ratings for soils and

- pesticides in section 11 of the field office technical guide. This information will be used to rank the various pesticides in terms of their potential to contaminate water resources and to consider other management options.
5. Include a reference section at the end of the specifications that contains those sources used in developing these specifications to provide easy access to more in-depth technical information.
  6. All specifications will be consistent with state and local regulations.

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# PIPELINE (Ft.) CODE 516

## DEFINITION

Pipeline installed for conveying water for livestock or for recreation.

## SCOPE

This standard applies to pipelines that have an inside diameter of less than 4 in. They are installed for livestock watering or for recreation areas.

## PURPOSE

To convey water from a source of supply to points of use.

## CONDITIONS WHERE PRACTICE APPLIES

Where conveyance of water in a closed conduit is desirable or necessary to conduct water from one point to another, to conserve the supply, or for reasons of sanitation.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff and infiltration. Compare to centralized water facilities that has increased soil compaction because of traffic livestock, vehicles, and humans.
2. Effects on surface and ground water of broken pipelines.

### Water Quality

1. The impact of water available at remote sites as a factor in keeping livestock out of streams and lakes, with the resulting reduction in bank erosion, sediment yield, and the direct deposit of manure in water courses.
2. Effects of bacteria, nutrients, salts and organic matter on surface and ground water because of increased recreation activity caused by the availability of water.
3. Effects of erosion and sediment yield from disturbed areas during construction.

## DESIGN CRITERIA

**Capacity.** For supply livestock water, the installation shall have a capacity to provide at least 12 gal per head per day for beef cattle and horses, 25 gal for dairy cattle, and 1.5 gal for sheep and goats.

For recreation areas, the capacity shall be adequate for all planned uses of the water, such as drinking, fire protection, showers, flush toilets, and irrigation of landscaped areas.

**Sanitary protection.** If water from the pipeline is likely to be used for human consumption, the requirements of the state health department for materials and installation must be met.

**Pipe.** Steel pipe shall meet the requirements specified in ASTM-A-120 or in AWWA Specification C-200. If because of local conditions, a coal-tar enamel protective coating is needed for steel pipe, the coating shall meet the requirements of AWWA Specification C-203. Plastic pressure pipe shall be suitable for underground use. The pipe shall conform to the requirements of the following ASTM specifications:

- D 1785 Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
- D 2104 Polyethylene (PE) Plastic Pipe, Schedule 40
- D 2241 Polyvinyl Chloride (PVC) Plastic Pipe (SDR-PR)
- D 1527 Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe, Schedules 40 and 80
- D 2282 Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe (SDR-PR)
- D 2239 Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Inside Diameter
- D 3035 Polyethylene (PE) Plastic Pipe (SDR-PR), Based on Controlled Outside Diameter
- D 2447 Polyethylene (PE) Plastic Pipe Schedules 40 and 80, Based on Outside Diameter
- D 2737 Polyethylene (PE) Plastic Tubing
- D 2672 Bell-End Polyvinyl Chloride (PVC) Pipe
- D 2740 Polyvinyl Chloride (PVC) Plastic Tubing

Pressure pipe fitting shall conform to the requirements of the following ASTM specifications:

- D 2466 Polyvinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40
- D 2467 Socket-Type Polyvinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
- D 2464 Threaded Polyvinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
- D 2611 Butt Fusion Polyethylene (PE) Plastic Pipe Fittings, Schedule 80 (for IPS Pipe)
- D 2610 Butt Fusion Polyethylene (PE) Plastic Pipe Fittings, Schedule 40 (for IPS Pipe)
- D 3036 Socket-Type Polyvinyl Chloride (PVC) Plastic Line Couplings
- D 2468 Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe Fittings, Schedule 40
- D 2469 Socket-Type Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe Fittings, Schedule 80
- D 2465 Threaded Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe Fittings, Threaded, Schedule 80
- D 2609 Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe
- D 3261 Butt Heat Fusion Polyethylene (PE) Plastic Fittings, for Polyethylene (PEP) Plastic Pipe and Tubing
- D 2683 Socket-type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
- D 3139 Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

Solvents for solvent-welded pipe joints shall conform to the following ASTM specifications:

- D 2564 Solvent Cements for Polyvinyl Chloride (PVC) Plastic Pipe and Fittings
- D 2235 Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
- D 2855 Making Solvent-Cemented Joints with Polyvinyl Chloride (PVC) Pipe and Fittings

Rubber gaskets for pipe joints shall conform to the requirements of ASTM Specification F 477, Elastomeric Seals (Gaskets) for joining Plastic Pipe.

**Drainage.** Valves or unions shall be installed at low points in the pipeline so that the line can be drained as needed.

**Vents.** For design velocities lower than 8 ft/s, some provision shall be included in the design for removing air. If parts of the line are above the hydraulic gradient, periodic use of an air pump may be required.

**Joints.** Watertight joints that have a strength equal to that of the pipe shall be used. Couplings must be of material compatible with that of the pipe. If they are made of material susceptible to corrosion, provisions must be made to protect them.

**Vegetation.** Distributed areas shall be established to vegetation or otherwise stabilized as soon as practicable after construction. Seedbed preparation, seeding, fertilizing, and mulching shall conform to the instructions provided in technical guides.

**Visual resources.** The visual design of pipelines in areas of high public visibility and those in fragile areas shall be carefully considered.

## **PLANS AND SPECIFICATIONS**

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

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**POND**  
(No.)  
**CODE 378**

**DEFINITION**

A water impoundment made by constructing a dam or an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at spillway elevation is 3 ft or more.

**PURPOSE**

To provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related uses, and to maintain or improve water quality.

**SCOPE**

This standard establishes the minimum acceptable quality for the design and construction of ponds if:

1. Failure of the dam will not result in loss of life; in damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.
2. The product of the storage times the effective height of the dam is less than 3,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.
3. The effective height of the dam is 35 ft or less, and the dam is hazard class (a).

**CONDITIONS WHERE PRACTICE APPLIES**

**Site conditions.** Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed emergency spillway, (2) a combination of a principal spillway and an emergency spillway, or (3) a principal spillway.

**Drainage area.** The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. The drainage area shall be large enough so that surface runoff and groundwater flow will maintain an adequate supply of water in the pond. The quality shall be suitable for the water's intended use.

**Reservoir area.** The topography and soils of the site shall permit storage of water at a depth and volume that ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of effects caused by seasonal or climatic changes.
3. Effects on the downstream flows or aquifers that could affect other water uses or users.
4. Potential for multiple use.
5. Effects on the volume of downstream flow to prohibit undesirable environmental, social or economic effects.

### Water Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment attached substances that are carried by runoff.
2. Effects on the visual quality of onsite and downstream water resources.
3. Short-term and construction-related effects of this practice on the quality of downstream water courses.
4. Effects of water level control on the temperatures of downstream water to prevent undesired effects on aquatic and wildlife communities.
5. Effects on wetlands and water-related wildlife habitats.
6. Effects of water levels on soil nutrient processes such as plant nitrogen use or denitrification.
7. Effects of soil water level control on the salinity of soils, soil water, or downstream water.
8. Potential for earth moving to uncover or redistribute toxic materials such as saline soils.

## DESIGN CRITERIA FOR EMBANKMENT PONDS

**Foundation cutoff.** A cutoff of relatively impervious material shall be provided under the dam if necessary. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall not be steeper than one horizontal to one vertical.

**Seepage control.** Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage creates swamping downstream, (3) such control is needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage may be controlled by (1) foundation, abutment, or embankment drains; (2) reservoir blanketing; or (3) a combination of these measures.

**Earth embankment.** The minimum top width for a dam is shown in table 1. If the embankment top is to be used as a public road, the minimum width shall be 16 ft for one-way traffic and 26 ft for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority.

Table 1.- Minimum top width for dams

Total height of embankment	Top width
<i>ft</i>	<i>ft</i>
10 or less	6
10 - 15	8
15 - 20	10
20 - 25	12
25 - 35	14
35 or more	15

The combined upstream and downstream side slopes of the settled embankments shall not be less than five horizontal to one vertical, and neither slope shall be steeper than two horizontal to one vertical. All slopes must be designed to be stable, even if flatter side slopes are required.

If needed to protect the slopes of the dam, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (Technical Releases 56 and 69).

The minimum elevation of the top of the settled embankment shall be 1 ft above the water surface in the reservoir with the emergency spillway flowing at design depth. The minimum difference in elevation between the crest of the emergency spillway and the settled top of the dam shall be 2 ft for all dams having more than a 20-acre drainage area or more than 20 ft in effective height.

The design height of the dam shall be increased by the amount needed to insure that after settlement the height of the dam equals or exceeds the design height. This increase shall not be less than 5 percent, except where detailed soil testing and laboratory analyses show that a lesser amount is adequate.

**Principal spillway.** A pipe conduit, with needed appurtenances, shall be placed under or through the dam, except where rock, concrete, or other types of mechanical spillways are used, or where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

The crest elevation shall be no less than 0.5 ft below the crest of the emergency spillway for dams having a drainage area of 20 acres or less, and no less than 1 ft for those having a drainage area of more than 20 acres.

When design discharge of the principal spillway is considered in calculating peak outflow through the emergency spillway, the crest elevation of the inlet shall be such that the full flow will be generated in the conduit before there is discharge through the emergency spillway. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long-duration, continuous, or frequent flows without flow through the emergency spillways. The diameter of the pipe shall not be less than 4 in. If the pipe conduit diameter is 10 in or greater, its design discharge may be considered when calculating the peak outflow rate through the emergency spillway.

Pipe conduits under or through the dam shall meet the following requirements. The pipe shall be capable of withstanding external loading without yielding, buckling, or cracking. Flexible pipe strength shall not be less than that necessary to support the design load with a maximum of 5 percent deflection. The inlets and outlets shall be structurally sound and made of materials compatible with those of the pipe. All pipe joints shall be made watertight by the use of couplings, gaskets, caulking, or by welding.

For dams 20 ft or less in effective height, acceptable pipe materials are cast-iron, steel, corrugated steel or aluminum, asbestos-cement, concrete, plastic, vitrified clay with rubber

gaskets, and cast-in-place reinforced concrete. Asbestos-cement, concrete, and vitrified clay pipe shall be laid in a concrete bedding. Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet-resistant materials and protected by coating or shielding, or provisions for replacement should be made as necessary. Connections of plastic pipe to less flexible pipe or structures must be designed to avoid stress concentrations that could rupture the plastic.

For dams more than 20 ft in effective height, conduits shall be plastic, reinforced concrete, cast-in-place reinforced concrete, corrugated steel or aluminum, or welded steel pipe. The maximum height of fill over any principal spillway steel or aluminum pipe must not exceed 25 ft. Pipe shall be watertight. The joints between sections of pipe shall be designed to remain watertight after joint elongation caused by foundation consolidation. Concrete pipe shall have concrete bedding or a concrete cradle, if required. Cantilever outlet sections, if used, shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed. Other suitable devices such as a Saint Anthony Falls stilling basin or an impact basin may be used to provide a safe outlet. Protective coatings of asbestos-bonded, asphalt coated, or vinyl coating on galvanized corrugated metal pipe, or coal tar enamel on welded steel pipe should be provided in areas that have a history of pipe corrosion, or where the saturated soil resistivity is less than 4,000 ohms-cm, or where soil pH is lower than 5.

Specifications in tables 2 and 3 are to be followed for polyvinyl chloride (PVC), steel, and aluminum pipe.

Cathodic protection is to be provided for coated welded steel and galvanized corrugated metal pipe where soil and resistivity studies indicate that the pipe needs a protective coating, and where the need and importance of the structure warrant additional protection and longevity. If cathodic protection is not provided for in the original design and installation, electrical continuity in the form of joint-bridging straps should be considered on pipes that have protective coatings. Cathodic protection should be added later if monitoring indicates the need.

Practice standard 430-FF provides criteria for cathodic protection of welded steel pipe.

Seepage control along a pipe conduit spillway shall be provided if any of the following conditions exist:

1. The effective height of dam is greater than 15 ft.
2. The conduit is of smooth pipe larger than 8 in. in diameter.
3. The conduit is of corrugated pipe larger than 12 in. in diameter.

Table 2.- Acceptable PVC pipe for use in earth dams<sup>1</sup>

Nominal pipe size	Schedule for standard dimension ratio (SDR)	Maximum depth of fill over pipe
<i>in</i>		<i>ft</i>
4 or less	Schedule 40	15
	Schedule 80	20
	SDR 26	10
6,8,10,12	Schedule 40	10
	Schedule 80	15
	SDR 26	10

1. Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ATSM-D-1785 or ATSM-D-2241.

Table 3.- Minimum gauge for corrugated metal pipe [2-2/3-in x 1/2-in corrugations]<sup>1</sup>

Fill height (ft)	Minimum gauge for steel pipe with diameter (in) of ____					
	21 and less	24	30	36	42	48
1 - 15	16	16	16	14	12	10
15 - 20	16	16	16	14	12	10
20 - 25	16	16	14	12	10	10

Fill height (ft)	Minimum thickness (in) of aluminum pipe <sup>2</sup> with diameter (in) of ____			
	21 and less	24	30	36
1 - 15	0.06	0.06	0.075	0.075
15 - 20	0.06	0.075	0.105	0.105
20 - 25	0.06	0.105	0.105	--- <sup>3</sup>

1. Pipe with 6-, 8-, and 10-in diameters has 1-1/2 in x 1/4-in corrugations.
2. Riveted or helical fabrication.
3. Not permitted.

Seepage along pipes extending through the embankment shall be controlled by use of a filter and drainage diaphragm, unless it is determined that antiseep collars will adequately serve the purpose

The drain is to consist of sand, meeting fine concrete aggregate requirements (at least 15% passing the No. 40 sieve but no more than 10% passing the No. 100 sieve). If unusual soil conditions exist, a special design analysis shall be made.

The drain shall be a minimum of 2 ft thick and extend vertically upward and horizontally at least three times the pipe diameter, and vertically downward at least 18 in. beneath the conduit invert. The drain diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam.

The drain shall be outletted at the embankment downstream toe, preferably using a drain backfill envelope continuously along the pipe to where it exits the embankment. Protecting drain fill from surface erosion will be necessary.

When antiseep collars are used in lieu of a drainage diaphragm, they shall have a watertight connection to the pipe. Maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe. Collar material shall be compatible with pipe materials. The antiseep collar(s) shall increase by 15% the seepage path along the pipe.

Closed conduit spillways designed for pressure flow must have adequate antivortex devices. To prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser.

A pipe with a suitable valve shall be provided to drain the pool area if needed for proper pond management or if required by State law. The principal spillway conduit may be used as a pond drain if it is located where it can perform this function.

Supply pipes through the dam to watering troughs and other appurtenances shall have an inside diameter of not less than 1-1/4 in.

**Emergency spillways.** Emergency spillways convey large flood flows safely past earth embankments.

An emergency spillway must be provided for each dam, unless the principal spillway is large enough to pass the peak discharge from the routed design hydrograph and the trash that comes to it without overtopping the dam. The following are minimum criteria for acceptable use of a closed conduit principal spillway without an emergency spillway: a conduit with a cross-sectional area of 3 ft<sup>2</sup> or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

The minimum capacity of a natural or constructed emergency spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table 4, less any reduction creditable to conduit discharge and detention storage.

The emergency spillway shall safely pass the peak flow, or the storm runoff shall be routed through the reservoir. The routing shall start either with the water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days' drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the emergency spillway or from the elevation that would be attained if the entire design storm were impounded, whichever is lower. Emergency spillways shall provide for passing the design flow at a safe velocity to a point downstream where the dam will not be endangered.

Constructed emergency spillways are open channels that usually consist of an inlet channel, a control section, and an exit channel. They shall be trapezoidal and shall be located in undisturbed or compacted earth. The side slopes shall be stable for the material in which the spillway is to be constructed. For dams having an effective height exceeding 20 ft, the emergency spillway shall have a bottom width of not less than 10 ft.

Upstream from the control section, the inlet channel shall be level for the distance needed to protect and maintain the crest elevation of the spillway. The inlet channel may be curved to fit existing topography. The grade of the exit channel of a constructed emergency spillway shall fall within the range established by discharge requirements and permissible velocities.

**Structural emergency spillways.** If chutes or drops are used for principal spillways or principal emergency or emergency spillways, they shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices and the National Engineering Handbook-Section 5, Hydraulics; Section 11, Drop Spillways; and Section 14, Chute Spillways. The minimum capacity of a structural spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table 4, less any reduction creditable to conduit discharge and detention storage.

**Visual resource design.** The visual design of ponds shall be carefully considered in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that it is generally curvilinear rather than rectangular. Excavated material can be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and to attract wildlife.

## DESIGN CRITERIA FOR EXCAVATED PONDS

**Runoff.** Provisions shall be made for a pipe and emergency spillway if necessary. Runoff flow patterns shall be considered when locating the pit and placing the spoil (see table 4).

**Side slopes.** Side slopes of excavated ponds shall be stable and shall not be steeper than one horizontal to one vertical. If livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than three horizontal to one vertical.

**Perimeter form.** If the structures are to be used for recreation or are highly visible to the public, the perimeter or edge should be curvilinear.

**Inlet protection.** If surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

**Excavated material.** The material excavated from the pond shall be placed so that its weight will not endanger the stability of the pond side slopes and so that it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

1. Uniformly spread to a height that does not exceed 3 ft, with the top graded to a continuous slope away from the pond.
2. Uniformly placed or shaped reasonably well, with side slopes assuming a natural angle of repose. The excavated material will be placed at a distance equal to the depth of the pond but not less than 12 ft from the edge of the pond.
3. Shaped to a designed form that blends visually with the landscape.
4. Used for low embankment and leveling.
5. Hauled away.

Table 4.-Minimum spillway capacity

Drainage Area	Effective ht. of dam <sup>1</sup>	Storage	Minimum design storm <sup>2</sup>	
			Frequency	Minimum duration
<i>Acre</i>	<i>ft</i>	<i>ac-ft</i>	<i>yr</i>	<i>hr</i>
20 or less	20 or less	< than 50	10	24
20 or less	> than 20	< than 50	25	24
> than 20		< than 50	25	24
All others			50	24

1. As defined under "Scope."

2. Select rain distribution based on climatological region.

## PLANS AND SPECIFICATIONS

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

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**POND SEALING OR LINING**  
**ASPHALT-SEALED FABRIC LINER**  
(No.)  
CODE 521E

**DEFINITION**

Installing a fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

**SCOPE**

This standard applies to the sealing of ponds by the use of flexible membrane linings made of asphalt-sealed fabric.

**PURPOSE**

To reduce seepage losses in ponds to an acceptable level.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where water loss from a pond through leakage is, or will be, of such proportion as to prevent the pond from fulfilling its planned purpose, or where leakage will damage land and crops or cause loss of unacceptable amounts of water or environmental problems.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects on the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of the practice's effects caused by seasonal or climatic changes.
3. Effects on downstream flows or aquifers that would affect other water uses.
4. Effects on the volume of downstream flow to prohibit undesirable environmental, social or economic effects.
5. Potential use for water management.

**Water Quality**

1. Effects on the movement of sediment, pathogens, and soluble material carried by seepage water.
2. Effects on the trapping of nutrients and pesticides and altering their effect on surface and ground water quality
3. Effects on the visual quality of downstream water resources.
4. Short-term and construction-related effects on the quality of the pool and downstream water.
5. Effects of water level control on the temperatures of pool and downstream water to prevent undesired effects on aquatic and wildlife communities.
6. Effects on wetlands or water-related wildlife habitats associated with the practice.

## **DESIGN CRITERIA**

Ponds to be lined shall be constructed to meet the SCS standards for Irrigation Pits or Regulating Reservoirs (552), Irrigation Storage Reservoirs (436), Ponds (378), Waste Treatment Lagoons (359), Waste Storage Ponds (425), or Wildlife Watering Facilities (648), as appropriate.

The flexible membranes to be used as linings shall be constructed of high-quality materials and shall be certified by the manufacturer to be suitable for this use. Base material used for asphalt-sealed liners shall be highly resistant to bacteriological deterioration.

Livestock shall be excluded from the site to prevent damage to the lining.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for sealing ponds with asphalt-sealed fabric liners shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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**POND SEALING OR LINING**  
**BENTONITE SEALANT**  
(No.)  
CODE 521C

**DEFINITION**

Installing a fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

**SCOPE**

This standard pertains to the sealing of ponds with bentonite or similar high swell clay materials.

**PURPOSE**

To reduce seepage losses in ponds to an acceptable level.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where water loss from a pond through leakage is or will be of such proportion as to prevent the pond from fulfilling its planned purpose or where leakage will damage land and crops or cause waste of water or environmental problems.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of the practice's effects caused by seasonal or climatic changes.
3. Effects on downstream flows or aquifers that would affect other water uses.
4. Potential use for water management to conserve water.

**Water Quality**

1. Effects on the movement of sediment, pathogens, and soluble material substances carried by seepage water.
2. Effects on the visual quality of downstream water resources.
3. Short-term and construction-related effects of this practice on the quality of the pool and downstream water.
4. Effects of soil water level control on the temperatures of downstream waters to prevent undesired effects on aquatic and wildlife communities.
5. Effects on wetlands or water-related wildlife habitats.

**DESIGN CRITERIA**

Ponds to be sealed shall be constructed to meet SCS standards for irrigation pits or regulating

reservoirs (552), irrigation storage reservoirs (436), ponds (378), waste treatment lagoons (359), waste storage ponds (425), or wildlife watering facilities (648), as appropriate.

**Soil properties.** Sealing with bentonite or similar materials is more applicable on coarse-grained soils where more than half of the soil material is larger than that passing the No. 200 sieve size.

**Rate of application.** The rate of application shall be based on laboratory tests unless sufficient data are available on the field performance of previously tested soils that are similar in texture and chemical properties to the soils to be sealed.

In the absence of laboratory tests or field performance data on the soils to be sealed, the minimum application shall be:

Pervious soil	Application method	Application rate <i>lb/ft<sup>2</sup></i>
Clay	Mixed layer	1.0-1.5
Sandy silt	Mixed layer	1.0-1.5
Silty sand	Mixed layer	1.5-2.0
Clean sand	Mixed layer	2.0-2.5
Open rock or gravel	Clay or sand mixed layer	2.5-3.0

**Thickness of treated blanket.** The minimum thickness of the finished treated blanket shall be 4 in. for water depths up to 8 ft. Additional thickness shall be provided for greater water depths and for areas subject to wave action.

## PLANS AND SPECIFICATIONS

Plans and specifications for sealing ponds with bentonite shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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**POND SEALING OR LINING**  
**CATIONIC EMULSION-WATERBORNE SEALANT**  
(No.)  
CODE 521D

**DEFINITION**

Installing a fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

**SCOPE**

This standard pertains to the sealing of ponds with cationic emulsion sealant materials.

**PURPOSE**

To reduce seepage losses in ponds to an acceptable level.

**CONDITIONS WHERE PRACTICE APPLIES**

Where water loss from a pond through leakage is, or will be, of such proportion as to prevent the pond from fulfilling its planned purpose, or where leakage can damage land and crops or can cause waste of water or environmental problems, and where a seepage reduction of 70 to 95 percent can adequately solve the leakage problem.

**PLANNING CONSIDERATIONS**

**Water Quantity**

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of the practice's effects caused by seasonal or climatic changes.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the volume of downstream flow to prohibit undesirable environmental, social or economic effects.
5. Potential use for water management to conserve water.

**Water Quality**

1. Effects on the movement of sediment, pathogens, and soluble substances carried by seepage water.
2. Effects on this practice on the trapping of nutrients and pesticides and altering their effect on surface and ground water quality.
3. Effects on the visual quality of the pool and downstream water resources.
4. Short-term and construction-related effects on the quality of the pool and downstream water.
5. Effects of water level control on the salinity of soils, soil water, or downstream water.
6. Effects of water level control on the temperatures of downstream waters to prevent undesired effects on aquatic and wildlife communities.
7. Effects on wetlands or water-related wildlife habitats.

## DESIGN CRITERIA

Ponds to be lined shall be constructed to meet SCS standards for Irrigation Pits or Regulating Reservoirs (552), Irrigation Storage Reservoirs (436), Ponds (378), Waste Treatment Lagoons (359), Waste Storage Ponds (425), or Wildlife Watering Facilities (648), as appropriate.

**Soil properties.** For electrochemical sealing, soils (in the surface 2 in.) shall have properties approximating the USDA textural soil classification for:

1. Very fine sands, fine sands, medium sands, coarse sands, and very coarse sands.
2. Nonexpansive loamy sand and sandy loam.

If the soil is relatively uniform throughout the entire pond, the seepage rate before sealing shall exceed 1 ft/day, measured vertically. If isolated sections in an area are suspected of causing most of the seepage loss, the seepage rate in the area before sealing shall exceed 1 ft/day.

The minimum rate of application shall be based on small-scale field tests with infiltration cylinders unless sufficient data are available on the field performance of previously tested soils that are similar in texture and chemical properties to the soil to be sealed.

In the absence of field test results for the soils to be sealed, the minimum application shall be 1 gal/yd<sup>2</sup>.

## PLANS AND SPECIFICATIONS

Plans and specifications for sealing ponds with cationic emulsion-waterborne sealant shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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**POND SEALING OR LINING - FLEXIBLE MEMBRANE**  
(NO.)  
CODE: 521A

**DEFINITION**

A manufactured hydraulic barrier consisting of a functionally continuous sheet of synthetic or partially synthetic, flexible material.

**PURPOSE**

To control seepage from water and waste impoundments for water conservation and environmental protection.

**CONDITION WHERE PRACTICE APPLIES**

On ponds and water storage structures that require treatment to control seepage rates within acceptable limits.

On waste storage and waste treatment facilities built in or of excavated earth, and which require treatment to prevent the migration of contaminants from the site.

**CRITERIA**

Structures to be lined shall have been constructed to meet all applicable NRCS standards. All inlets, outlets, ramps, and other appurtenances may be installed before, during, or after the liner placement, but shall be done in a manner that does not damage or impair the proper operation of the liner.

All flexible membranes shall be certified by the manufacturer to be suitable for the intended use.

Design of the flexible membrane shall be in accordance with manufacturer recommendations. All flexible membrane installations shall meet the material and installation requirements of the plans and specifications provided for each installation, and shall be certified by the installer.

<b>Minimum Criteria for Membranes</b>	
<b>Type</b>	<b>Limiting Parameter</b>
HDPE	40 mil thickness
LLDPE	40 mil thickness
PVC	30 mil thickness
GCL	0.75 lb./sq ft (bentonite)
EPDM	45 mil thickness

HDPE = High Density Polyethylene  
LLDPE = Linear Low Density Polyethylene  
PVC = Polyvinyl Chloride  
GCL = Geosynthetic Clay Liner  
EPDM = Synthetic Rubber

Select soil materials shall be used as cover for liners where required for the proper performance, protection, and durability of the installation. Cover soils shall not contain sharp, angular stones or any objects that could damage the liner. Maximum allowable particle size of soil cover material shall be 3/8-in (10 mm), unless the liner is cushioned by a needle punched, non-woven geotextile. Cover materials shall be stable under all operational and exposure conditions.

Subgrade preparation shall conform to manufacturer recommendations. Subgrade materials shall not contain sharp, angular stones or any objects that could damage the liner or adversely impact its function.

All structures shall be fenced to protect the liner from damage and for the safety of humans, livestock, wildlife, and pets.

Manufacturer recommendations shall be followed with regard to protection from weather and exposure.

If venting is used, manufacturer recommendations shall be followed regarding vent type and spacing.

## **CONSIDERATIONS**

Venting should be considered if gas build up under the liner is anticipated.

If high water tables could adversely affect the proper functioning of the facility, interceptor or relief type drainage systems should be considered to control uplift pressures.

## **PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared for specific field sites in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended uses.

## **OPERATION AND MAINTENANCE**

A plan for operation and maintenance of the liner shall be prepared.

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# **POND SEALING OR LINING**

## **SOIL DISPERSANT**

(No.)

CODE 521B

### **DEFINITION**

Installing a fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

### **SCOPE**

This standard applies to the sealing of ponds with soil dispersants.

### **PURPOSE**

To reduce seepage losses in ponds to an acceptable level.

### **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where water loss from a pond through leakage is, or will be, of such proportion as to prevent the pond from fulfilling its planned purpose or where leakage will damage land and crops or cause waste of water or environmental problems.

### **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

#### **Quantity**

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of the practice's effects caused by seasonal or climatic changes.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the volume of downstream flow to prohibit undesirable environmental, social, or economic effects.
5. Potential use for water management to conserve water.

#### **Quality**

1. Effects on the movement of sediment, pathogens, and soluble substances carried by seepage toward the ground water.
2. Effects on the visual quality of the downstream water resources.
3. Short-term and construction-related effects of this practice on quality of the local downstream water resources.
4. Effects on the movement of dissolved substances below the pool area and toward ground water.
5. Effects on wetlands or water-related wildlife habitats.

## DESIGN CRITERIA

Ponds to be lined shall be constructed to meet the SCS standard for Irrigation Pits or Regulating Reservoirs (552), Irrigation Storage Reservoirs (436), Ponds (378), Waste Treatment Lagoons (359), Waste Storage Ponds (425), or Wildlife Watering Facilities (648) as appropriate.

**Soil Properties.** For chemical sealing, soils shall have properties approximating the following:

1. At least 50 percent finer than 0.074 mm diameter (No. 200 sieve)
2. At least 15 percent finer than 0.002 mm diameter.
3. Less than 0.50 percent soluble salts (based on dry soil weight).

**Dispersants.** Tetrasodium pyrophosphate (TSPP) and sodium tripolyphosphate (STPP) shall be used in preference to other polyphosphate salts. Commercial phosphatic fertilizer is not acceptable. Soda ash, technical grade, 99-100 percent sodium carbonate may be used.

These dispersants shall be finely granular; 95 percent of the material shall pass a number 30 sieve and less than 5 percent a number 100 sieve.

Standard commercial sodium chloride is satisfactory in the granulated form normally available.

Other dispersants may be used in the form found to be satisfactory by local experience.

**Rate of application.** The rate of application and the kind of dispersant to use shall be based on laboratory tests unless sufficient data are available on the field performance of previously tested soils that are similar to the soil to be sealed in texture and chemical characteristics.

In the absence of laboratory tests for the soils to be sealed, the minimum application shall be:

Sodium polyphosphate	5 to 10lb/100 ft <sup>2</sup>
Sodium chloride	20 to 33 lb/100 ft <sup>2</sup>
Soda ash	10 to 20 lb/100 ft <sup>2</sup>
Other	As found to be adequate by local experience.

**Thickness of treated blanket.** The finished treated blanket shall be at least 6 in. thick for water depths 8 ft. or less. For greater depths of water, the blanket thickness shall be 12 in., and treated in two 6 in. lifts. A minimum thickness of 12 in. is recommended for all areas in the vertical range of water surface fluctuation.

In addition to the treated blanket, at least 2 ft. of fine-grained soil shall be placed over fractured rock outcrop or other highly permeable material.

## PLANS AND SPECIFICATIONS

Plans and specifications for sealing ponds with soil dispersants shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# PRECISION LAND FORMING

(acre)  
CODE 462

## DEFINITION

Reshaping the surface of land to planned grades.

## SCOPE

This standard applies to all precision land-forming operations for drainage and erosion control as well as other purposes such as moisture conservation, leaching, and improving water quality. All land-forming operations under this standard will be on the basis of a detailed engineering survey and layout. It does not include Land Smoothing (466), or Recreation Land Grading and Shaping (566), and Irrigation Land Leveling (464).

## PURPOSE

To improve surface drainage, provide more effective use of rainfall, facilitate installation of more workable drainage systems, reduce the incidence of mosquito infestation, control erosion, improve water quality, and prevent damage to land by water logging.

## CONDITIONS WHERE PRACTICE APPLIES

On all land that is suitable for the purpose required and where precision land forming is practical. Soils shall be of sufficient depth and of suitable textures so that after precision land forming is completed an adequate root zone remains to permit the planned use of the land and application of proper conservation measure, soil amendments, and fertilizer.

All precision land forming shall be planned as an integral part of an overall system to facilitate the conservation use of soil and water resources.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, deep percolation, and evaporation.
2. Potential for changes in plant growth and transpiration resulting from the changes in the volume of soil water.

### Water Quality

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried on by runoff.
2. Effects from the use and management of nutrients and pesticides on surface and ground water quality.
3. Short-term and construction effects of installation on downstream water resources.
4. Potential for earth moving to uncover or redistribute toxic materials, such as saline soils, and make them available to water or plants.
5. Downstream temperature changes.
6. Effects on the visual quality of downstream water resources.

## DESIGN CRITERIA

Design and installation shall be based on adequate engineering surveys and investigation. If the land is to be formed for more than one purpose, it must be formed to meet the requirements of the most restrictive purpose and crop.

All forming work must be designed within the slope limits required for the proposed use and provide for the removal of excess surface water. If other conservation practices such as grassed waterways, drainage field ditches, and filter strips are needed to accomplish the stated purpose, they shall be included in the plans for improvement.

**Slope requirements.** Slope may be uniform in the direction of flow or may increase or decrease. Reverse grades in the direction of planned water flow shall not be permitted. Short level sections are permissible to meet field conditions. Cross slopes must be designed so that “breakthroughs” from rainfall runoff are held to a minimum.

**Slope to control erosion caused by runoff from rainfall.** Design field grades shall be such that erosion caused by runoff from rainfall can be controlled within the limits permissible for conservation farming. When benching between land-formed plots exceeds 1 ft (304 mm) a permanent grassed area or border ridge must be left between the plots to reduce the possibility of gully erosion.

**Surface drainage.** All precision land-forming systems shall include plans for removing or otherwise providing for control of excess water.

Designs must provide field elevation and field grades that will permit proper functioning of the planned drainage facilities.

**Borrow computations.** Excavation and fill material required for or obtained from such structures as ditched, ditch pads, and roadways shall be considered part of the precision land-forming design, and the appropriate yardage shall be included when balancing cuts and fills and determining borrow requirements.

## PLANS AND SPECIFICATIONS

Plans and specifications for precision land forming shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# **PRESCRIBED BURNING**

(Acre)  
CODE 338

## **DEFINITION**

Applying controlled fire to predetermined area.

## **PURPOSES**

- To control undesirable vegetation.
- Prepare sites for planting or seeding.
- Control plant disease.
- Reduce wildfire hazards.
- Improve wildlife habitat.
- Improve forage production quantity and/or quality.
- Slash and debris removal.
- Enhance seed and seedling production.
- To facilitate distribution of grazing and browsing animals.

## **CONDITIONS WHERE PRACTICE APPLIES**

On all landuses.

## **CRITERIA**

The procedure, equipment, and the number of trained personnel shall be adequate to accomplish the intended purpose. The timing of the burn will be based on, as a minimum: relative humidity, wind conditions, air temperature, and fuel conditions.

Comply with applicable laws and regulations, including the state's Best Management Practices (BMPs).

## **CONSIDERATIONS**

Burning should be managed with consideration for wildlife needs such as nesting and feeding cover.

Existing barriers such as lakes, streams, wetlands, roads, and constructed firebreaks are important to the design and layout of this practice.

Adjoining landowners within the airshed should be notified prior to burning.

Liability and safety precautions are to be planned before the burn and monitored during the burn.

## **PLANS AND SPECIFICATIONS**

Specifications (burn plan) for burning shall be prepared for each site. Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Operation and maintenance requirements are not applicable for this practice.

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# **PRESCRIBED GRAZING**

(Acre)  
CODE 528A

## **DEFINITION**

The controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective.

## **PURPOSES**

This practice may be applied as part of a conservation management system to accomplish one or more of the following purposes:

- Improve or maintain the health and vigor of selected plant(s) and to maintain a stable and desired plant community.
- Provide or maintain food, cover and shelter for animals of concern.
- Improve or maintain animal health and productivity.
- Maintain or improve water quality and quantity.
- Reduce accelerated soil erosion and maintain or improve soil condition for sustainability of the resource.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice may be applied on all lands where grazing and/or browsing animals are managed.

## **CRITERIA**

### **General Criteria Applicable For All The Purposes Stated Above.**

Removal of herbage will be in accordance with production limitations, plant sensitivities and management goals using Sections I & II of the FOTG and other references as guidance.

Frequency of defoliations and season of grazing will be based on the rate and physiological conditions of plant growth.

Duration and intensity of grazing will be based on desired plant health and expected productivity of key forage species to meet management unit objectives.

Maintain enough vegetative cover to prevent accelerated soil erosion due to wind and water.

Application of this practice will manipulate the intensity, frequency, duration, and season of grazing to:

- Insure optimum water infiltration,
- Maintain or improve riparian and upland area vegetation,
- Protect stream banks from erosion,
- Manage for deposition of fecal material away from water bodies, and
- Promote ecological and economical stable plant communities on both upland and bottom land sites which meet landowner objectives.

### **Additional Criteria For Improved Animal Health And Productivity.**

Movement of animals will be in a manner to improve and/or maintain animal health and performance, and to reduce or prevent spread of disease, parasites, and contact with harmful insects.

Grazing should be applied in accordance with forage quality and quantity criteria that best meets the production requirements for the kind and/or class of animal.

#### **Additional Criteria For Water Quality.**

Duration, intensity, frequency, and season of grazing in or near surface waters will be applied in such a manner that the impacts to vegetative and water quality will be positive.

Duration, intensity, frequency, and season of grazing will be applied to enhance nutrient cycling by better manure distribution and increased rate of decomposition.

#### **Additional Criteria For Soil Erosion and Condition.**

Duration, intensity, frequency, and season of grazing shall be managed to minimize soil compaction or other detrimental effects.

Duration, intensity, frequency, and season of grazing shall be applied to sustain vegetative cover to minimize soil erosion.

### **CONSIDERATIONS**

Supplemental feed may be necessary to meet the desired nutritional levels for animals of concern. Placement of supplemental feed should be considered to reduce negative impacts to soil, water, air, plant, and animal resources.

Use of natural or artificial shelter will be included as part of this practice when conditions demand.

Animal husbandry requirements which may affect the design of the grazing prescription will be considered.

Prescribed Grazing should consider the needs of other enterprises utilizing the same land, such as wildlife and recreational uses.

### **PLANS AND SPECIFICATIONS**

A Prescribed Grazing schedule will be prepared for all fields and pastures incorporating any additional feed supplementation for the operating unit or portion of an operating unit being addressed. Grazing schedules will be recorded in a manner that is readily understood and useable by the decision maker in their daily operations. The manner of documentation will depend upon the size and complexity of the operating unit and the details required for a grazing prescription.

A prescribed grazing schedule will include the following information:

1. Documentation of the expected forage quantity and quality for each management unit(s), i.e., pastures during the grazing season.
2. Documentation of the number of domestic livestock by kinds and class, and the number of grazing/browsing wildlife of concern anticipated within the management unit(s).
3. Documentation of nutritional surpluses and deficiencies from the forage resources for each kind and class of livestock and grazing/browsing wildlife of concern in the management unit(s).

4. Supplemental feed requirements needed to meet the desired nutritional level for the kind and class of livestock and grazing/browsing wildlife of concern in the management unit(s).
5. Development of a planned grazing schedule for livestock which identifies periods of grazing, resting, and other treatment activities for each management unit(s).
6. A contingency plan that details potential problems, i.e., drought, and a guide for adjusting the grazing prescription to insure resource management and economic feasibility without resource degradation will be developed.

#### **OPERATION AND MAINTENANCE**

**Operation:** The manager will apply Prescribed Grazing on a continuing basis, making adjustments as needed to insure that the concept and objectives of its application are met.

**Maintenance:** The Prescribed Grazing schedule will specify when evaluations of the current feed and forage supply should be made. If an imbalance is determined the prescription should be adjusted accordingly or other harvesting techniques applied.

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# PUMPING PLANT FOR WATER CONTROL

(No.)  
CODE 533

## DEFINITION

A pumping facility installed to transfer water for a conservation need, including removing excess surface or ground water; filling ponds, ditches or wetlands; or pumping from wells, ponds, streams, and other sources.

## PURPOSE

To provide a dependable water source or disposal facility for water management on wetlands or to provide a water supply for such purposes as irrigation, recreation, livestock, or wildlife.

## CONDITIONS WHERE PRACTICE APPLIES

Wherever water must be pumped to accomplish a conservation objective. It is especially applicable for maintaining critical water levels in existing swamps, marshes, or open water and for providing water sources for newly constructed wetlands and ponds.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effect of the pumping plant on upstream and downstream quantity.

### Water Quality

1. Sediment production caused by erosion during construction.
2. Possible effects on surface and ground water of spilled fuels and lubricants used to operate and maintain the facility.

## DESIGN CRITERIA

The efficiency of units, type of power, quality of building, automation, and accessories installed shall be in keeping with the value and importance of the system, shall accomplish the conservation and environmental objectives.

**Pump requirements.** The capabilities, range of operating lifts, and general class and efficiency of equipment shall be determined from appropriate technical studies. The size and number of pumps and their performance requirements shall be determined on the basis of the conservation requirements of the system. The total head shall be determined for critical operating conditions, taking into account all hydraulic losses. Automatic controls shall be included in the plans as required.

**Power units.** The power units shall be selected on the basis of costs, operating conditions, conservation needs, and objectives, including need for automation. The power unit shall be matched to the pump and be capable of operating the pump effectively within the range of operating conditions. The horsepower requirements, pump efficiency, and total head on the pump shall be computed.

**Suction and discharge pipes.** The size of suction and discharge pipes shall be based on studies of efficiencies and effects on costs and operations. The arrangement and length of discharge pipe shall be based on the need for recovery of head through symphonic action, and for delivery of water in keeping with conservation and environmental objectives. Gates, valves, pipe connections, discharge bays, and other protective works shall be installed, as needed, for satisfactory plant operation.

**Building and accessories.** The design of the plant and associated housing, if required, shall consider the need for protecting equipment from the elements, malicious damage, and fire and the need for equipment maintenance and repairs. The appearance of the plant shall be in keeping with its surrounding environment and its importance or value.

The foundations shall be designed to safely support the loads imposed. Sheet piling or other measures shall be used, as required, to prevent piping beneath the foundation.

Pumps may be mounted in the open, on piling, or in well or pit.

Suction bays (or sumps) shall be designed to conform to the hydraulic characteristics established by the pump manufacturer.

The discharge bay or connection with distribution system shall be ample to meet hydraulic and structural requirements. Provisions for repair or removal of pumps and engines shall be provided. Trash racks shall be provided, as needed, to exclude debris and trash from the pump.

All structural features and equipment shall provide adequate safety features to protect workers and public against injury.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing pumping plants for water control shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

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# **PUMPED WELL DRAIN**

(No.)  
CODE 532

## **DEFINITION**

A well sunk into an aquifer from which water is pumped to lower the prevailing water table.

## **SCOPE**

This standard applies to drilled or driven wells used for pumping ground water to lower the water table level in a given area. It does not apply to vertical drains, sometimes called drainage wells, constructed to discharge drain effluent into porous underground formations. Pumps, motors, or other appurtenances needed to pump water from the aquifers are not included.

This standard does not apply to test wells established for investigating purposes before the installation of a permanent well because they are considered temporary.

## **PURPOSE**

To provide subsurface drainage by lowering the prevailing water table to a level that will provide minimum benefits to crop or soils by removing excess ground water and/or salts from the soil profile.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to areas that have a high water table and are in need of subsurface drainage, where pumping from wells is feasible. This requires a permeable aquifer at a depth and of such thickness and magnitude that, when pumped, will lower the water table to the desired degree.

An adequate outlet for the pumped drain water, considering its quantity and quality, must be available.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects of the cone of depression on adjacent water uses and users.
2. Downstream effects of the pumped water.

### **Water Quality**

1. Effects of the quality of pumped water on the surrounding environment, water uses, or water users.
2. Effects of well pumping on soil and water salinity.
3. Effects of discharges of pumped water on downstream water temperatures.
4. Temporary and long-term effects on the visual quality of downstream waters.

## DESIGN CRITERIA

**Quantity of water.** The amount of ground water to be pumped from the well or wells shall be that required to provide the desired drawdown in the area being drained.

**Multiple well drains.** If more than one well is used in the system, the coned of depression developed by each shall overlap to such an extent that the points of least drawdown will be at the desired level after drainage.

**Depth and diameter.** The well depth and diameter shall be of such that the amount of water that can be drawn from the aquifer is sufficient to maintain the desired drawdown throughout the crop-growing season. Gravel envelopes may be used in conjunction with screens to serve as a filter and to increase the effective diameter of the well.

**Casing.** All wells shall be cased with steel, concrete, plastic, asbestos-cement, or other material of adequate strength and durability. The casing shall have a diameter that is adequate to accommodate the required pumping equipment.

**Screens.** All wells shall be equipped with manufactured screen sections, well points, shop-perforated metal casing sections, or field-perforated sections meeting the criteria stated below.

The screen openings for aquifer material of near uniform size shall be slightly smaller than the average diameter of the aquifer material. For graded aquifer materials (of nonuniform gradation), the screen openings shall be of such that 25 to 40 percent of the aquifer material is larger than the screen opening.

A sufficient length of screen shall be provided to maintain the entrance velocity of water into the well at an acceptable level, preferably less than 1/10 ft/s.

The position of the screen in the well shall be governed by the depth of the aquifer below the ground surface and the thickness of the aquifer to be penetrated by the well.

**Quality of water.** If the water from the well drain is to be used for human consumption, it shall meet all requirements of the state health department or other state agencies having jurisdiction. If the water has a high salt content or is not potable, means of disposal shall be planned and installed concurrently with the installation of the well, which will not adversely affect potable water sources and the environment.

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing well drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# **RANGE PLANTING**

(Acre)  
CODE 550

## **DEFINITION**

Establishment of adapted perennial vegetation such as grasses, forbs, legumes, shrubs, and trees.

## **PURPOSES**

This practice may be applied as part of a conservation management system to accomplish one or more of the following purposes:

- Restore a plant community similar to its historic climax or the desired plant community.
- Provide or improve forages for livestock.
- Provide or improve forage, browse or cover for wildlife.
- Reduce erosion by wind and/or water.
- Improve water quality and quantity.

## **CONDITIONS WHERE THIS PRACTICE APPLIES**

On rangeland, native or naturalized pasture, grazed forest or other suitable location where the principle method of vegetation management will be with herbivores. This practice shall be applied where desirable vegetation is below the acceptable level for natural reseeding to occur, or where the potential for enhancement of the vegetation by grazing management is unsatisfactory.

## **CRITERIA**

### **General Criteria Applicable For All The Purposes Stated Above.**

Species, cultivars or varieties selected, must be compatible with management objectives and adapted to climate conditions, soils, landscape position, (e.g., aspect) and range site(s).

Species, cultivars or varieties selected shall provide adequate cover to control erosion by wind and/or water within an acceptable period of time.

Seedbed preparation and planting methods will be suitable to meet any special needs for obtaining an acceptable establishment of planted materials.

Planting depths, dates, seeding rates, soil amendments and fertilizer needs for establishment, minimum seed quality standards, and management during the establishment period such as weed control and deferment from grazing shall be followed to enhance establishment success.

Seeding rates will be calculated on a pure live seed (PLS) basis or percent germination.

### **Additional Criteria For Improved Forages For Livestock.**

Selection of a species or combination of species shall be designed to meet the desired nutritional and palatability requirements for the kind and class of livestock.

Selection of species or combination of species shall be designed to meet the desired season of use or grazing period.

#### **Additional Criteria For Improved Water Quality And Quantity.**

Select a species or combination of species that will maintain a stable soil surface and increase infiltration.

Species that have high evapotranspiration rates, such as some woody species and phreatophytes, shall not be planted when watershed yields are the primary objective.

A mixture of shrubs and trees indigenous to the site shall be planted when riparian area, stream bank stability and water temperature criteria are important.

#### **Additional Criteria For Improving Forage, Browse Or Cover For Wildlife.**

Selection of planted species shall meet dietary and palatability requirements for the intended wildlife species.

Species will be selected and planted in a designed manner that will meet the cover requirements of the wildlife species of concern.

### **CONSIDERATIONS**

Planting materials selected should contribute to wildlife and aesthetics when opportunities exist.

Other practices such as Brush Management, Herbaceous Weed Management, or Grazing Land Mechanical Treatment may be used to promote a satisfactory site preparation to insure a successful range planting.

Use of certified planting materials should be encouraged, however, distance and source limitations on seed and planting stock should be considered in terms of logistics and costs.

Any special handling requirements for planting materials need to be followed for best results, (e.g., beards or awns on seed, hard seed coats, seed mixture ratios).

### **PLANS AND SPECIFICATIONS**

For standard plantings, appropriate forms, worksheets, etc. may be used to develop specifications and documentation. Plantings that require more detailed information, may require the use of other practices prior to planting and require a specific site specification prepared.

### **OPERATION AND MAINTENANCE**

**Operation:** Identify any required items needed to assist in stand establishment such as mowing, burning, flash grazing and herbicides to control weeds. Address insect and disease control needs where they are likely to create establishment problems.

**Maintenance:** Any necessary replanting due to drought, insects or other uncontrollable event which prevented adequate stand establishment should be addressed as soon as possible. Recommendations may vary from complete re-establishment to overseeding or spot replanting. Thin stands may only need additional grazing deferment during the growing season.

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# RECREATION AREA IMPROVEMENT

(Acre)  
CODE 562

## DEFINITION

Establishing grasses, legumes, vines, shrubs, trees, or other plants or selectively reducing stand density and trimming woody plants to improve an area for recreation.

## PURPOSE

To increase the attractiveness and usefulness of recreation areas and to protect the soil and plant resources.

## CONDITIONS WHERE PRACTICE APPLIES

On any area planned for recreation use.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, and transpiration.

### Water Quality

1. Effects of erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that could be carried by runoff. Important factors are short-term changes caused by construction (sediments, fuels, oils, and other chemicals) compared to long-term changes caused by the same substances resulting from recreation activities.
2. Effects of changes in ground water from infiltrating soluble substances associated with vegetation management and recreation activities.

## SPECIFICATIONS GUIDE

Treatments, plant materials, and maintenance measures for each type of recreation area.

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# RECREATION LAND GRADING AND SHAPING

(acre)  
CODE 566

## DEFINITION

Altering the surface of the land to meet the requirements of recreation facilities.

## SCOPE

This standard applies where modification of the land surface is required to permit installation of recreation facilities.

## PURPOSE

To permit effective use of the land area for recreation.

On sites where surface irregularities, slopes, kinds of soil, obstructions, or wetness interfere with planned recreational use; or where such use requires designed land surfaces.

Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects of grading on runoff and surface storage.
2. Effects of the amount and timing of decreased infiltration on evapotranspiration, change in soil moisture in the root zone, and deep percolation.

### Water Quality

1. Effects of erosion and sediment yield on changes in runoff. Factors are the slope of the land before and after grading, the results caused by the construction process, and the amount of vegetation reestablished on the graded or shaped site.
2. Effects on ground water quality of decreased loading of dissolved pollutants, particularly the dissolved nutrients from decaying surface residues.
3. Effects of increased recreation and activities on the quality of both surface and ground water quality.

## DESIGN CRITERIA

**Shaping.** If only shaping is required, the cuts and fills may be estimated by observation or by a minimum amount of work with engineer's level.

**Grading.** If grading to uniform surfaces is required, the design shall be based on a complete topographic or grid survey.

**Erosion control and drainage.** The requirements for erosion control and surface and subsurface drainage shall be included in the plan.

**Specific uses.** Grading and shaping for specific uses, such as athletic fields shall be according to the requirements of the intended use.

**Vegetation.** Distributed areas shall be established to vegetation as soon as practicable after grading. Seedbed preparation, seeding, fertilizing, and mulching shall comply with recommendations in technical guides.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for recreation land grading and shaping shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# RECREATION TRAIL AND WALKWAY

(ft)  
CODE 568

## DEFINITION

A pathway prepared especially for pedestrian, equestrian, and cycle travel.

## SCOPE

This standard applies to walkways and trails constructed in recreation and scenic areas.

## PURPOSE

To provide users of recreation areas with travel routed for activities such as walking, sightseeing, horseback riding, and bicycling; to prevent erosion; and to preserve and protect soil, plant, animal, and visual resources.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to lands where prepared paths, trails, and walkways are needed for effective and safe use of the recreation resources.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Impacts of impervious walkways and trails on increased surface runoff.
2. Changes in deep percolation with increased surface runoff. Consider evaporation losses before infiltration, evapotranspiration changes with decreased infiltration, and average changes in root zone storage.

### Water Quality

1. Change in ground water quality caused by decreased dissolved chemical infiltration.
2. Potential changes in erosion and sediment yield caused by increase runoff and temporary increases in erosion during construction.
3. Effects of dissolved chemicals in runoff resulting from recreation activities.

## DESIGN CRITERIA

**Visual resources.** Special attention shall be given to saving and maintaining key trees and other vegetation that have scenic value, provide shade, reduce erosion and runoff, provide den and food for wildlife, or add to the visual quality of the area.

**Grade.** Sustained grades shall be dictated by good judgment for the purpose intended, considering the topography, and shall not exceed 10 percent.

**Width.** Generally, the minimum treat width shall be 4 ft. The width in cuts for pedestrian trails on sidehill sections may be reduced to 3 ft if greater width would increase the cost materially or adversely affect the visual resources.

**Side slopes.** Cut and fill slopes shall be stable for the soil or soil material.

**Drainage.** Adequate drainage shall be provided. A raised or elevated trail or walkway may be required for wet sites that cannot be drained.

**Erosion control.** Plans shall include provisions for control of erosion. Distributed areas shall be established to vegetation as soon as practicable after construction. If soil or climatic conditions precludes the use of vegetation, and protection is needed, nonvegetative means, such as mulches or gravel, may be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with recommendations in technical guides.

**Bridges.** Bridges shall be designed for the maximum expected loading with an adequate factor of safety.

**Surfacing.** If surfacing is required for a firm trail, the surfacing material may be pit or creek-run gravel, concrete, asphalt, or other material that can withstand the traffic and the elements at the site.

**Safety.** Due consideration shall be given to safety. Protection from slides and falling rocks shall be provided, if needed. Adequate directional and warning signs, handrails, bridges, and culvert shall be placed as dictated by the site and intended use.

**Maintenance.** Provisions shall be made for maintaining all wearing surfaces, signs, and drainage structures.

**General.** Equestrian and pedestrian trails may vary from specific grades, widths, and clearing requirements if so dictated by location and topography.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing recreation trails and walkways shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# REGULATING WATER IN DRAINAGE SYSTEMS

(acre)  
CODE 554

## DEFINITION

Controlling the removal of surface or subsurface runoff, primarily through the operation of water-control structures.

## SCOPE

This standard applies to the regulation of surface and subsurface water outflow through drainage systems. This frequently requires other allied practices, (see "Design Criteria").

## PURPOSE

To conserve surface or subsurface water by controlling the outflow from drainage systems to maintain optimum soil moisture conditions. Such conservation of water will make it possible to:

1. Establish and encourage the growth of desired field or forest plants,
2. Reduce subsidence and wind erosion of organic soils, and
3. Hold water in channels in forest areas to act as ground-fire breaks and provide drinking water for wildlife and a resting and feeding place for waterfowl.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas where drainage is needed during certain periods and where it is advantageous to limit the outflow or pumping rate at other times. This practice is especially applicable in organic soils and in highly permeable soils of low available water capacity.

Regulation of outflow shall be undertaken only if soil water salinity or alkalinity is not likely to be a problem.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects of the water budget variations on the water supply either above or below the point of control.
2. Effects of changes in the flow of downstream water courses.

### Water Quality

1. Effects of outflow on erosion in downstream water courses.
2. Effects of possible changes in the yields of sediment and sediment-attached substances.
3. Potential for changes in dissolved chemical loading from nitrates and other salts including managing denitrification.
4. Salinity of soils and of ground and surface waters.
5. Effects on downstream temperatures.
6. Effects of the planned drainage outflow on the visual quality of discharge or downstream water.

## **DESIGN CRITERIA**

The water management system must have the depth, spacing, and capacity to provide the necessary drainage relief for the plants when controls are open. Control of outflow shall be by structures or pumps capable of removing the design flow or if regulating water stages in the drainage system. The outflow controls shall be related to the amount of water available and the degree of control necessary for soil and plant requirements.

The design of related water management practices will need to be coordinated with this practice for it to achieve its intended purpose.

For crops that are highly sensitive to excessive and inadequate soil water conditions, the field surface must be smooth, and the distance between the soil water level and the ground surface must be as uniform as practical. Fields shall be smoothed or graded, as required, to achieve this uniformity. Structures and pumps shall be located where they are accessible and subject to convenient control.

## **PLAN OF OPERATION**

A plan of operation shall be prepared for the system that will insure that the objectives are met. The plan of operation shall include such information as time and stage to hold water in ditches, pumping schedules, and coordination of water management operations in the system with rainfall, season, and crop and soil moisture needs.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for regulating water in drainage systems shall be in keeping with this standard and shall describe the requirements for properly installing and operating the practice to achieve its intended purpose.

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# **RESIDUE MANAGEMENT, MULCH TILL**

(Acre)  
CODE 329B

## **DEFINITION**

Managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round, while growing crops where the entire field surface is tilled prior to planting.

## **PURPOSES**

This practice may be applied as part of a conservation system to support one or more of the following:

- Reduce sheet and rill erosion.
- Reduce wind erosion.
- Maintain or improve soil organic matter content and tilth.
- Conserve soil moisture.
- Manage snow to increase plant available moisture.

Provide food and escape cover for wildlife.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all cropland and other land where crops are grown.

This standard includes tillage methods commonly referred to as mulch tillage, or chiseling and disking. It applies to stubble mulching on summer fallowed land, to tillage for annually planted crops, and to tillage for planting perennial crops.

## **CRITERIA**

### **General Criteria Applicable To All Purposes Named Above**

Loose residue to be retained on the field shall be uniformly distributed on the soil surface. Combines shall be equipped with spreaders capable of redistributing residue over at least 80 percent of the working width of the header.

Residue shall not be burned.

Tillage implements shall be equipped to operate through plant residues without clogging, and to maintain residue on or near the soil surface by undercutting or mixing.

Planters, drills, or air seeders shall be equipped to plant in residue distributed on the soil surface or mixed in the tillage layer.

The number, sequence, and timing of tillage and planting operations, and the selection of ground-engaging components, shall be managed to achieve the planned amount, distribution, and orientation of residue after planting or at other essential time periods. Acceptable alternative tillage sequences shall be initially determined by a residue budget using locally applicable data on residue production by crops and residue reduction by tillage machines. Further adjustments shall

be made as needed during the tillage sequence based on field measurements of remaining residue.

#### **Additional Criteria To Reduce Sheet And Rill Erosion**

The amount of residue needed to reduce erosion within the soil loss tolerance (T) or any other planned soil loss objective, shall be determined using current approved erosion prediction technology. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed. Calculations shall account for the effects of other practices in the conservation management system.

Tillage operations shall be limited to methods that leave residue on the surface and maintain the planned cover conditions.

#### **Additional Criteria To Reduce Wind Erosion**

The amount and orientation of residue needed to reduce erosion within the soil loss tolerance (T) or other planned soil loss objective shall be determined using current approved wind erosion prediction technology. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed. Calculations shall account for the effects of other practices in the conservation management system.

#### **Additional Criteria To Maintain Or Improve Soil Organic Matter Content**

The amount of residue and the number and type of tillage operations needed to achieve the desired soil condition, shall be determined using the current approved soil conditioning index procedure. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed. Calculations shall account for the effects of other practices in the conservation management system.

#### **Additional Criteria To Conserve Soil Moisture**

A minimum quantity of 50 percent residue cover shall be maintained throughout the year. Residue shall be evenly distributed and maintained on the soil surface. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed.

#### **Additional Criteria To Manage Snow To Increase Plant Available Moisture**

Stubble shall be left standing as high as possible by the harvesting operation, but not less than 6 inches in any case.

Stubble shall be maintained in a standing orientation over winter to trap and retain snow. Loose residue may be removed providing that the remaining residue is left standing. Fall tillage operations shall be limited to undercutting tools such as blades, sweeps, or deep tillage implements such as rippers or subsoilers, in order to maintain stubble in a standing condition through the months when snow occurs.

#### **Additional Criteria To Provide Food And Escape Cover For Wildlife**

The amount of residue and height of stubble needed to provide cover shall be determined using an approved habitat evaluation procedure. Residues shall not be removed unless it is determined by the habitat evaluation procedure that removal would not adversely affect habitat values. Stubble shall be maintained standing over winter. Tillage shall be delayed until spring, in order to maintain waste grain on the soil surface during winter.

## **CONSIDERATIONS**

Excess removal of plant residue by such means as baling or grazing often produces negative impacts on resources. These activities should not be performed without full evaluation of impacts on soil, water, animal, plants, and air.

Mulch till may be practiced continuously throughout the crop sequence, or may be managed as part of a residue management system that includes other tillage methods such as no till. Selection of acceptable tillage methods for specific site conditions may be aided by an approved Soil Tillage Suitability Rating.

Production of adequate amounts of crop residue necessary for the proper functioning of this practice can be enhanced by selection of high residue producing crops and crop varieties in the rotation, use of cover crops, and adjustment of plant populations and row spacings.

Where improvement of soil tilth is a concern, use of undercutting tools will enhance accumulation of organic material in the surface layer.

The effectiveness of stubble to trap snow increases with stubble height. Variable height stubble patterns may be created to further increase snow storage.

Leaving rows of unharvested crop standing at intervals across the field can enhance the value of residues for wildlife habitat.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and operation of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and O&M described in this standard. Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

No operation and maintenance requirements, national in scope, have been identified for this practice.

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# **RESIDUE MANAGEMENT, NO TILL/STRIP TILL**

(Acre)  
CODE 329A

## **DEFINITION**

Managing the amount, orientation and distribution of crop and other plant residues on the soil surface year-round, while growing crops in narrow slots, or tilled or residue free strips in soil previously untilled by full-width inversion implements.

## **PURPOSES**

This practice may be applied as part of a conservation management system to support one or more of the following:

- Reduce sheet and rill erosion.
- Reduce wind erosion.
- Maintain or improve soil organic matter content.
- Conserve soil moisture.
- Manage snow to increase plant available moisture or reduce plant damage from freezing or desiccation.
- Provide food and escape cover for wildlife.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all cropland and other land where crops are grown.

This standard includes tillage and planting methods commonly referred to as no till, zero till, slot plant, row till, zone till, or strip till.

## **CRITERIA**

### **General Criteria Applicable to All Purposes Named Above**

Loose residues to be retained on the field, shall be uniformly distributed on the soil surface. Where combines or similar machines are used for harvesting, they shall be equipped with spreaders capable of distributing residue over at least 80 percent of the working width of the header.

Planters or drills shall be equipped to plant directly through untilled residue or in a tilled seedbed prepared in a narrow strip along each row by planter attachments such as rotary tillers, sweeps, multiple coulters, or row cleaning devices.

Residues shall not be burned, or disturbed by full-width tillage operations except as follows:

- Seedbed preparation, planting, and fertilizer placement shall disturb no more than one third of the row width. The row area formed by the planting operation shall be level with or slightly above the adjacent row middles unless the rows are planted on the contour.
- If row cultivation or spot treatment for weed escapes, leveling ruts, or similar operations become necessary, tillage shall be limited to undercutting operations which minimize burial of surface residue.

### **Additional Criteria to Reduce Sheet and Rill Erosion**

The amount of randomly distributed, flat residue needed to reduce erosion within the soil loss tolerance (T) or any other planned soil loss objective, shall be determined using current approved erosion prediction technology. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed. Calculations shall account for the effects of other practices in the conservation management system.

### **Additional Criteria to Reduce Wind Erosion**

The amount and orientation of residue needed to reduce erosion within the soil loss tolerance (T) or other planned soil loss objective shall be determined using current approved wind erosion prediction technology. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed.

Calculations shall account for the effects of other practices in the conservation management system.

### **Additional Criteria to Maintain or Improve Soil Organic Matter Content**

The amount of residue needed to achieve the desired soil condition, shall be determined using the current approved soil conditioning index procedure. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed. Calculations shall account for the effects of other practices in the conservation management system.

### **Additional Criteria to Conserve Soil Moisture**

A minimum quantity of 50 percent residue cover shall be maintained throughout the year. Residue shall be evenly distributed and maintained on the soil surface. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed.

### **Additional Criteria to Manage Snow to Increase Plant Available Moisture or Reduce Plant Damage From Freezing or Desiccation**

Stubble shall be left standing as high as possible by the harvesting operation, but not less than 6 inches in any case. Stubble shall remain standing over winter to trap and retain snow. Loose residue may be removed providing that the remaining residue is left standing.

When crops are planted in the fall, the width of the tilled strip or slot shall be no more than one third of the row width, in order to reduce the disturbance of standing stubble.

### **Additional Criteria to Provide Food and Escape Cover for Wildlife**

Residue height, amount, and time period shall be determined using an approved habitat evaluation procedure. Residues shall not be removed unless it is determined by the habitat evaluation procedure that removal would not adversely affect habitat values.

## **CONSIDERATIONS**

No till or strip till may be practiced continuously throughout the crop sequence, or may be managed as part of a system which includes other tillage and planting methods such as mulch till. Selection of acceptable tillage methods for specific site conditions may be aided by an approved Soil Tillage Suitability Rating.

Production of adequate amounts of crop residues necessary for the proper functioning of this practice can be enhanced by selection of high residue producing crops and crop varieties in the rotation, use of cover crops, and adjustment of plant populations and row spacings.

Maintaining a continuous no till system will maximize the improvement of soil organic matter content. Also, when no till is practiced continuously, soil reconsolidation provides additional resistance to sheet and rill erosion.

The effectiveness of stubble to trap snow or reduce plant damage from freezing or desiccation increases with stubble height. Variable height stubble patterns may be created to further increase snow storage.

Leaving rows of unharvested crop standing at intervals across the field can enhance the value of residues for wildlife habitat.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and operation of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation and Maintenance described in this standard. Specifications shall be recorded using approved specification 329A – 3 sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

No operation and maintenance requirements, national in scope, have been identified for this practice.

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# **RESIDUE MANAGEMENT, RIDGE TILL**

(Acre)  
CODE 329C

## **DEFINITION**

Managing the amount, orientation, and distribution of crop and other plant residues on the soil surface year-round, while growing crops on preformed ridges alternated with furrows protected by crop residue.

## **PURPOSES**

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

- 
- Reduce sheet and rill erosion.
- Reduce wind erosion.
- Maintain or improve soil organic matter content and tilth.
- Manage snow to increase plant available moisture.
- Modify cool wet site conditions.
- Provide food and escape cover for wildlife

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all cropland and other land where crops are grown.

This standard includes tillage and planting methods commonly referred to as ridge till or ridge planting. It does not include no till planting on ridges, or bedding or listing operations which bury crop residues.

## **CRITERIA**

### **General Criteria Applicable to All Purposes Named Above**

Following crop harvest and any secondary residue removal, residues shall be maintained until planting with no additional disturbance except for normal weathering.

Ridge height shall be maintained throughout the harvest and winter seasons by controlling equipment or livestock traffic.

After planting, residues shall be maintained in the furrows until the ridges are rebuilt by cultivation. Ridges shall be rebuilt to their original height and shape during the last row cultivation.

Loose residues to be retained on the field shall be uniformly distributed on the soil surface. Cultivation and planting equipment designed to operate on ridges shall be used, such as cultivators equipped with ridging attachments, and planters equipped with ridge planting attachments such as row cleaning devices and guidance systems.

### **Additional Criteria to Reduce Sheet and Rill Erosion**

The amount and placement of residue needed, and the orientation of ridges in relation to the contour, shall be determined using current approved erosion prediction technology. Calculations shall account for the effects of other practices in the conservation management system. Partial removal of residue by means such as baling or grazing, shall be limited to retain the amount needed.

Planting and fertilizer placement shall disturb no more than one third of the row width. Soil and residue removed from the top of the ridge shall be moved into the furrow between the ridges.

After planting, the top of the ridge shall be maintained at least 3 inches higher than the furrow between the ridges.

The ridge shall be shaped to prevent erosion along the row by directing runoff to the protected furrow area.

### **Additional Criteria to Reduce Wind Erosion**

The amount and orientation of residue needed during periods when wind erosion is expected to occur, shall be determined using current approved wind erosion prediction technology. Partial removal of residue by means such as baling or grazing, shall be limited to retain the amount needed. Calculations shall account for the effects of ridge height, spacing, and direction, and of other practices in the conservation management system.

### **Additional Criteria to Maintain or Improve Soil Organic Matter Content and Tilth**

The amount of residue needed to achieve the desired soil condition, shall be determined using the current approved soil conditioning index procedure. Partial removal of residue by means such as baling or grazing shall be limited to retain the amount needed. Calculations shall account for the effects of other practices in the conservation management system.

Cultivation to rebuild ridges shall be done using tools which maintain residues in the surface layer.

### **Additional Criteria to Manage Snow to Increase Plant Available Moisture**

Stubble shall be left standing as high as possible by the harvesting operation, but not less than 6 inches in any case. Stubble shall be maintained standing over winter to trap and retain snow. In cases where the 6 inch stubble height cannot be achieved, ridges shall be oriented not to exceed 45 degrees from perpendicular to the prevailing wind direction during periods of expected snow cover.

### **Additional Criteria To Modify Cool Wet Site Conditions**

Ridge height prior to planting shall not be less than 6 inches. After planting, the top of the ridge shall be maintained at least 3 inches higher than the furrow between the ridges.

### **Additional Criteria to Provide Food and Escape Cover for Wildlife**

The amount of residue and height of stubble needed to provide cover during winter months shall be determined using an approved habitat evaluation procedure. Residues shall not be removed unless it is determined by the habitat evaluation procedure that removal will not adversely affect habitat values. Stubble shall be maintained standing over winter.

## **CONSIDERATIONS**

Burning of plant residue or excess removal of residue by such means as baling or grazing often produces negative impacts on resources. These activities should not be performed without full evaluation of impacts on soil, water, animal, plants, and air resources.

Ridge till may be practiced continuously throughout some crop sequences, or may be managed as part of a residue management system which includes other tillage and planting methods such as mulch till or no till. In mixed systems, ridges must be periodically re-established. Selection of acceptable tillage methods for specific site conditions may be aided by an approved Soil Tillage Suitability Rating.

Production of adequate amounts of crop residues necessary for the proper functioning of this practice can be enhanced by selection of high residue producing crops and crop varieties in the rotation, use of cover crops, and adjustment of plant populations and/or row spacings. By providing a choice of weed control methods, this practice can reduce herbicide requirements when used in a conservation management system.

Where improvement of soil tilth is a concern, continuous ridge planting will allow organic material to accumulate in the surface horizon. Reconstruction of ridges in the same row area year after year will maximize organic matter buildup and biological activity in the row.

Soil compaction may be reduced by controlled traffic, where wheel traffic from all operations is limited to the area between designated rows or traffic areas.

Where ridges direct runoff to areas of concentrated flow, these areas can be protected by grassed waterways, water and sediment control basins, underground outlets, or other suitable practices.

The value of residues for wildlife habitat can be enhanced by leaving rows of unharvested crop standing at intervals across the field.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and operation of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation and Maintenance described in this standard. Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

No operation and maintenance requirements, national in scope, have been identified for this practice.

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# RESIDUE MANAGEMENT, SEASONAL

(Acre)  
CODE 344

## DEFINITION

Managing the amount, orientation, and distribution of crop and other plant residues on the soil surface during part of the year, while growing crops in a clean tilled seedbed.

## PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following:

- 
- Reduce sheet and rill erosion.
- Reduce soil erosion from wind.
- Manage snow to increase plant available moisture.
- Provide food and escape cover for wildlife.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all cropland and other land where crops are grown.

This standard includes residue management methods practiced during the part of the year from harvest until residue is buried by tillage for seedbed preparation.

## CRITERIA

### General Criteria Applicable to All Purposes Named Above:

Loose residue to be retained on the field shall be uniformly distributed on the soil surface. Where combines or similar machines are used for harvesting, they shall be equipped with spreaders capable of redistributing residues over at least 80 percent of the working width of the header.

Residues shall not be burned.

### Additional Criteria to Reduce Sheet and Rill Erosion

The amount of residue needed to reduce erosion within the soil loss tolerance (T) or any other planned soil loss objective, shall be determined using current approved erosion prediction technology. Partial removal of residue by means such as baling or grazing, shall be limited to retain the amount needed. The remaining residue shall be maintained on the surface through periods when sheet and rill erosion has the potential to occur, or until planting, whichever occurs first. Calculations shall account for the effects of other practices in the conservation management system.

Any tillage that occurs during the management period shall be limited to methods which leave residue on the surface and maintain the planned cover conditions.

### **Additional Criteria to Reduce Soil Erosion From Wind**

The amount of residue needed to reduce erosion within the soil loss tolerance (T) or any other planned soil loss objective, shall be determined using current approved wind erosion prediction technology. Partial removal of residue by means such as baling or grazing, shall be limited to retain the amount needed. The remaining residue shall be maintained on the surface through periods when soil erosion by wind has the potential to occur, or until planting, whichever occurs first. Calculations shall account for the effects of other practices in the conservation management system.

Any tillage that occurs during the management period shall be limited to methods which leave residue on the surface and maintain the planned cover conditions.

### **Additional Criteria to Manage Snow to Increase Plant Available Moisture**

Stubble shall be left standing as high as possible by the harvesting operation, but not less than 6 inches in any case.

Stubble shall be maintained in a standing orientation over winter to trap and retain snow. Any tillage that occurs during this period shall be limited to undercutting tools such as blades, sweeps, or deep tillage implements such as rippers or subsoilers.

Loose residue may be removed providing that the remaining residue is left standing.

### **Additional Criteria to Provide Food and Escape Cover for Wildlife**

The amount of residue, height of the stubble, and length of the management period necessary for meeting habitat requirements for the target species or wildlife population shall be determined using an approved habitat evaluation procedure.

Residues shall not be removed unless it is determined by the habitat evaluation procedure that such removal will not adversely affect habitat values.

Tillage shall be delayed until the end of the management period to maintain the food and cover value of the residue.

## **CONSIDERATIONS**

Excess removal of plant residue by baling or grazing often produces negative impacts on resources. These activities should not be performed without full evaluation of impacts on soil, water, animal, plant, and air resources.

Production of adequate amounts of crop residue necessary for the proper functioning of this practice can be enhanced by selection of high residue producing crops and crop varieties, by the use of cover crops, and by adjustment of plant populations and row spacing.

When planting on a clean seedbed, exposure to erosion can be minimized by completing tillage and planting in a single operation, or by performing primary tillage no more than three days before planting.

When planting on a clean seedbed in areas with limited moisture, moisture for germination can be increased by completing tillage and planting in a single operation, or by performing primary tillage no more than three days before planting.

The effectiveness of stubble to trap snow increases with stubble height. Variable height stubble patterns may be created to further increase snow storage.

The value of residue for wildlife habitat can be enhanced by leaving rows of unharvested crop standing at intervals across the field.

## **PLANS AND SPECIFICATIONS**

Specifications for establishment and operation of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and O&M described in this standard.

Specifications shall be recorded using approved certification sheets, job sheets, narrative statements in the conservation plan, or other acceptable methods.

## **OPERATION AND MAINTENANCE**

No operation and maintenance requirements, national in scope, have been identified for this practice.

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# RESTORATION AND MANAGEMENT OF DECLINING HABITATS

(acre)  
CODE 643

## DEFINITION

Restoring and conserving rare or declining native vegetated communities and associated wildlife species.

## PURPOSE

- Restore land or aquatic habitats degraded by human activity
- Provide habitat for rare and declining wildlife species by restoring and conserving native plant communities.
- Increase native plant community diversity.
- Management of unique or declining native habitats.

Note: NRCS uses the term “wildlife” to include all animals, terrestrial and aquatic.

## CONDITIONS WHERE PRACTICE APPLIES

On any landscape which once supported or currently supports the habitat to be restored or managed.

## CRITERIA

### General Criteria Applicable to All Purposes

- Methods used will be designed to protect the soil resource from erosion.
- Vegetative manipulations to restore plant and/or animal diversity can be accomplished by prescribed burning or mechanical, biological or chemical methods, or a combination of the four.
- Management measures must be provided to control invasive species and noxious weeds in order to comply with state noxious weed laws.
- To benefit insect food sources for grassland nesting birds, spraying or other control of noxious weeds will be done on a “spot” basis to protect forbs and legumes that benefit native pollinators and other wildlife.
- Management practices and activities are not to disturb cover during the primary nesting period in each state. Exceptions could be granted for periodic burning or mowing when necessary to maintain the health of the plant community. Mowing may be needed during the establishment period to control weeds.
- Rotate periodic planned management or other treatments throughout the restored/managed area.
- Where feasible prescribed burning will be utilized instead of mowing.
- Species will be adapted to soil-site conditions.
- Species will be suitable for the planned purpose.
- Seeding rates will be adequate to accomplish the planned purpose.
- Only certified, high quality, and ecologically adapted native seed and plant material will be used.
- Planting dates, and care in handling and planting of the seed or plant material will ensure that established vegetation will have an acceptable rate of survival.
- Site preparation shall be sufficient for establishment and growth of selected species.

- Timing and use of equipment will be appropriate for the site and soil conditions.

## **CONSIDERATIONS**

Confer with other agencies and organizations to develop guidelines and specifications for conserving declining habitats.

In many cases threatened and endangered species or species of concern will benefit from conservation of declining habitats. Follow-up habitat assessments shall be performed on a regular basis.

Haying and grazing will be planned and managed as necessary to achieve and maintain the intended purpose.

All habitat manipulations will be planned and managed according to soil capabilities and recommendations for management will avoid excessive soil loss.

Plant materials centers and commercial growers should be encouraged to develop plant materials for habitat restorations.

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# **RIPARIAN FOREST BUFFER**

(Acre)  
CODE 391A

## **DEFINITION**

An area of trees and/or shrubs located adjacent to and up-gradient from water bodies.

## **PURPOSES**

- Create shade to lower water temperatures to improve habitat for aquatic organisms.
- Provide a source of detritus and large woody debris for aquatic organisms and habitat for wildlife.
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

## **CONDITIONS WHERE PRACTICE APPLIES**

On areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge.

## **CRITERIA**

### **General Criteria Applicable To All Purposes Named Above.**

The location, layout and density of the riparian forest buffer will accomplish the intended purpose and function. The buffer will consist of a zone (identified as zone 1) that begins at the normal water line, or at the top of the bank, and extend a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water body.

Dominant vegetation will consist of existing or planted trees and shrubs suited to the site and the intended purpose. Occasional removal of some tree and shrub products such as high value trees is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance.

Necessary site preparation and planting shall be done at a time and manner to insure survival and growth of selected species. Only viable, high quality, and adapted planting stock will be used. Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose.

Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

### **Additional Criteria To Reduce Excess Amounts of Sediment, Organic Material, Nutrients and Pesticides in Surface Runoff and Reduce Excess Nutrients and Other Chemicals in Shallow Ground Water Flow.**

An additional strip or area of land, zone 2, will begin at the edge and up-gradient of zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water body. The minimum combined width of zones 1 and 2 will be 100 feet or 30 percent of the geomorphic flood plain whichever is less, but not less than 35 feet.

Criteria for zone 1 shall apply to zone 2 except that removal of tree and shrub products such as timber, nuts and fruit is permitted on a periodic and regular basis provided the intended purpose is not compromised by loss of vegetation or harvesting disturbance.

Concentrated flow erosion or mass soil movement shall be controlled in the up-gradient area immediately adjacent to zone 2 prior to establishment of the riparian forest buffer. This area is delineated and identified as zone 3. Zone 3 shall be designed in accordance with criteria in the Filter Strip (393A).

### **CONSIDERATIONS**

The severity of bank erosion and its influence on existing or potential riparian trees and shrubs should be assessed. Watershed-level treatment or bank stability activities may be needed before establishing a riparian forest buffer.

Where ephemeral, concentrated flow erosion and sedimentation is a concern in zone 3, consider the application of a vegetated strip consisting of grasses and forbs. When concentrated flow erosion and sedimentation cannot be controlled vegetatively, consider structural or mechanical treatments.

Favor tree and shrub species that are native and have multiple values such as those suited for timber, biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides.

Avoid tree and shrub species which may be alternate hosts to undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

Woody phreatophytes and hydrophytes that deplete ground water should be used with caution in water-deficit areas.

The location, layout and density of the buffer should compliment natural features.

### **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

### **OPERATION AND MAINTENANCE**

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

The riparian forest buffer will be inspected periodically and protected to maintain the intended purpose from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition will be continued until the buffer is, or will progress to, a fully functional condition.

As applicable, control of concentrated flow erosion or mass soil movement shall be continued in zone 3 to maintain buffer function.

Any removals of tree and shrub products shall be conducted in a manner that maintains the intended purpose.

Any use of fertilizers, pesticides and other chemicals to assure buffer function shall not compromise the intended purpose.

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# RIPARIAN HERBACEOUS COVER

(acre)  
CODE 390

## DEFINITION

Riparian areas are ecosystems that occur along water courses or at the fringe of water bodies. Riparian herbaceous cover consist of grasses, grasslike plants, and forbs.

## PURPOSE

Riparian areas serve the following functions:

Riparian areas provide habitat (food, shelter, and water) for aquatic and terrestrial organisms.

Intercept direct solar radiation, create shade, and increase the depth to width ratio to help maintain or restore suitable water temperatures for fish and other aquatic organisms while providing a milder microclimate for wildlife.

Improve and protect water quality by reducing the amount of sediment and other pollutants, such as pesticides, organic, and nutrients in surface runoff as well as nutrients and chemicals in shallow ground water flow.

Provide food, in the form of plant detritus, for aquatic insects which are important food items for fish.

Help stabilize the channel bed and streambank.

To serve as corridors to provide landscape linkages between existing habitats.

Provide room for water courses to establish geomorphic stability.

To manage existing riparian herbaceous habitat to improve or maintain desired plant communities.

## CONDITION WHERE PRACTICE APPLIES

Along water courses or on the fringe of water bodies where the natural plant community is dominated by herbaceous vegetation.

Where the ecosystem has been altered and the potential natural plant community has changed or has been converted to cropland, pastureland, grazing land, etc.

## CRITERIA

### General Criteria Applicable to All Purposes

Select native species that are adapted to site conditions and provide diversity, cover and food for wildlife. Species selected should also provide a deep, binding root mass to strengthen streambanks and improve soil health.

Protect and enhance riparian vegetation and water quality by reducing the use of that vegetation for haying and grazing until the desired plant community is well established. A plan for limited livestock grazing or haying will be designed to protect and enhance established and emerging vegetation, stream bank stability, wildlife habitat, and out of the stream during critical periods for aquatic species.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Management systems applied will be designed to maintain the vigor and reproduction of the desired plant community. Timing of haying or grazing periods will avoid periods when streambanks are saturated and vulnerable to livestock or mechanical damage.

The plant communities established and target successional stage will depend on wildlife needs, existing resources in the watershed, and local management objectives.

Necessary site preparation and planting shall be done at a time and manner to insure survival and growth of selected species. Only viable, high quality, and adapted planting stock will be used. Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose.

The management plan shall consider habitat and wildlife objectives such as: habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors, and native plant communities.

Riparian widths will vary depending on the requirements of wildlife species and associated environmental concerns.

Other applicable practices include, but are not limited to:

Streambank and Shoreline Protection - 580

Stream Channel Stabilization - 584

Vegetative Bioengineering - NCS

Fence - 382

Riparian Forest Buffer - 391

Pasture and Hayland Planting - 512

Range Planting - 550

#### **Additional Criteria to Protect or Improve Water Quality**

Concentrated flow erosion or mass soil movement shall be controlled in the up gradient area prior to establishment of the riparian herbaceous cover.

The native or natural plant community should be managed and maintained to optimize functions of the riparian zone which control erosion and maintain water quality.

## **CONSIDERATIONS**

Site hydrology must be considered. Plant species selected must be adapted to the duration of saturation and inundation of the site.

Channel and streambank stability must be considered in selecting this practice or determining that this practice may need to be combined with other practices that better address stability issues.

This practice can be combined with filter strips to improve water quality.

Considerations should be given to how this practice will provide riparian habitat and linkage to other habitats.

Target riparian buffer restoration on a watershed basis to address habitat fragmentation, connectivity, and provide corridors for wildlife by maintaining continuous streamside vegetation.

Establish alternative water sources or controlled access stream crossings to manage livestock access to the stream and riparian area.

Select plant species that are native and have multiple values such as those suited for biomass, nesting, aesthetics, and tolerance to locally used herbicides.

Avoid plant species which may be alternate hosts to undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

The location, layout and density of the buffer should compliment natural features.

Corridor configuration, species planted, and management should enhance habitats for threatened, endangered, and other species of concern, where applicable.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specification shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

The purpose of operation, maintenance, and management is to insure that the practice functions as intended over time.

The riparian area will be inspected periodically and protected to maintain the intended purpose from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage and fire.

As applicable, control of concentrated flow erosion or mass soil movement shall be continued in the up-gradient area to maintain riparian function.

Any use of fertilizers, pesticides and other chemicals to assure riparian area function shall not compromise the intended purpose.

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# **ROCK BARRIER**

(ft)  
**CODE 555**

## **DEFINITION**

A rock retaining wall constructed across the slope to form and support a bench terrace that will control the flow of water and check erosion on sloping land.

## **SCOPE**

This standard applies to all rock barriers 6 ft or less in height on land slopes as much as 50 percent.

## **PURPOSE**

To stabilize steeply sloping land so that it can be farmed with a minimum of soil loss.

## **CONDITIONS WHERE PRACTICE APPLIES**

Rock barriers are applicable to land suitable for cultivation where soil depth is adequate for benching and where the effectiveness of less intensive measures for soil and water conservation would be questionable. Suitable natural outlets or satisfactory sites for constructing outlets must be available.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Potential for change in plant growth and transpiration because of changes in the volume of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses.
4. Effects on the volume of downstream flow to prohibit undesirable environmental, social or economic effects.
5. The effect on the water table of the field to ensure that it will provide a suitable rooting depth for anticipated land uses.
6. Potential use for water management.

### **Water Quality**

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
2. Effects of the use and management of nutrients and pesticides on surface and ground water quality.
3. Effects on the visual quality of downstream water resources.
4. Short-term and construction-related effects on this practice on the quality of downstream water.
5. Potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive soil layers.

6. Potential for earth moving to uncover or redistribute toxic materials, or low productive soils.
7. Effects on the movement of dissolved substances below the root zone toward ground water.
8. Effects on wetlands or water-related wildlife habitats associated with the practice.

## **DESIGN CRITERIA**

**Grade.** The top of the rock barrier may be level or have a grade toward the outlet. Maximum grade shall be 0.5 percent.

**Cross slope.** The bench between barriers shall have a negative slope from the top of one barrier to the toe of the upslope barrier. Cross slopes shall have a grade of 1.0 to 3.0 percent.

**Surface drain.** Surface drainage shall be provided by a longitudinal ditch not less than 0.5 ft<sup>2</sup> in area along the toe of the upslope barrier.

**Height.** The height of the rock barrier shall not exceed 6 ft.

**Base width.** The minimum base width shall be 18 in, plus 1.5 in. for each 0.5 ft of height in excess of 2.5 ft. The exposed face of the barrier shall have a batter of 3 in./ft of height.

**Vertical interval.** Vertical interval between adjacent benches shall not exceed 5 ft.

**Horizontal interval.** The minimum horizontal distance between barriers shall 10 ft.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing rock barriers shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# ROOF RUNOFF MANAGEMENT

(No.)  
CODE 558

## DEFINITION

A facility for collecting, controlling, and disposing of runoff water from roofs.

## SCOPE

This standard establishes the minimally acceptable requirements for design, construction, and operation of roof management facilities. Such facilities include but are not limited to erosion-resistant channel or subsurface drains with rock-filled trenches along building foundations below eaves, roof gutters, downspouts, and appurtenances.

## PURPOSE

To prevent roof runoff water from flowing across concentrated waste areas, barnyards, roads, and alleys, and to reduce pollution and erosion, improve water quality, prevent flooding, improve drainage, and protect the environment.

## CONDITIONS WHERE PRACTICE APPLIES

The practice applies where: (1) a roof runoff management facility is included in an overall plan for a waste management system; (2) roof runoff water may come in contact with wastes or cause soil erosion; and (3) barnyard flood protection or improved drainage is needed.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on downstream flows or aquifers that would affect other water uses.
3. Potential use for water management to conserve water.

### Water Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
2. The effects on wetland and water-related wildlife habitats associated with the practice.

## DESIGN CRITERIA

Capacity. Design of roof runoff management facilities shall be based on the runoff from a 10-year frequency, 5-minute rainfall except that a 25-year frequency, 5-minute rainfall shall be used to design such facilities for exclusion of roof runoff from waste treatment lagoons, waste storage ponds, or similar practices. Rainfall from figures 1 and 2 or reliable local records may be used for design.

**Materials.** Roof gutters and downspouts may be made of aluminum, galvanized steel, wood, or plastic. Aluminum gutters and downspouts shall have a nominal thickness of at least 0.07 and 0.05 cm, (0.027 and 0.020 in), respectively. Galvanized steel gutters and downspouts shall be at least 28 gage. Wood shall be clear and free of knots. A water repellent preservative shall be applied to the flow of areas of wood other than redwood, cedar, or cypress. Plastics shall contain ultraviolet stabilizers. Dissimilar metals shall not be in contact with each other.

**Supports.** Gutter supports shall have sufficient strength to withstand anticipated water, snow, and ice loads. They shall have a maximum spacing of 120 cm (48 in) for galvanized steel and 81 cm (32 in) for aluminum or plastic. Wood gutters shall be mounted on fascia boards using furring blocks that are a maximum of 61 cm (24 in) apart. Downspouts shall be securely fastened at the top and bottom with intermediate supports that are a maximum of 3 m (10 ft) apart.

**Outlets.** The water from roof runoff management facilities may empty into surface drains or underground outlets, or onto the ground surface. When downspouts empty onto the ground surface, there shall be an elbow to direct water away from the building and splash blocks or other protection shall be provided to prevent erosion.

**Protection.** Roof runoff management facilities and outlets shall be protected from damage by livestock and equipment. Where appropriate, snow and ice guards may be installed on roofs to protect gutters and reduce the hazard to humans and animals below. Gutters may be installed below the projection of the roof line to further reduce gutter damage from snow and ice.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing roof runoff management facilities shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

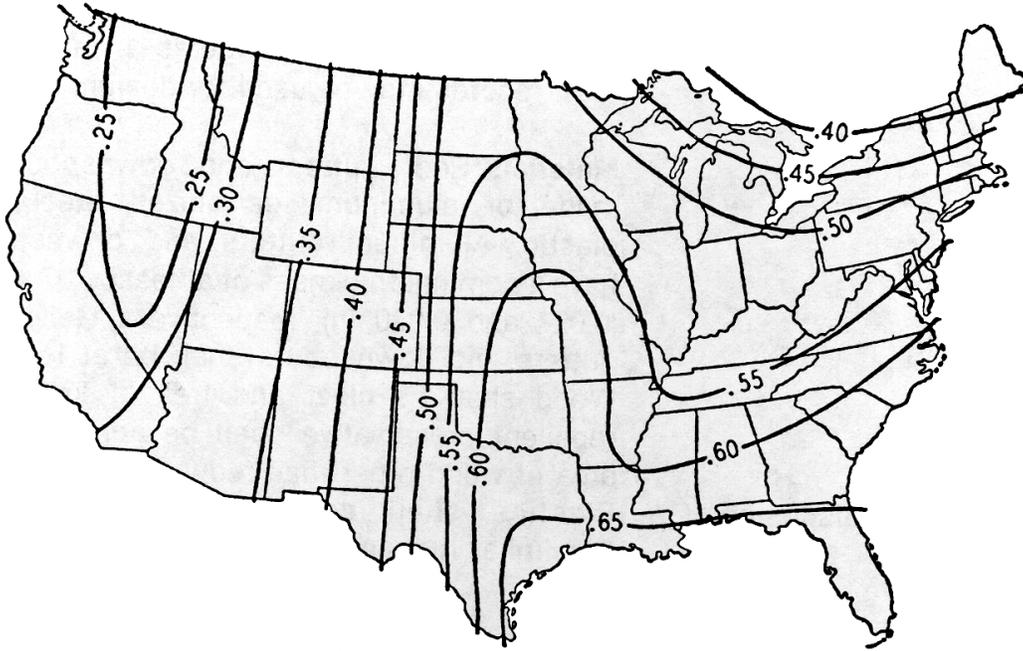


Figure 1.—Ten-year frequency, five-minute rainfall (inches).

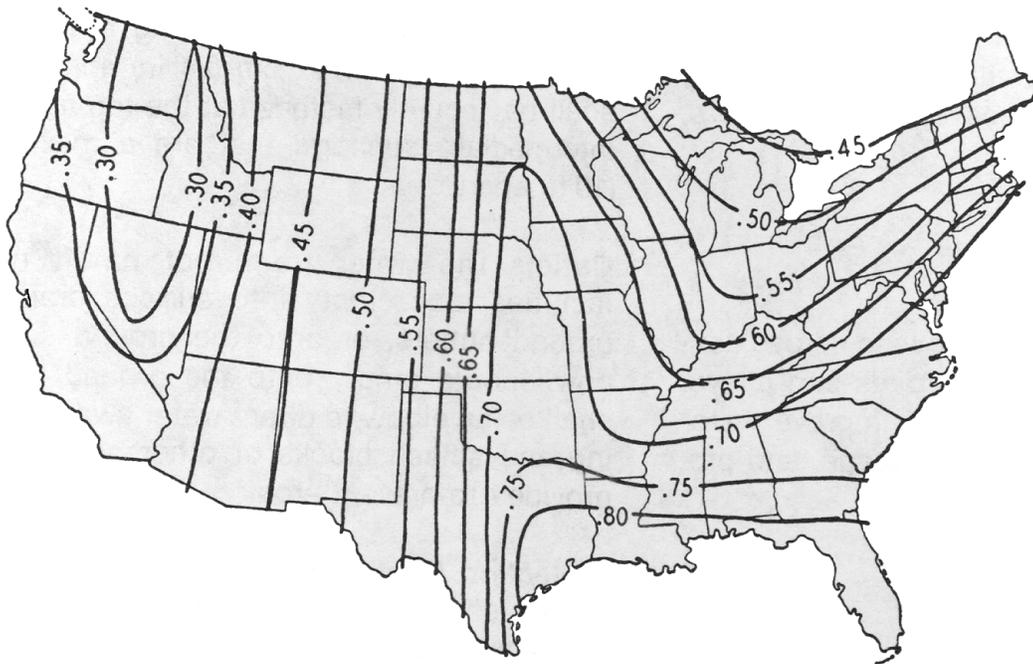


Figure 2.—Twenty-five-year frequency, five-minute rainfall (inches).

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# ROW ARRANGEMENT

(acre)  
CODE 557

## DEFINITION

Establishing a system of crop rows on planned grades and lengths primarily for erosion control and water management.

## SCOPE

This standard applies to row arrangement on all cropland where crops are grown in rows and a problem of inadequate drainage, soil erosion, or inadequate use of available rainfall or irrigation water exists.

## PURPOSE

To establish crop rows in direction, grade, and length so as to provide adequate drainage and erosion control and permit optimum use of rainfall and irrigation water.

## CONDITIONS WHERE PRACTICE APPLIES

Proper row arrangement is applicable:

1. As part of a surface drainage system for a field where the rows are planned to carry excess water to surface drains.
2. To facilitate optimum use of water in graded furrow irrigation systems.
3. In dryland areas where it is necessary to control the grade of rows to use available rainfall more fully.
4. On sloping land, with or without other conservation practices, where control of the length, grade, and direction of rows can help reduce soil erosion.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects upon components of the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of effects caused by seasonal or climatic changes.
3. Effects of vegetation on soil moisture.
4. Effects of snowcatch and melt on water budget components.
5. The potential for a change in plant growth and transpiration because of changes in the volume of soil water.
6. Effects on downstream flows or aquifers that would affect other water uses or users.
7. Effects on the volume of downstream flow to prohibit undesirable environmental, social or economic effects.
8. The effect on the water table of the field to ensure that it will provide a suitable rooting depth for anticipated land uses.
9. Potential use for water management to conserve water.

## **Water Quality**

1. Effects of both growing and decaying vegetation or nutrient balance in the root zone.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Effects on the visual quality of downstream water resources.
4. Effects on the movement of dissolved substances below the root zone and toward ground water.
5. Effects of water levels on solid nutrient processes such as plant nutrient use.
6. Effects of soil and water level control on the salinity of soils, soil water or downstream water.
7. Effects on wetlands and water-related wildlife habitats.
8. Effects on the field nutrient budget as related to removal, residence, and accumulation of nutrients.

## **DESIGN CRITERIA**

**General.** Row arrangement shall facilitate the use of applicable field machinery in the field.

**Surface drainage.** As part of a surface drainage system, row arrangement shall:

1. Conform with the drainage part of the technical guide for the area regarding grade and length.
2. Facilitate flow of excess water from the field into surface ditches.

**Furrow irrigation.** As part of a furrow irrigation system, row arrangement shall:

1. Conform with the irrigation guide for the areas regarding grade and length.
2. Facilitate irrigation water management in the field.

**Erosion control and water conservation.** As part of an erosion control and/or water conservation system for a field, row arrangement shall:

1. Conform with the technical guide for the area for the particular practice for which the row arrangement is a facilitating measure.
2. Conform with the grade and length requirements for terraced if the arrangement is used without and other engineering practice.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for row arrangements shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# **RUNOFF MANAGEMENT SYSTEM**

(No. and acre)

**CODE 570**

## **DEFINITION**

A system for controlling excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances.

## **SCOPE**

This standard applies to the planning, design, installation, operation, and maintenance of runoff management systems, including adequate outlet facilities and components required for adequate management of storm runoff, as determined by site conditions.

## **PURPOSE**

Mainly to regulate the rate and amount of runoff and sediment from development sites during and after construction operations to minimize such undesirable effects as flooding, erosion, and sedimentation.

## **CONDITIONS WHERE PRACTICE APPLIES**

The practice applies if there is a need to control runoff, erosion, and sedimentation to compensate for increased peak discharges and erosion resulting from construction operations at development sites or from other changes in land use. The discharges may be caused by such factors as increased runoff, reduced time of concentration, reduced natural storage.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects of onsite detention on decreased runoff volume and peak flow, potentially increased infiltration, and the effectiveness of infiltration devices and controlled outlets.
2. Potential changes in evapotranspiration of vegetation in the infiltration areas and changes in soil moisture storage and volume of deep percolation.

### **Water Quality**

1. Effects of reduction in erosion and sediment yield, with reductions in construction related pollutants adsorbed on sediments, such as fields and oils.
2. Effects of increases in dissolved nutrients and other chemicals through increased infiltration and deep percolation.
3. Effects on the visual quality of decreased sediment in downstream water resources.

## **DESIGN CRITERIA**

**Overall.** A runoff management system must be compatible with the flood plain management program of the local jurisdiction and with local regulations for controlling sediment, erosion, and runoff. The system, a single component or a combination of components, must properly regulate storm discharges from a site to a safe, adequate outlet. Consideration shall be given to the

duration of flow as well as the peak discharge. Adequate erosion-control measure and other water-quality practices must be provided. The components must be planned and designed to insure minimal impact on visual quality and human enjoyment of the landscape. Structures and materials must harmonize with surrounding areas.

The peak discharge from the 2-year and 100-year, 24-hour storms shall be analyzed. No increase in peak from these storms shall be allowed unless downstream increases are compatible with the overall flood plain management system.

**Components.** Components include but are not limited to dams, excavated ponds, infiltration trenches, parking lot storage, rooftop storage, and underground tanks.

Each component shall be designed according to sound engineering principles to insure that the system achieves its intended purpose. Design criteria for individual components shall be based on the following:

1. Dams shall meet the requirements, specified in 40 - part 520, subpart C of the National Engineering Manual
2. Excavated ponds shall meet the requirements specified for Ponds (378).
3. The design of infiltration trenches shall be based on such factors as soil permeability, soil depth, seepage, quality of water to be temporarily stored, foundations for adjacent buildings and structures, drainage conditions, and vegetation. Other considerations are:
  - a. Only relatively clean water shall enter the trench to insure that oils, grease, and sediments do not seal trench walls and bottom and thus reduce the effectiveness of the practice. At parking lots and at other areas having a similar contamination potential, filter strips; sediment traps; grease traps or filter traps, or both, shall be installed to remove objectionable materials from the water before it reaches the infiltration device. A strip of close growing grasses at least 25 ft wide must be properly placed and maintained to insure the effectiveness of the trench. Water must move through the grass as sheet flow. If local site conditions warrant, a wider filter strip can be used.
  - b. Trenches shall be located above the seasonally high water table.
  - c. The size of the trench shall depend on the volume of storage required and the void ratio of the stones in the excavation. The volume of water infiltrating the walls and bottom of the trench during a storm shall be assumed to be zero in calculating the required volume. The permeability rate of the soil is used in determining the dewatering time, which shall not exceed 5 days.
  - d. The soils used for installing an infiltration trench must be well drained. If permeability of the surrounding soils is less than about 0.6 in./h, suitability of the site for an infiltration trench may not be practicable.
  - e. An infiltration trench must not adversely affect nearby foundations for buildings, roads, and parking lots and must not impair the growth of significant woody vegetation.
  - f. Stone used in the excavation must be poorly graded and about 1 to 2 in. in size.
  - g. In areas where spring runoff from snowmelt is likely to occur before the trench thaws, provisions shall be made for removing the excess water.
  - h. Provisions shall be made to insure that salts or other soluble pollutants entering the trench do not contaminate local water supplies.
  - i. The trench bottom and the stone surface must be level to insure adequate storage capacity and uniform infiltration.
4. Parking lot storage areas can be used to help control runoff from impervious paving. Most parking lot storage area include small ponding areas that have an increased curb height and an outlet control structure. The following factors shall be considered in designing these areas:
  - a. The practice generally used to control runoff from areas less than 3 acres in size.

- b. The parking lot design and installation grades must insure positive flow to the storage area. The storage area must be nearly level, but the slope must be steep enough to facilitate drainage.
  - c. Trash guards must be provided to prevent clogging of the outlet control device.
  - d. Generally, ponding on the parking lot must not exceed 6 in. in areas where cars and light trucks are to be parked or 10 in. where heavy trucks are to be parked.
  - e. Emergency overflow outlets must be provided.
  - f. Such auxiliary practices as porous pavement and vegetative strips may be used in or adjacent to parking lots to permit infiltration.
5. For rooftop storage, the following requirements are applicable:
- a. The roof shall be structurally capable of holding detained storm water and of withstanding the effects of high winds and snow. Requirements for structural stability are outside the scope of this standard and shall be determined by the building designer.
  - b. An adequate number of roof drains shall be provided.
  - c. Emergency overflow measures shall be provided to prevent overloading if roof drains become plugged.
  - d. Detention rings shall be placed around all roof drains in areas to be used for storage. The required number of holes or the size of openings in the rings shall be computed on the basis of the area of roof drainage per detention ring and the runoff criteria.
  - e. Maximum time of storage on the roof shall not exceed 24 hours.
6. The design of underground tanks shall be based on the following criteria:
- a. The tank must be structurally capable of handling the anticipated loadings and be suited to the soils. Requirements for structural stability are outside the scope of this standards and must be based on sound engineering principles.
  - b. The outlet from the tank shall not be less than 5 in. in diameter. Provisions shall be made to prevent debris from entering the tank. Debris collectors shall be placed so that the need for maintenance can be readily detected and cleaning operations easily performed.
  - c. The bottom of the tank shall be on a slight grade to insure complete drainage of the tank.
  - d. Access must be provided to the tank to permit removal of sediment and other debris.
  - e. The maximum time of storage shall not exceed 5 days.

**Sequence of installation.** Components shall be designed and installed in a sequence that permits each to function as intended without causing a hazard. Single components shall not be installed until plans for the entire runoff management system are completed.

**Safety.** Appropriate safety features and devices shall be installed to protect humans and animals from such accidents as falling or drowning. Temporary fencing can be used until barrier plantings are established. Such protective measures as guard-rails and fences shall be used on spillways and impoundments as needed.

**Visual resource.** Landscape architectural practices must insure that all measures are visually compatible with the surrounding landscape.

**Protection.** A protective cover of grasses shall be established on exposed surfaces and other disturbed areas. Other protective measures, such as mulches, also can be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with recommendations in technical guides for the area.

## **OPERATION AND MAINTENANCE.**

A plan of operation and maintenance shall be prepared for use by the owner or others responsible for the system to insure that each component functions properly. This plan shall

provide requirements for inspection, operation, and maintenance of individual components, including outlets. It shall be prepared before the system is installed and shall specify who is responsible for maintenance. Adequate rights-of-way must be provided for maintenance access.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for runoff management systems shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# **SEDIMENT BASIN**

(No.)  
CODE 350

## **DEFINITION**

A basin constructed to collect and store debris or sediment.

## **SCOPE**

This standard applies to the installation of all basins where the primary purpose is to trap and store waterborne sediment and debris.

## **PURPOSE**

To preserve the capacity of reservoirs, ditches, canals, diversion, waterways, and streams; to prevent undesirable deposition on bottom lands and developed areas; to trap sediment originating from construction sites; and to reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, stone, agricultural wastes, and other detritus.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where physical conditions or land ownership preclude treatment of a sediment source by the installation of erosion-control measures to keep soil and other material in place or where a sediment basin offers the most practical solution to the problem.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.
2. Effects on downstream flows and aquifers that would affect other water uses and users.
3. Effects on volume of discharge flow on the environmental, social, and economic conditions.
4. Effects on the water table downstream and the results of changes of vegetative growth.

### **Water Quality**

1. Effects on erosion, movement of sediment, pathogens, and soluble and sediment-attached substances that could be carried by runoff.
2. Effects on the visual quality of onsite and downstream water resources.
3. Effects of construction and early establishment of protective vegetation on the surface and ground water.
4. Effects on wetlands and water-related wildlife habitats.

## **DESIGN CRITERIA**

The capacity of the sediment basin shall equal the volume of sediment expected to be trapped at the site during the planned useful life of the basin or the improvements it is designed to protect. If

it is determined that periodic removal of sediment will be practicable, the capacity may be proportionately reduced.

The design of dams, spillways, and drainage facilities shall be according to SCS standards for ponds (378) and grade stabilization structures (410) or according to the requirements in TR-60, as appropriate for the class and kind of structure being considered.

Temporary basins having drainage areas of 5 acres or less and a total embankment height of 5 ft or less may be designed with less conservative criteria if conditions warrant. The embankment shall have a minimum top width of 4 ft and side sloped of 2:1 or flatter. An outlet shall be provided of earth, pipe, stone, or other devices adequate to keep the sediment in the trap and to handle the 10-year-frequency discharge without failure or significant erosion.

Provisions shall be made for draining sediment pools if necessary for safety and vector control. Fencing and other safety measures shall be installed as necessary to protect the public from floodwater and soft sediment. Due consideration shall be given to good visual resource management.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing sediment basins shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **EFFICIENCIES**

Sediment traps and basins are a widely used BMP for construction sites, therefore it is important to recognize their reported efficiencies. There has been much research regarding sediment traps with a wide range of sediment removal efficiencies. Brown and Caraco (1997) states that the traps and basins must operate at a 95 to 99% sediment removal efficiency in order to produce a non-turbid discharge. Through related research, however, they found removal capabilities only between 70 and 90% (Brown and Caraco, 1997).

There are three informative field studies regarding sediment basin performance. Horner's (1990) study of three highway sediment basins in Washington state found mean percent reductions in Total Suspended Solids (TSS) at about 75.1% to 98.6%. Schueler and Lugbill (1990) examined five basins and traps in a suburban Maryland piedmont. Four of the five basins and traps yielded TSS mean percent reductions greater than 55% (ranging from 54.7% to 99.8%). One misleading study area had an 18.0% mean reduction. This is unrepresentative of a true study because the site suffered from internal erosion at the inlets. Although some of these efficiencies seem very high, it is important to note that there is high variability in removal efficiencies due to the fact that the Schueler and Lugbill test sites had similar soil types, eroded particle soil size, and basin design criteria

Computer models have been popular alternative to field studies. Sturm and Kirby (1991) performed a computer analysis to predict sediment removal efficiencies on a Georgia piedmont that contained three soil types (sandy loam, silty loam, and clay loam). This model was based on a 10-year, 24-hour storm event. The resulting predictions were removal efficiencies between 82 and 87% for the sandy loam soil, 70 to 77% for the silty loam, and 42 to 54% for the clay loam. Barfield and Clar (1985) performed a computer analysis for a Maryland coastal plain containing the same type soils as the Sturm and Kirby study. Barfield and Clar reported removal efficiencies between 94 and 99.5% for the sandy loam soil, 68 to 97% for the silty loam, and 76 to 96% for the clay loam.

To improve the trapping efficiency of sediment basins, the installation of a perforated riser has shown to be effective. Engle and Jarrett (1995) conducted a study on three configurations of

perforated risers and calculated TSS removal efficiencies after a 1.5 hour dewatering time and a 3.0 hour dewatering time. The first configuration was a standard perforated riser and was shown to have removal efficiencies of 59.8% and 71.0%, respectively, for the two dewatering times. The second configuration was a perforated riser with a gravel filter. This was found to have removal efficiencies of 78.3% and 85.6%, respectively, for the two dewatering times. The third configuration was a perforated riser with expanded polystyrene chips (EPS). This configuration had similar results to the perforated riser with a gravel filter. It had the same removal efficiency (78.3%) as the perforated riser with a gravel filter for the 1.5 hour dewatering time, but was slightly higher (89.0%) at the 3.0 hour dewatering time.

In 1996, Jarrett conducted a study that combined the use of silt fence barriers and perforated risers in order to improve trapping efficiency. He also included the use of a skimmer affixed on the perforated riser. Four design features were tested. The first was just a perforated riser without the skimmer and the silt fence barrier. A sediment removal efficiency of 94.2% was recorded. Next, the perforated riser was combined with a silt fence barrier. Jarrett recorded a 95.4% sediment removal efficiency. The third design feature comprised of the skimmer attached to the perforated riser. A 96.9% efficiency was reported with this basin configuration. Finally, all three features were used together and yielded a 96.6% efficiency. The slight decrease in the removal efficiency might be attributed to dead storage zones, which the silt fence barrier may produce.

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# SHALLOW WATER MANAGEMENT FOR WILDLIFE

(acre)  
CODE 646

## DEFINITION

Managing shallow water on agricultural lands and moist soil areas for wildlife habitat.

## PURPOSE

- To provide open water areas on agricultural fields and moist soil areas to facilitate waterfowl resting and feeding.
- To provide habitat for reptiles and amphibians and other aquatic species which serve as important prey species for waterfowl, raptors, herons, and other wildlife.

## CONDITIONS WHERE PRACTICE APPLIES

On agricultural and moist soil areas where water can be impounded or regulated by diking, ditching, or flooding.

This practice can be used to facilitate the conservation of declining wetland dependent and threatened and endangered species.

This practice does not apply to: Wetland Restoration (657) intended to rehabilitate a degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to original conditions; Wetland Enhancement (659) intended to rehabilitate a degraded wetland where specific functions and/or values are enhanced beyond original conditions; or Wetland Creation (658) for creating a wetland on a site location which historically was not a wetland or on a site which was formerly a wetland but will be replaced with a wetland type not naturally occurring on the site.

## CRITERIA

- Soils should have low permeability to inhibit subsurface drainage and allow for maintenance of proper water levels.
- Shallow water impoundments require an adequate water supply for reflooding and a water control structure for removing water when necessary.
- Landowner shall obtain all local, state, and federal permits necessary.
- If pumping, water rights must be assured.
- The Standards and Specifications for Dike (356), Pumping Plant for Water Control (533), and Structure for Water Control (587) will be used as appropriate. Refer to Chapter 6, "Structures," for additional design information. Existing drainage systems will be utilized, removed, or modified as needed to achieve the intended purpose.

## CONSIDERATIONS

To insure that foods are available to dabbling ducks, impoundments should be gradually flooded to a depth of 6 - 18 inches.

Consider the effects of the timing of the flooding and drawdown, as well as the type of drawdown, on plant species composition (moist soil areas).

Consider the species flooding tolerances and the composition of seed in the soil at the site (moist soil areas).

Consider effects on wetlands or wildlife habitats that would be associated with the practice.

Consider the effects of residual herbicides (moist soil areas).

Consider the targeted plant species' tolerances with respect to timing and type of drawdown.

Consider effects on movement of dissolved substances to groundwater and to downstream surface waters.

Consider effects on downstream flows that would affect other water uses or users.

## **PLANS AND SPECIFICATIONS**

Plans and Specifications for installing structures for water control shall be in keeping with this standard and shall prescribe the requirements for applying the practice to achieve its intended purpose.

## **OPERATION AND MAINTENANCE**

The impoundment should be dewatered and disked or burned at 2 to 3 year intervals to control the invasion by undesirable plants.

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance).

Any use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals to assure the shallow water or moist soil area function shall not compromise the intended purpose.

Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible.

Operation and maintenance shall include monitoring and management of the site as well as structural components.

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# SOIL SALINITY MANAGEMENT - NONIRRIGATED

(acre)  
CODE 571

## DEFINITION

Management of land, water, and plants to control harmful accumulations of salts on the soil surface or in the root zone on nonirrigated areas.

## SCOPE

This standard establishes the minimum acceptable requirements for the planning, design, operation, and maintenance of interrelated practices used to remedy and control the formation of saline or sodic areas. It does not apply to saline or sodic conditions related to or induced by irrigation.

## PURPOSE

Treatment of saline or sodic-affected areas on nonirrigated land to permit desired plant growth and protect surface and ground water resources.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all nonirrigated land where (a) human-induced soil salinity or sodicity is at or approaching a level that adversely affects land use, or (b) combinations of factors - topography, soils, geology, precipitation, and land use - indicate the future probability of such adverse effects.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

### Water Quality

1. Potential for transfer of salinity conditions to another location where surface or subsurface drains are used.
2. Effects of erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances, including salts, that could be carried by runoff.

## INVESTIGATIONS

1. Test the soil water extract of the soil surface and potential root zone to determine the presence and concentration of saline or sodic substances. Refer to National Engineering Handbook, Section 16, Chapter 4, for guidance on how electrical conductivity levels affect potential yields.
2. Map the affected area.
3. Determine the relationship of the ground surface topography and the water table contours in and adjacent to the problem area. One suggested method involves installing nine

(three rows of three) auger hole observation wells for water table measurements. Additional wells may be needed to adequately define the recharge area.

## **PLANNING AND DESIGN**

1. Correct the salinity problem by applying the practice(s) as part of an overall resource management system (RMS).
2. Planned actions should give first consideration to prevention rather than correction.
3. To the maximum extent practical, use vegetation to utilize soil water in the recharge areas.
4. When subsurface drains are needed, the configuration selected will give priority consideration to placing interceptor drains close to the recharge area to maximize the benefited area and provide a drain effluent of the best possible water quality.
5. Where applicable, improve surface drainage in the recharge area.
6. Corrective measures must comply with water quality laws and regulation. Monitoring of before and after conditions may be recommended.

## **SPECIFICATIONS GUIDE**

1. List plants and provide management details on the plants adapted for use in recharge and affected area. Consider factors such as water usage, salt tolerance, and erosion control characteristics.
2. Incorporate, by reference, appropriate conservation practices that constitute components of the treatment of recharge and affected areas.
3. List the types and extent of environmental and ecological monitoring and evaluation that may be necessary.

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# **SPOIL SPREADING**

(acre)  
CODE 572

## **DEFINITION**

Disposing of surplus excavated materials.

## **SCOPE**

This standard applies to the disposal of spoil by placing it in surface depressions, by shaping, by spreading it over the surface of adjacent lands along the ditch, canal, or other excavations from which the spoil was removed, or by placing it on other specified areas.

## **PURPOSE**

To permit use of land occupied by spoil for agriculture and other purposes, to facilitate establishing and controlling vegetation along banks, to provide a travelway along banks for use and maintenance, to provide borrow for land grading, leveling, or smoothing, or to improve landscape quality.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to sites where spoil material is available from excavation of channels, drainage ditches, irrigation canals, or other construction sites and where it is desirable and economically feasible to achieve one or more purposes.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on the water budget, especially on runoff, infiltration, deep percolation, and ground water recharge.
2. Effects on the distribution of snow derived soil moisture.

### **Water Quality**

1. Erosion during establishment.
2. Effects of spoil placement on long-term erosion and sediment delivery.
3. Whether or not placement causes dissolved substances, including toxics, to enter surface or ground water.
4. Effects on visual quality of downstream water.

## **DESIGN CRITERIA**

Spoil shall be spread over a designated area according to an approved plan or as modified by a technician at the site where authorized in the contract or otherwise feasible. Provisions shall be made for the diversion or safe passage of surface water concentrating on the landside of the spoil-banks along channels, ditches, or canals. Location and placement of spoil should be such as to avoid unnecessary destruction of riparian vegetation.

The spoil shall be placed so as not to endanger the stability of the ditch bank and shall not exceed 3 ft. (0.9 m) in height above the natural ground surface, except by special design. The finished surface shall slope away from the edge of the channel or berm as feasible.

For spoil spreading along channels, ditches, or canals, surfaces of spoil shall not be steeper than 4 horizontal to 1 vertical on the landside and 3 horizontal to 1 vertical on the channel side if a berm is established. If the spoil is spread to the edge of the channel, the channel side slope of the spoil shall be shaped to join the side slope of the ditch bank so that loose spoil will not roll or wash into the channel or ditch.

Spoil spreading for other construction sites shall be in accordance with the standard and specification of the applicable conservation practices and shall be shaped to a designed form that blends visually with the landscape. Where appropriate, consideration should be given to using spoil for direct or indirect human benefits such as blocking views, deflecting or redirecting wind or snow, and other uses that may be identified as desirable.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for spoil spreading shall be in keeping with this standard and shall describe the requirements for properly applying the practice to achieve its intended purpose.

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# SPRING DEVELOPMENT

(No.)  
CODE 574

## DEFINITION

Improving springs and seeps by excavating, cleaning, capping, or providing collection and storage facilities.

## SCOPE

This standard applies to springs and seeps developed as a source of water. It does not apply to Troughs or Tanks (614) or to Pipelines (516).

## PURPOSE

Mainly to improve the distribution of water or to increase the quantity of water for livestock or wildlife. Also to obtain water for irrigation if water is available in a suitable quantity and quality.

## CONDITIONS WHERE PRACTICE APPLIES

Developments shall be confined to springs or seepage areas that can furnish a dependable supply of suitable water during the planned period or periods of use.

The need for and feasibility of protection from flooding, sedimentation, and contamination shall be considered in determining the suitability of a site for development.

## PLANNING CONSIDERATIONS

### Water Quantity

Potential changes in surface water quantity, especially base flow. Factor is the removal of obstructions and vegetation in the spring area.

### Water Quality

Potential temporary degradation of water quality caused by erosion and sedimentation from the area disturbed during construction.

## DESIGN CRITERIA

**Fracture and tubular springs.** If water issues from rock fractures, the individual openings shall be cleaned and enlarged, as needed, to provide an increase in flow. The water from these individual openings shall be collected and conveyed to a central sump or spring box by means of tile or perforated pipeline or by a gravel-filled ditch. The collection works shall be constructed an adequate distance below the elevation of the openings to permit free discharge.

If water issues from single opening, such as a solution channel in a soluble rock formation or a tunnel in lava, the opening shall be cleaned or enlarged as needed. A collection system usually is not required, but a spring box or sump shall be installed at an elevation sufficiently low that water will not pond over the spring opening to a depth that will materially reduce the yield.

**Perched or contact springs.** Perched or contact springs occur where an impermeable layer outcrops beneath a water-bearing permeable layer. These springs shall be developed by intercepting and collecting the flow from the water-bearing formation. Collection trenches shall be used for developing these types of springs.

**Artesian springs.** Artesian springs shall be developed by removing obstructions, cleaning or enlarging joints or fractures, or by lowering the outlet elevation. Sumps and spring boxes shall be located so as to hold ponding over the spring outlet to a minimum.

**Collection systems.** If a collecting trench along the outcrop of the water-bearing formation is to be used, the trench shall be excavated so that it extends into the impervious layer.

An impervious cutoff wall of well-tamped clay, masonry, concrete, or other suitable materials shall be constructed along the downstream side of the trench if needed to insure that the flow enters the collection system.

The collection system shall consist of subsurface drainage tubing or perforated pipe not less than 3 in. in diameter, or a wood box drain enclosed in a sand-gravel filter. A crushed rock or gravel backfill, not less than 12 in. deep, may be used instead of these types of drains.

**Spring boxes.** Spring boxes, if needed, shall be of durable material and shall have a tight, removable cover. The boxes shall have a minimum cross-sectional area of 1-1/2 ft<sup>2</sup>. The floor of the spring box shall be not less than 6 in. below the outlet of the collection system. Spring boxes for perched springs shall be floored with concrete unless the underlying material is solid rock or other stable impervious material.

**Outlets.** The outlet pipe from a spring box shall be placed not less than 6 in. above the floor of the box to provide a sediment trap. However, the outlet must not be so high as to cause a head on the spring that can reduce flow. The outlet pipe shall be installed so as to insure a watertight connection with the spring box. Measures required to protect the development from damage by freezing, flooding, sedimentation, contamination, and livestock shall be included in the design.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing spring developments shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# STREAM CHANNEL STABILIZATION

(ft)  
CODE 584

## DEFINITION

Stabilizing the channel of a stream with suitable structures.

## SCOPE

This standard applies to the structural work done to control aggradation or degradation in a stream channel. It does not include work done to prevent bank cutting or meander.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to stream channels undergoing damaging aggradation or degradation that cannot be feasibly controlled by clearing or snagging, by the establishment of vegetative protection, or by the installation of upstream water control facilities.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Stage-discharge and flow velocity relative to the water budget components, geologic materials comprising the stream channel, and objectives of the channel modification.
2. Effects on water tables, soil moisture storage, and rooting depths and transpiration of vegetation.

### Water Quality

1. Temporary and long-term effects on erosion and sedimentation.
2. Changes in stream water temperature that may result from the clearing of vegetation or alteration of water sources to the channel.
3. Effects on the visual quality of the water resource.

## DESIGN CRITERIA

It is recognized that channels may aggrade or degrade during a given storm or over short periods. A channel is considered stable if over long periods the channel bottom remains essentially at the same elevation.

In the design of a channel for stability, consideration shall be given to the following points:

1. The character of the materials comprising the channel bottom.
2. The quantity and character of the sediments entering the reach of channel under consideration. This shall be analyzed on the basis of both present conditions and projected changes caused by changes in land use or land treatment and upstream improvements or structural measures.
3. Streamflow peaks, velocities, and volumes at various flow frequencies.
4. The effects of changes in velocity of the stream produced by the structural measures.

Structures installed to stabilize stream channels shall be designed and installed to meet SCS standards for the particular structure and type of construction.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for stream channel stabilization shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# **STREAMBANK AND SHORELINE PROTECTION**

(Ft)  
**CODE 580**

## **DEFINITION**

Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries.

## **PURPOSE**

- To prevent the loss of land or damage to land uses, or other facilities adjacent to the banks, including the protection of known historical, archeological, and traditional cultural properties.
- To maintain the flow or storage capacity of the water body or to reduce the offsite or downstream effects of sediment resulting from bank erosion.
- To improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, recreation.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to streambanks of natural or constructed channels and shorelines of lakes, reservoirs, or estuaries where they are susceptible to erosion. It applies to controlling erosion where the problem can be solved with relatively simple structural measures, vegetation, or upland erosion control practices. It does not apply to erosion problems on main oceanfronts and similar areas of complexity not normally within the scope of NRCS authority or expertise.

## **CRITERIA**

### **General Criteria Applicable to All Purposes**

Measures must be installed according to a site-specific plan and in accordance with all applicable local, state, and federal laws and regulations.

Protective measures to be applied shall be compatible with improvements planned or being carried out by others.

Protective measures shall be compatible with the bank or shoreline materials, water chemistry, channel or lake hydraulics, and slope characteristics both above and below the water line.

End sections shall be adequately bonded to existing measures, terminate in stable areas, or be otherwise stabilized.

Protective measures shall be installed on stable slopes. Bank or shoreline materials and type of measure installed shall determine maximum slopes.

Designs will provide for protection from upslope runoff.

Internal drainage for bank seepage shall be provided when needed. Geotextiles or properly designed filter bedding shall be used on structural measures where there is the potential for migration of material from behind the measure.

Measures applied shall not adversely affect threatened and endangered species nor species of special concern as defined by the appropriate state and federal agencies.

Measures shall be designed for anticipated ice action and fluctuating water levels.

All disturbed areas around protective measures shall be protected from erosion. Disturbed areas that are not to be cultivated shall be protected as soon as practical after construction.11.

Vegetation shall be selected that is best suited for the soil/moisture regime.

#### **Additional Criteria for Streambanks**

The channel grade shall be stable based on a field assessment before any permanent type of bank protection can be considered feasible, unless the protection can be constructed to a depth below the anticipated lowest depth of streambed scour.

A protective toe shall be provided based on an evaluation of stream bed and bank stability.

Channel clearing to remove stumps, fallen trees, debris, and bars shall only be done when they are causing or could cause detrimental bank erosion or structural failure. Habitat forming elements that provide cover, food, and pools, and water turbulence shall be retained or replaced to the extent possible.

Changes in channel alignment shall not be made unless the changes are based on an evaluation that includes an assessment of both upstream and downstream fluvial geomorphology. The current and future discharge-sediment regime shall be based on an assessment of the watershed above the proposed channel alignment.

Measures shall be functional for the design flow and sustainable for higher flow conditions based on acceptable risk.

Measures shall be designed to avoid an increase in natural erosion downstream.

Measures planned shall not limit stream flow access to the floodplain.

Stream segments to be protected shall be classified according to a system deemed appropriate by the state. Segments that are incised or contain the 5-year return period (20 percent probability) or greater flows shall be evaluated for further degradation or aggradation.

When water surface elevations are a concern, the effects of protective measures shall not increase flow levels above those that existed prior to installation.

#### **Additional Criteria for Shorelines**

All revetments, bulkheads, or groins are to be no higher than 3 feet (1 meter) above mean high tide, or mean high water in non-tidal areas

Structural shoreline protective measures shall be keyed to a depth to prevent scour during low water.

For the design of structural measures, the site characteristics below the waterline shall be evaluated for a minimum of 50 ft (15 meters) horizontal distance from the shoreline measured at the design water surface.

The height of the protection shall be based on the design water surface plus the computed wave height and freeboard. The design water surface in tidal areas shall be mean high tide.

When vegetation is selected as the protective treatment, a temporary breakwater shall be used during establishment when wave run up would damage the vegetation.

### **Additional Criteria for Stream Corridor Improvement**

Stream corridor vegetative components shall be established as necessary for ecosystem functioning and stability. The appropriate composition of vegetative components is a key element in preventing excess long-term channel migration in re-established stream corridors.

Measures shall be designed to achieve any habitat and population objectives for fish and wildlife species or communities of concern as determined by a site-specific assessment or management plan. Objectives are based on the survival and reproductive needs of populations and communities, which include habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors and native plant communities. The type, amount, and distribution of vegetation shall be based on the requirements of the fish and wildlife species or communities of concern to the extent possible.

Measures shall be designed to meet any aesthetic objectives as determined by a site-specific assessment or management plan. Aesthetic objectives are based on human needs, including visual quality, noise control, and microclimate control. Construction materials, grading practices, and other site development elements shall be selected and designed to be compatible with adjacent land uses.

Measures shall be designed to achieve any recreation objectives as determined by a site-specific assessment or management plan. Recreation objectives are based on type of human use and safety requirements.

## **CONSIDERATIONS**

An assessment of streambank or shoreline protection needs should be made in sufficient detail to identify the causes contributing to the instability (e.g. watershed alterations resulting in significant modifications of discharge or sediment production). Due to the complexity of such an assessment an interdisciplinary team should be utilized.

When designing protective measures, consider the changes that may occur in the watershed hydrology and sedimentation over the design life of the measure.

Consider utilizing debris removed from the channel or streambank into the treatment design.

Use construction materials, grading practices, vegetation, and other site development elements that minimize visual impacts and maintain or complement existing landscape uses such as pedestrian paths, climate controls, buffers, etc. Avoid excessive disturbance and compaction of the site during installation.

Utilize vegetative species that are native and/or compatible with local ecosystems. Avoid introduced or exotic species that could become nuisances. Consider species that have multiple values such as those suited for biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides. Avoid species that may be alternate hosts to disease or undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests. Species on noxious plant lists should not be used.

Livestock exclusion should be considered during establishment of vegetative measures and appropriate grazing practices applied after establishment to maintain plant community integrity. Wildlife may also need to be controlled during establishment of vegetative measures. Temporary and local population control methods should be used with caution and within state and local regulations.

Measures that promote beneficial sediment deposition and the filtering of sediment, sediment-attached, and dissolved substances should be considered.

Consider maintaining or improving the habitat value for fish and wildlife, including lowering or moderating water temperature, and improving water quality.

Consideration should be given to protecting side channel inlets and outlets from erosion.

Toe rock should be large enough to provide a stable base and graded to provide aquatic habitat.

Consider maximizing adjacent wetland functions and values with the project design and minimize adverse effects to existing wetland functions and values.

When appropriate, establish a buffer strip and/or diversion at the top of the bank or shoreline protection zone to help maintain and protect installed measures, improve their function, filter out sediments, nutrients, and pollutants from runoff, and provide additional wildlife habitat.

Consider conservation and stabilization of archeological, historic, structural and traditional cultural properties when applicable.

Measures should be designed to minimize safety hazards to boaters, swimmers, or people using the shoreline or streambank.

Protective measures should be self-sustaining or require minimum maintenance.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for streambank and shoreline protection shall be prepared for specific field sites and based on this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **OPERATION AND MAINTENANCE**

An operation and maintenance plan shall be prepared for use by the owner or others responsible for operating and maintaining the system. The plan shall provide specific instructions for operating and maintaining the system to insure that it functions properly. It shall also provide for periodic inspections and prompt repair or replacement of damaged components or erosion.

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# STRIPCROPPING, FIELD

(acre)  
CODE 586

## DEFINITION

Growing crops in a systematic arrangement of strips or bands across the general slope (not on the contour) to reduce water erosion. The crops are arranged so that a strip of grass or a close-growing crop is alternated with a clean-tilled crop or fallow.

## PURPOSE

To help control erosion and runoff on sloping cropland where contour stripcropping is not practical.

## CONDITIONS WHERE PRACTICE APPLIES

On sloping cropland and on certain recreation and wildlife land.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground-water recharge.
2. Variability of practice's effects caused by seasonal weather variations.
3. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.

### Water Quality

1. Filtering effects of vegetation on movement of sediment and dissolved and sediment-attached substances.
2. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
3. Potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive layers
4. Effects on the visual quality of downstream water resources.

## SPECIFICATIONS GUIDE

Specify width of strips for different crops, percentage of slopes, and soils.

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# STRUCTURE FOR WATER CONTROL

(No.)  
CODE 587

## DEFINITION

A structure in an irrigation, drainage, or other water management systems that conveys water, controls the direction or rate of flow, or maintains a desired water surface elevation.

## SCOPE

This standard applies to the structures normally installed in a well-planned irrigation or drainage system, wildlife facility or other water management systems for the conveyance, flow control, or level regulation of water. It covers the planning and functional design of such water-control structures but not the detailed design criteria or construction specifications for specific structures. It does not apply to structural components of irrigation pipelines or to subsurface drains or grade-stabilization structures (410).

## PURPOSE

To control the stage, discharge, distribution, delivery, or direction of flow of water in open channels or water use areas. Also used for water quality control, such as sediment reduction or temperature regulation. These structures are also used to protect fish and wildlife and other natural resources.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies wherever a permanent structure is needed as an integral part of an irrigation, drainage, or other water-control systems to serve one or more of the following functions:

1. To conduct water from one elevation to a lower elevation within, to, or from a ditch, channel, or canal. Typical structures: drops, chutes, turnouts, surface water inlets, head gates, pump boxes, and stilling basins.
2. To control the elevation of water in drainage or irrigation ditches. Typical structure: checks.
3. To control the division or measurement of irrigation water. Typical structures: division boxes and water measurement devices.
4. To keep trash, debris, or weed seeds from entering pipelines. Typical structure: debris screens.
5. To control the direction of channel flow resulting from tides and high water or backflow from flooding. Typical structure: tide and drainage gates.
6. To control the level of a water table or to remove surface or subsurface water from adjoining land, to flood land for frost protection or to manage water levels for wildlife or recreation. Typical structures: water level control structures, pipe drop inlets, and box inlets.
7. To provide water control for recreation or similar purposes.
8. To convey water over, under, or along a ditch, canal, road, railroad, or other barriers. Typical structures: bridges, culverts, flumes, inverted siphons.
9. To modify water flow to provide habitat or fish, wildlife, and other aquatic animals. Typical structures: deflectors, chutes, cold water release, or structures to make pools and riffles.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Potential for a change in the rate of plant growth and transpiration because of changes in the volume of soil water.
3. Effects on downstream flows or aquifers that would affect other water uses or users.
4. Effects on the volume of downstream flow that might cause environmental, social or economic effects.
5. The effect on the water table of the field to ensure that it will provide a suitable rooting depth for the anticipated crop.
6. Potential use for irrigation management to conserve water.

### **Water Quality**

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substances below the root zone and to ground water.
3. Short term and construction-related effects of this practice on the quality of downstream water.
4. Effects of water level control on the temperatures of downstream waters for their effects on aquatic and wildlife communities.
5. Effects on wetlands or water-related wildlife habitats.
6. Effects on the visual quality of downstream water resources.

## **DESIGN CRITERIA**

Structures shall be designed on an individual job basis, or applicable SCS standard drawings shall be adapted, to meet site conditions and functional requirements. They shall be part of an approved and overall engineering plan for irrigation, drainage, wildlife, recreation, channel improvement, or similar purposes.

The plan shall specify the location, grades, dimensions, materials, and hydraulic and structural requirements for the individual structure. Provisions must be made for necessary maintenance. Care must be used to insure that the area's visual resources are not damaged. If watercourse fisheries are important, special precautions or design features may be needed to insure continuation of fish migrations.

If soil and climatic conditions permit, a protective cover of vegetation shall be established on all disturbed earth surfaces. If soil or climatic conditions preclude the use of vegetation and protection is needed, nonvegetative means, such as mulches or gravel, may be used. In some places, temporary vegetation may be used until permanent vegetation can be established. The structure can be fenced, if necessary, to protect the vegetation. Seedbed preparation, weeding, fertilizing, and mulching shall comply with the instructions in technical guides.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing structures for water control shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# **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.

## **SCOPE**

This standard applies to the design and installation of conduits placed beneath the surface of the ground to provide drainage.

## **PURPOSE**

The purpose of subsurface drainage is to:

1. Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
  - a. regulating water table and ground water flows,
  - b. intercepting and preventing water movement into a wet area,
  - c. relieving artesian pressures,
  - d. removing surface runoff,
  - e. leaching of saline and sodic soils,
  - f. serving as an outlet for other subsurface drains, and
  - g. regulating subirrigated areas or waste disposal areas.
2. Collect ground water for beneficial uses.
3. Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal.
4. Regulate water to control health hazards caused by pests such as live fluke, flies, or mosquitoes.

## **CONDITIONS WHERE PRACTICE APPLIES**

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

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

## **DESIGN CRITERIA**

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

**Capacity.** The required capacity shall be determined by one or more of the following:

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.
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.

**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 3 in.

**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 ft. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet or 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 ft 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 ft for trench widths of 2 ft or less (measured at tubing and to 1 ft above top of tubing). Heavy duty tubing shall be specified for depths greater than 10 ft, trench widths more than 2 ft, 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 ft. 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.

**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 ft/s. If a hazard exists,

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 velocities by soil texture:

Soil texture	Velocity <i>ft/s</i>
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silt 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:

1. Enclose continuous perforated pipe or tubing with fabric-type filter material or property graded sand and gravel.
2. Use nonperforated continuous tubing, a watertight pipe, or seal joints.
3. Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available.
4. Select rigid butt end pipe or tile with straight smooth sections and square ends to obtain tight fitting joints.
5. Wrap open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric-type filter material.
6. Install open air risers for air release or entry.

**Iron ochre considerations**

If drains are to installed in sites where iron ochre 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 is in its insoluble form.

Where possible, in areas where the potential for ochre problems is high, protection against ochre 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 ft on each side of the drain. A distance of 50 ft should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drains located close to the fruit trees.

Where corps 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 drainlines 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 of the site. All conduits shall meet or exceed the minimum requirements indicated in the Materials section of the specifications.

## **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 insure 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, low plasticity silts, or fine sands (ML or SM with P.I. less than 7),
3. where deep soil cracking is expected, or
4. where the method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation will be based on the gradation of the base material surrounding the conduit within the following limits:

- D15 size smaller than 7 times d85 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, D15 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 in. on 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, organic, or similar material, Sand-gravel envelope materials shall all pass a 1.5-in. 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 in. in diameter. Where such conditions are present the trench must be overexcavated a minimum of 6 in. and refilled to grade with a suitable bedding material.

The conduit must be placed on a firm foundation to insure 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 or corrugated plastic tubing 8 in. 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 in. thick, to provide support
3. Compacted soil bedding material beside and to 3 in. above the tubing.

For trench installations of corrugated plastic tubing larger than 8 in., 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.

For trench installations where a sand-gravel or a compacted bedding is not specified, the conduit should be blinded with selected material containing no hard objects larger than 1.5 in. in diameter. Blinder should be carried to a minimum of 3 in. 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 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, orifice plated, and/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 in. in diameter.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2 ft 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 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 ½ ft of soil cover.

If not connected to a structure, the upper end of each subsurface drain line will be capped with a tight-fitting 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. 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 standards for Regulating Water in Drainage Systems (554) or Water Table Control (641).

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 ft. Under certain conditions shorter sections are appropriate; e.g., steep-sided main and laterals (1:1 or less) with a narrow bottom width of 3 ft, commonly referred to as “minimum ditches,” for outletting individual subsurface drain laterals. For conduits 10 in. in diameter and greater, longer outlet sections should be considered, such as:
  - 10 in. and 12 in. in diameter, use 12 ft.
  - 15 in. and 18 in. in diameter, use 16 ft.
  - Use 20-ft outlet pipe for all diameters larger than 18 in.
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.

## **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.

## **SUBSURFACE DRAIN SPECIFICATIONS**

### **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
<i>Plastic</i>	
Corrugated polyethylene (PE) tubing and fittings 3-6 in.	ASTM-F-405 <sup>1</sup>
Corrugated polyethylene (PE) tubing and fittings 8-24 in.	ASTM-F-667 <sup>1</sup>
Corrugated polyvinyl chloride (PVC) tubing and compatible fittings	ASTM-F-800 <sup>1</sup>
Polyvinyl chloride (PVC) corrugated sewer pipe with a smooth interior and fittings 4-8 in.	ASTM-F-949 <sup>1</sup>
Polyvinyl chloride (PVC) sewer pipe and fittings	ASTM-D-2729 <sup>1</sup>
Polyvinyl chloride (PVC) pipe	ASTM-D-3033 <sup>1</sup> or D-3034 type PSM or PSP
<i>Clay</i>	
Clay drain tile	ASTM-C-4 <sup>1</sup>
Clay drain tile, perforated	ASTM-C-498 <sup>1</sup>
Clay pipe, perforated, standard and extra strength	ASTM-C-700 <sup>1</sup>
Clay pipe, testing	ASTM-C-301 <sup>1</sup>
<i>Concrete</i>	
Concrete drain tile	ASTM-C-4 <sup>1</sup>
Concrete pipe for irrigation or drainage	ASTM-C-118 <sup>1</sup>
Concrete pipe or tile, determining physical properties of	ASTM-C-497 <sup>1</sup>
Concrete sewer, storm drain, and culvert pipe	ASTM-C-14 <sup>1</sup>
Reinforced concrete culvert, storm drain, and sewer pipe	ASTM-C-444 <sup>1</sup>
Perforated concrete pipe	ASTM-C-76 <sup>1</sup>
Portland cement	ASTM-C-150 <sup>1</sup>
<i>Other</i>	
Styrene rubber plastic drain pipe and fittings	ASTM-D-2852 <sup>1</sup>
Pipe, corrugated (aluminum alloy)	Federal Specification WW-P-402 <sup>2</sup>
Pipe, corrugated (iron or steel, zinc Federal coated)	Specification WW-P-405 <sup>2</sup>

<sup>1</sup> Specifications can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103

<sup>2</sup> Specifications can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

### 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.<sup>2</sup>/ft of conduit length. Round perforations shall not exceed 3/16-in. in diameter except where filters, envelopes, or other protection is provided or for organic soils, where a maximum hole diameter of ½ in. may be used. Slotted perforations shall not exceed 1/8 in. in width.

## **SPECIFICATIONS—FLEXIBLE CONDUIT**

### **I. 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 overexcavated a minimum of 6 in. 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 degrees "V"-shape (90 degree "V" suitable for 3-8 in. 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 overexcavation 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 ½ in.

## 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, handcut 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 ½ in. in diameter in the trench to a minimum depth of 6 in. 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 tile 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 in., 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:

Class of tile	Acid soils:	
	Lower permissible limits of pH values	
	Organic and sandy soils	Medium and heavy-textured soils
<i>ASTM-C-412</i>		
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
<i>ASTM-C-14,</i>		
<i>C-118, C-444</i>	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 and cement (minimum)	Permissible maximum limit of sulfates, singly or in combination <i>ppm</i>
Tile: ASTM-C-412 Special quality C-14, C-118, C-444	7,000
Cement: ASTM-C-150, Type V	
Tile: ASTM-C-412 Extra quality, Heavy- duty extra quality C-14, C-118, C-444	3,000
Cement: ASTM-C-150, Type II or V	
Tile: ASTM-C-412 Standard quality C-14, C-118, C-444	1,000
Cement: ASTM-C-150, any type	

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 in. 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 overexcavated a minimum of 6 in. 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 in. 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 ½ in. 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 in. around the drain. Blinding material shall contain no hard objects larger than 1 ½ in. in diameter.

When a sand-gravel filter is specified, all openings in the conduit must be covered with at least 3 in. 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 in. of blinding material.

Joints between drain tile shall not exceed 1/8 in. 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 slows 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.

## **PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY**

### **Quantity**

1. Effects on the water budget.
2. Effects on baseflow and runoff to water uses and users.
3. Effects on ground water recharge.
4. The volume of soil water needed to improve plant growth.

### **Quality**

1. Effects on the delivery of sediment and dissolved and sediment-attached
2. Effect of changes in the delivery of dissolved salts, such as nitrates, on downstream water uses and users.
3. In areas of ground water recharge, changes in the delivery of dissolved substances to the aquifer.
4. Effect on downstream water temperatures.
5. Effects on the visual quality of downstream water.

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**SURFACE DRAINAGE**  
**FIELD DITCH**  
(ft)  
**CODE 607**

**DEFINITION**

A graded ditch for collecting excess water in a field.

**SCOPE**

This standard applies to drainage ditches installed to collect water from a field. It does not apply to surface drainage, main or lateral (608) or to grassed waterways or outlets (412).

**PURPOSE**

To drain surface depressions; collect or intercept excess surface water, such as sheet flow, from natural and graded land surfaces or channel flow from furrows and carry it to an outlet; and collect or intercept excess subsurface water and carry it to an outlet.

**CONDITIONS WHERE PRACTICE APPLIES**

Applicable sites are flat or nearly flat and:

1. Have soils that are slowly permeable (low permeability) or that are shallow over barriers, such as rock or clay, which hold or prevent ready percolation of water to a deep stratum.
2. Have surface depressions or barriers that trap rainfall.
3. Have insufficient land slope for ready movement of runoff across the surface.
4. Receive excess runoff or seepage from uplands.
5. Require the removal of excess irrigation water.
6. Require control of the water table.
7. Have adequate outlets available for disposal of drainage water by gravity flow or pumping.

**PLANNING CONSIDERATIONS**

**Water Quantity**

- 1 Effects on water budget components, especially relationships between runoff and infiltration.
- 2 The effect of changes in the water table on the rooting depth for anticipated land uses.

**Water Quality**

1. Downstream effects of erosion and yields of sediment and sediment-attached substances.
2. Effects on the salinity of the soil in the drained field.
3. Effects on the loadings of dissolved substances downstream.
4. Potential changes in downstream water temperature.
5. Effects on wetlands or other water-related wildlife habitat.
6. Effects on the visual quality of downstream water courses.

## DESIGN CRITERIA

Drainage field ditches shall be planned as integral parts of a drainage system for the field served and shall collect and intercept water and carry it to an outlet with continuity and without ponding.

**Investigations.** An adequate investigation shall be made of all sites.

**Location.** Ditches shall be established, insofar as topography and property boundaries permit, in straight or nearly straight courses. Random alinement may be used to follow depressions and isolated wet areas of irregular or undulating topography. Excessive cuts and the creation of small irregular fields shall be avoided.

On extensive areas of uniform topography, collection or interception ditches shall be installed as required for effective drainage.

**Design.** The size, depth, side slopes, and cross section area shall:

1. Be adequate to provide the required drainage for the site.
2. Permit free entry of water from adjacent land surfaces without causing excessive erosion.
3. Provide effective disposal or reuse of excess irrigation water (if applicable).
4. Conduct flow without causing excessive erosion.
5. Provide stable side slopes based on soil characteristics.
6. Permit crossing by field equipment if feasible.
7. Permit construction and maintenance with available equipment.

## PLANS SPECIFICATIONS

Plans and specifications for constructing drainage field ditches shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

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# **SURFACE DRAINAGE MAIN OR LATERAL (ft) CODE 608**

## **DEFINITION**

An open drainage ditch constructed to a designed size and grade.

## **SCOPE**

This standard applies to ditches for disposal of surface and subsurface drainage water primarily collected by drainage field ditches and subsurface drains.

It provides minimum drainage requirements for multiple-purpose channels that provide drainage outlets for agricultural lands. Mains or laterals having a drainage area of more than 1 mi<sup>2</sup> must meet the stability and maintenance requirements of the standard for Open Channels (582). Field Ditch (607), for the disposal of surface water is not applicable.

## **PURPOSE**

To dispose of excess surface or subsurface water, intercept ground water, control ground water levels, provide for leaching of saline or alkali soils, or a combination of these objectives.

## **CONDITIONS WHERE PRACTICE APPLIES**

All lands to be drained shall be suitable for agriculture after installation of required drainage and other conservation practices.

In areas where an outlet for the drainage system will be available, either by gravity flow or by pumping. The outlet shall provide for the quantity and quality of water to be disposed of. Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on the water budget components, especially with regard to effect on runoff, soil water, and water tables.
2. Potential changes in soil moisture that will affect the growth of desirable vegetation.
3. Effect on ground water recharge.

### **Water Quality**

1. Effects on the detachment and transport of sediment and chemicals and dissolved and sediment-attached substances into water courses.
2. Effects on the salinity of drained soils and downstream water courses.
3. Effects on wetlands.
4. Effect on the quality of ground water.
5. Potential for changes in downstream water temperatures.

6. Effects on downstream visual quality.

## DESIGN CRITERIA

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

**Drainage requirements.** Mains and laterals shall be located and designed to serve as integral parts of a surface or subsurface drainage system that meets the conservation and land use needs. The degree of drainage required by the crops shall be determined and expressed in terms of drainage coefficients or depth and spacing of drains.

**Capacity.** The ditch capacity shall be adequate to provide for the removal of excess water, based on climatic and soil conditions and the needs of crops. The required capacity shall be obtained by determining the watershed area; the required topographic, soil, and land use information; and use of the appropriate drainage coefficient curves.

The required capacity of open ditches for subsurface drainage in western irrigated areas shall be determined by evaluating site conditions, including irrigation water deliveries, irrigation canal or ditch losses, soil stratification and permeability, deep percolation losses, field irrigation losses, subsurface drain discharge, and quantity of surface water to be carried by the drainage ditch.

**Hydraulic gradeline.** The hydraulic gradeline for drainage ditch design shall be determined from control points, including elevations of significant low areas served by the ditch and hydraulic gradelines of any tributary ditches and the outlet. If control point elevations are estimated rather than computed from survey data, the hydraulic gradeline shall be no less than:

1. 1 ft. below fields that will receive normal drainage from ditches draining more than 1 mi<sup>2</sup>.
2. 0.5 ft for ditches draining 40 to 640 acres.
3. 0.3 ft for ditches draining less than 40 acres.

For lands to be used only for water-tolerant crops, such as trees and grasses, these requirements may be modified and the hydraulic gradeline set at ground level. These provisions do not apply to channels where flow is contained by dikes.

The effects of hydraulic losses caused by culverts, bridges, or other obstructions in the channel section shall be considered.

**Depth.** Drainage ditches shall be designed deep enough to allow for normal siltation. If needed, the design depth and capacity may be increased to provide adequate subsurface drainage or for normal flow. The increase shall be based on an evaluation of site conditions. Ditches that serve as outlets for subsurface drains shall be designed for a normal water surface at or below the invert of the outlet end of the drain. The clearance between a drain invert and the ditch bottom shall be least 1 ft. for ditches that fill with sediment at a normal rate, except where lower valves are specified for a job because of unusual site conditions. The normal water surface is the elevation of the usual low flow during the growing season.

**Cross section.** The design ditch cross section shall be set below the design hydraulic gradeline and shall meet the combined requirements of capacity, limiting velocity, depth, side slopes, bottom width, and, if needed, allowances for initial sedimentation. Side slopes shall be stable, shall meet maintenance requirements, and shall be designed on the basis of on-site conditions.

**Velocity.** The maximum permissible design velocity shall be based on site conditions and shall insure stability of the ditch bottom and side slopes. A desirable minimum velocity is 1.5 ft/s. On flat grades, a channel cross section shall be selected on the basis of the depth and maintenance requirements, which will result in the desirable minimum velocity if possible.

The velocity for newly constructed channels with drainage areas in excess of 1 mi<sup>2</sup> shall meet the stability requirements specified for Open Channels (582).

**Capacity design.** Manning's Formula shall be used in determining the design velocity, and the value of *n* shall be based on alinement, probable vegetative growth expected with normal maintenance, other roughness factors, and the hydraulic radius. Unless special site studies are available to justify other values, the following values of *n*, based on the hydraulic radius of the channel and assuming an aged channel with good maintenance and good alinement, shall be used in solving the Manning Formula for mains and laterals when determining the design for required capacity.

Hydraulic radius	<i>n</i>
Less than 2.5	.040 — .045
2.5 to 4.0	.035 — .040
4.1 to 5.0	.030 — .035
More than 5.0	.025 — .030

**Berms and spoil banks.** Adequate berms shall be provided and shaped, as required, to provide access for maintenance equipment, to eliminate the need for moving spoil banks in future operations, to provide for work areas and facilitate spoilbank spreading, to prevent excavated material from washing or rolling back into ditches, and to lessen sloughing of ditchbanks caused by heavy loads too near the edge of the ditchbanks. The following minimum berm widths shall be provided, except where spoil is spread according to the engineering standard for spoilbank spreading:

Ditch depth	Minimum berm width
<i>ft</i>	<i>ft</i>
2 — 6	8
6 — 8	10
More than 8	15

If spoil material is to be placed in banks along the ditch rather than spread over adjacent fields, the spoilbanks shall have stable side slopes. Provision must be made to channel water through the spoil and into the ditch without causing serious erosion.

**Operation and maintenance.** Requirements for operating and maintaining all drainage mains and laterals having drainage areas in excess of 1 mi<sup>2</sup> shall be according to the standard for Open Channels (582).

**Related structures and ditch protection.** Mains and laterals shall be protected against erosion by chutes, drop structures, pipe drops, other suitable structures or grassed waterway, or specially graded channel entrances where surface water or shallow ditches enter deeper ditches.

Grade control structures, bank protection, or other suitable measures shall be used if necessary to reduce velocities and control erosion.

Culverts and bridges shall have enough hydraulic capacity and depth for drainage needs and to minimize obstruction to flow.

Capacities of pipe or drop structures generally shall be determined by use of the applicable drainage coefficients with the "island-type" of construction used to protect the structure from washout.

Each structure for an open ditch system shall be designed according to SCS standards for the kind of structure and type of construction used.

**Channel vegetation.** Vegetation shall be established according to the standard for Channel Vegetation (322).

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing mains or laterals shall be in keeping with this standard and shall describe the requirements for constructing the practice to achieve its intended purpose.

## **MAIN OR LATERAL SPECIFICATIONS**

### **CLEARING**

The channel area shall be cleared of trees, logs, stumps, and other materials necessary for construction. Care must be taken to protect all trees to be saved for environmental purposes. All material shall be disposed of by an acceptable method as shown on the plans.

### **EXCAVATION**

Channels shall be excavated to line and grade as shown on the plans or as staked in the field. The excavated surface shall be reasonably smooth. Construction activities shall be carried on in a manner that will not restrict flow from upstream channels. Care must be taken to reduce and prevent pollution of water.

### **SPOIL**

Spoil shall be disposed of as shown on the plans or as marked in the field.

### **STRUCTURES**

All structures and other related protection devices shall be installed as the work progresses to permit proper functioning of the ditch and to prevent environmental damage during the installation period.

### **VEGETATION**

Vegetation shall be planted at times and rates shown in the plans or in the specifications for each job.

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# **SURFACE ROUGHENING**

(acre)  
CODE 609

## **DEFINITION**

Roughening the soil surface by ridge or clod-forming tillage.

## **PURPOSE**

To reduce wind erosion on cultivated land, especially during periods of high probability for erosive winds.

## **CONDITIONS WHERE PRACTICE APPLIES**

On soils that have a surface layer suitable for clod formation or ridging and have high potential for wind erosion due to lack of vegetative cover.

## **PLANNING CONSIDERATIONS**

General information applicable to planning or applying the practice may be included.

### **Water Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff and infiltration.

### **Water Quality**

1. Effects on erosion and the movement of soil and soil-attached substances by wind.
2. Effects on erosion and the movement of sediment, and soluble and sediment-attached substances carried by runoff.

## **SPECIFICATIONS GUIDE**

Specify methods, time of tillage, and suitability of soils.

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# **TERRACE**

(ft, m)  
**CODE 600**

## **DEFINITION**

An earth embankment, a channel, or a combination ridge and channel constructed across the slope.

## **SCOPE**

This standard applies to the planning and design of all types of terraces. It does not apply to diversions.

## **PURPOSE**

To: (1) reduce slope length, (2) reduce erosion, (3) reduce sediment content in runoff water, (4) improve water quality, (5) intercept and conduct surface runoff at a nonerosive velocity to a stable outlet, (6) retain runoff for moisture conservation, (7) prevent gully development, (8) reform the land surface, (9) improve farmability, or (10) reduce flooding.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where:

1. Water erosion is a problem.
2. There is a need to conserve water.
3. The soils and topography are such that terraces can be constructed and farmed with reasonable effort.
4. A suitable outlet can be provided.
5. Runoff and sediment can damage land or improvements downstream or impair water quality.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability effects caused by seasonal or climatic changes.
3. Effects of snowcatch and melt on water budget components.
4. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.
5. Effects on the downstream or aquifers that could affect other water uses and users.
6. The effect on the water table of the field to ensure that it will provide a suitable rooting depth, field wide, for anticipated land uses.
- 7 Potential for water management to supply alternate uses.

## Water Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.
2. Effects of nutrients and pesticides on surface and ground water quality.
3. Effects on the visual quality of onsite and downstream water.
4. Short-term and construction-related effects on the quality of onsite and downstream water.
5. Potential for development of saline seeps or other salinity problems resulting from increased infiltration in soils that have restrictive layers.
6. Potential for uncovering or redistributing toxic materials such as saline soils.
7. Effects on the movement of dissolved substances below the root zone and to the ground water.
8. Effects on wetlands and water related wildlife habitats.

## DESIGN CRITERIA

**Spacing.** The maximum spacing for terraces for erosion control shall be determined by one of the following methods:

1.  $V.I. = xs + y$  or  $H.I. = (xs+y) (100/s)$

Where:

$V.I.$  = vertical interval in ft(m)

$H.I.$  = horizontal interval in ft.(m) (see figures 1 and 2)  $x$  = a variable with values from 0.4 to 0.8 (0.12 to 0.24)

$s$  = land slope in percent

$y$  = a variable with values from 1.0 to 4.0 (0.3 to 1.2)

Values of  $x$  for different geographical zones are shown in figure 4. Values of  $y$  are influenced by soil erodibility, cropping system, and crop management practices. A value of 1.0 (0.3) shall be selected for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4.0 (1.2) shall be used for erosion-resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre or 3.4 metric tons per hectare) on the surface. A value of 2.5 (0.75) shall be used if one of the factors indicated is favorable and the other unfavorable. Other values between 1.0 (0.3) and 4.0 (1.2) may be used according to the estimated quality of the factors. The horizontal spacing does not have to be less than 90 ft.

2. Universal soil loss equation (USLE). The spacing shall not exceed the slope length determined by using the allowable soil loss, the most intensive use planned, the expected level of management, and the terrace P factor (table 1).

In no case shall the maximum horizontal spacing exceed that shown in table 2 for the conditions shown. The maximum limits may not be exceeded when making the adjustments indicated below. Spacing may be increased as much as 10 percent to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10 percent for terraces with underground outlets. The spacing shall be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths. The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval.

For level terraces used for erosion control and water conservation, the spacing shall be determined as indicated earlier, but the maximum horizontal spacing shall not exceed 600 ft (180 m). An  $x$  value of 0.8 (0.24) may be used for all level terraces used primarily

to impound water. Figures 1 and 2 show the horizontal interval or erosion length to be used in calculating terrace spacing (figure 3).

For terraces on noncropland, the maximum spacing shall be governed by the capacity equipment.

Figure 1

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### Horizontal Interval for Steep Back-Slope Terraces

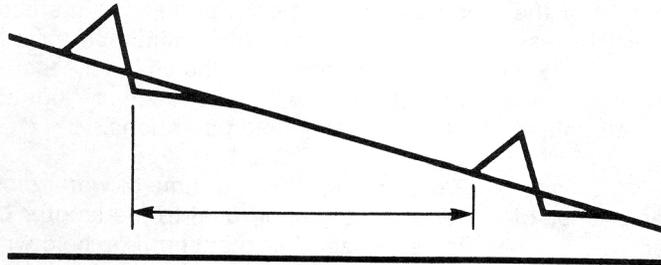


Figure 2

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### Horizontal Interval for Broad-Based Terraces

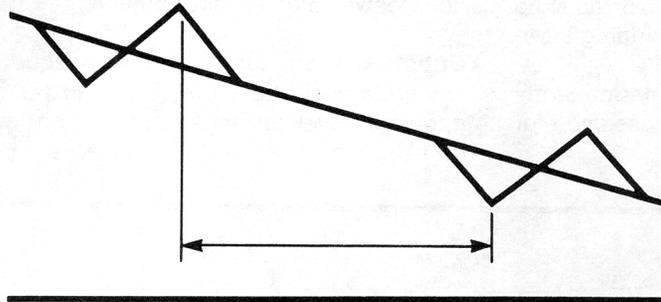


Figure 3

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### Terrace Spacing

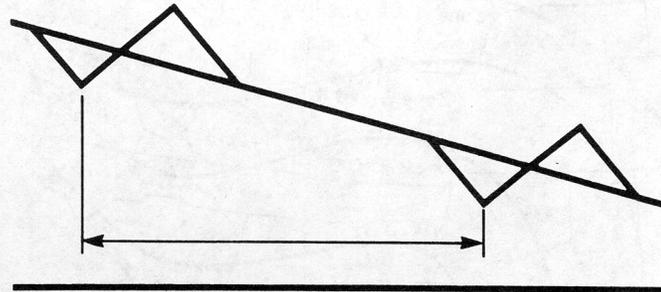


Table 1.- Terrace P factors

Horizontal Interval		Closed Outlets <sup>1</sup>	Open outlets, with percent grade of <sup>2</sup>		
(ft)	(m)		0.1 - 0.3	0.4 - 0.7	0.8
Less than 110	Less than 33	0.5	0.6	0.7	1.0
110 - 140	33 - 42	0.6	0.7	0.8	1.0
1.0	43 - 54	0.7	0.8	0.9	1.0
180 - 225	55 - 68	0.8	0.8	0.9	1.0
225 - 300	68 - 90	0.9	0.9	1.0	1.0
More than 300	More than 90	1.0	1.0	1.0	1.0

NOTE: If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

1 "P" factors for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

2 The channel grade is measured on the 300 ft of terrace or the one-third of total terrace length closest to the outlet, whichever distance is less.

Table 2.- Maximum horizontal spacing for terraces

Slope	USLE									
	R factor of						With contour		For concentrated	
	0 - 35		35 - 175		More than 175		stripcropping		flow control	
Percent	ft	m	ft	m	ft	m	ft	m	ft	m
0 - 2	700	210	500	150	450	130	600	180	700	210
2 - 4	700	210	400	120	300	90	600	180	700	210
4 - 6	600	180	400	120	200	60	600	180	600	180
6 - 9	400	120	300	90	150	45	400	120	500	150
9 - 16	400	120	250	75	150	45	250	75	500	150
12 - 18	250	75	200	60	150	45	150	45	400	120
More than 18	250	75	200	60	150	45	150	45	300	90
Minimum spacing required, all slopes	200	60	150	45	90	27	90	27	200	60

**Alignment.** Terraces shall be parallel if feasible and as parallel as practicable. Curves shall be long and gentle to accommodate farm machinery. Land forming, extra cut fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods shall be used to achieve good alignment.

Field efficiency may be used to compare alternative terrace systems. Field efficiency is the ratio of time required to farm the field being planned, to that required to farm a rectangular field of the same acreage ½ mi. long.

**Capacity.** The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation, unless provisions are made to maintain the design capacity through maintenance. Terrace systems designed to provide flood protection or to function with other structures shall have adequate capacity to control a storm of a frequency consistent with the potential hazard. When the capacity is determined by the formula  $Q = AV$  and the  $V$  is calculated by using Manning's formula, an  $n$  value of 0.06 shall be used for bare channels; and SCS-TP-61, Handbook of Channel Design for Soil and Water Conservation, or equivalent, shall be used for vegetated channels.

**Cross section.** The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. Additional height shall be added if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, and safety. The ridge shall have a minimum width of 3 ft. (1 m) at the design elevation. The minimum slope of a vegetated front or back ridge slope is 2:1. If necessary, steeper slopes may be used for special purposes but must be stable. The opening at the outlet end of gradient and open-end level terraces shall have a cross section equal to that specified for the terrace channel.

**End closures.** Level terraces may have open ends, partial end closures, or complete end closures. Partial and complete end closures shall be used only on soils and slopes where the stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

If terraces with closed or partly closed ends are specified, the end closures must be installed before the terraces are completed. The end closures shall be designed so that the water flows over the end closure before overtopping the terrace ridge.

Partial end closures shall not be more than half the effective height of the terrace ridge. Complete end closures are more than half the height of the ridge. The cross section of the closures may be less than the terrace cross section.

**Channel grade.** Channel grade shall be determined by one of the following methods:

1. Maximum channel grade in the lower reaches of the channel shall not exceed 0.6 percent.
2. Maximum channel velocity for farmed channels shall be nonerosive for the soil and planned treatment. Maximum velocity for erosion-resistant soils is 2.5 ft/s (0.75 m/s); for average soils, 2.0 ft/s (0.6 m/s); and for easily erodible soils, 1.5 ft/s (0.45 m/s). Maximum velocity for Hawaii shall be 5.5 ft/s (1.65 m/s). Velocity shall be computed by Manning's formula, using an n value of 0.035.
3. Maximum channel velocities for permanently vegetated channels shall not exceed those used for grassed waterways.

Channel grades may be uniform or variable. Channel velocity shall not exceed that which is nonerosive for the soil and planned treatment. For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment. If terraces have an underground outlet, water and sediment will pond in the channel, thus reducing the velocity and allowing steeper channel grades near the outlet. Minimum grades shall be such that ponding in the channel grades shall be such that ponding in the channel because of minor irregularities will not cause serious damage to crops or delay field operations.

**Terrace length.** The volume of water stored in level terraces is proportional to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break is minimized. Level terrace length shall not exceed 3,500 ft (1,000 m) unless the channel is blocked at intervals not exceeding 3,500 ft. (1,000 m). Normally, the gradient terrace length is controlled by the capacity and the nonerosive velocity requirements.

**Outlets.** All terraces must have adequate outlets.

Vegetated outlets may be used for gradient or open-end level terraces. Such an outlet may be a grassed waterway or a vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets shall be installed and vegetated before the terrace is constructed if necessary to provide a stable nonerodible outlet or to insure establishment of vegetative cover. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.

Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. An orifice plate, increase in conduit size, or other features shall be installed as needed to control the release rate and prevent excessive pressure when more than one terrace discharges into the same conduit. The discharge, when combined with the storage, shall be such that a 10-year frequency, 24-hour storm will not overtop the terrace, and growing crops will not be damaged significantly by standing water. The release time shall not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops, depending on soils characteristics and water tolerance of crops to be grown.

The underground conduit shall meet the requirements specified for underground outlets (620) or for subsurface drains (606). Conduits must be installed deep enough to prevent damage from tillage equipment. The inlet shall consist of a vertical perforated pipe of a material suitable for the intended purpose. The inlet shall be located uphill of the front slope of the terrace ridge, if farmed, to permit passage of farm machinery and, if necessary, provide for the anticipated accumulation of sediment and subsequent raising of the terrace ridge. The outlet of the conduit shall have adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective, usually in well-drained soils.

Soil infiltration may be used as the outlet for level terraces. Soil infiltration must permit drainage of the design storm from the terrace channel with a reasonable period so that crops are not significantly damaged by standing water.

Combinations of different types of outlets may be used on the same system to maximize water conservation and to provide for economical installation of a more farmable system.

## **SAFETY AND MAINTENANCE**

A program shall be established for maintaining terrace capacity, storage, ridge height, and outlets. Each inlet for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately.

Terrace ridges, especially those with steep back slopes, can be very hazardous. For this reason, some farmers prefer steep front slopes, thus keeping machinery away from the steep back slopes. All cut and fill slopes that are to be farmed must be no steeper than those on which farm equipment can operated safely. Any hazards must be brought to the attention of the responsible person.

Vegetation. All areas to be vegetated shall be established to grass as soon as practicable after construction. The sod shall be maintained and trees and brush controlled by chemical or mechanical means.

## **PLANS AND SPECIFICATIONS**

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

## **CONSTRUCTION**

All dead furrows, ditches, or gullies shall be filled before constructing the terrace or shall be part of the construction. All old, terraces, fence rows, hedge rows, trees, and other obstructions shall be removed, as necessary, to install a farmable system.

The terraces shall be constructed according to planned alignment, grade and cross section with the specified overfill for settlement and the channel graded to drain reasonably well.

Any ditch or depression at the bottom of the back slope shall be filled and smoothed so that drainage will be away from the terrace and not parallel to us.

Provisions must be made to prevent piping if underground circuits are located under terrace ridges. Mechanical compaction, water packing, trench sidewall sloping, and installation and backfill of conduit trenches early enough to allow adequate settlement are methods that can be used. The materials used for the inlet and the conduit shall be suitable for the purpose intended (see standard 606). Terrace ridges constructed across gullies or depressions shall be compacted by machinery travel or by other suitable means to insure proper functioning of the terrace.

The surface of the finished terrace shall be reasonably smooth and present a workmanlike finish.

If necessary, topsoil shall be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

If vegetation is required, seedbed preparation, fertilizing, seeding, and mulching shall comply with specifications in technical guides.

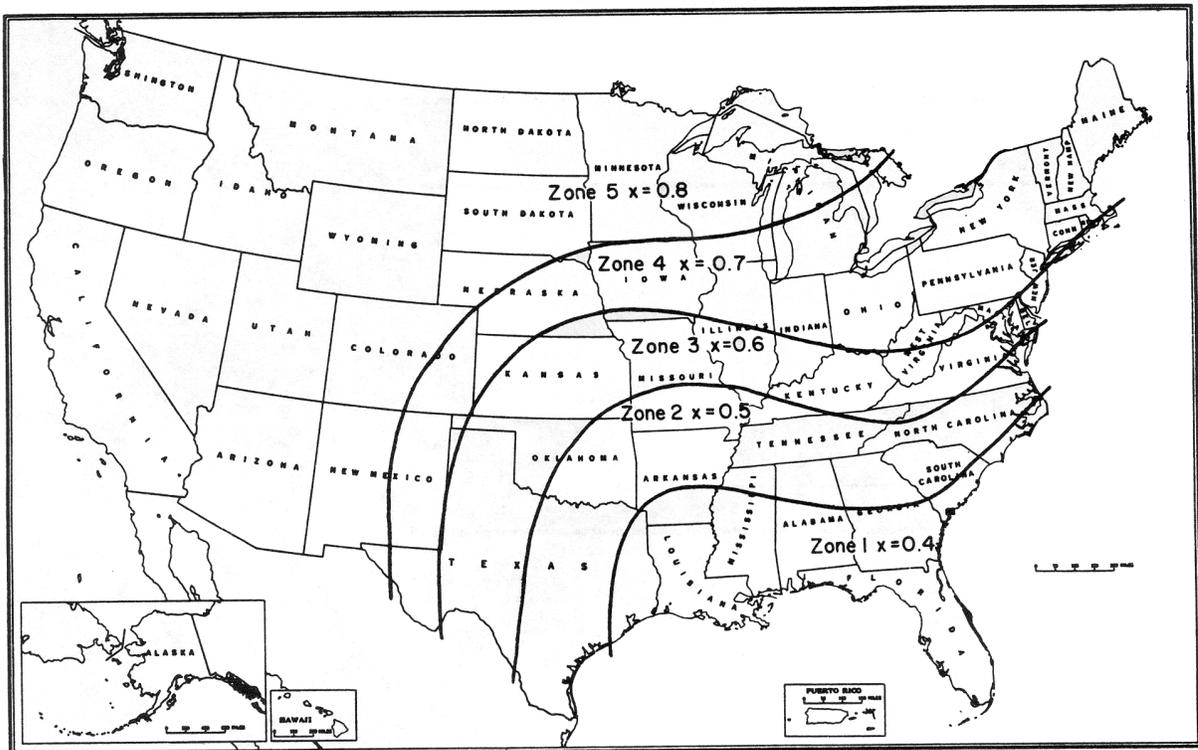


Figure 4. Values of x in equation  $V.I. = xs + y$  or  $H.I. = (xs+y) (100/s)$

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# TOXIC SALT REDUCTION

(acre)  
CODE 610

## DEFINITION

Reducing or redistributing the harmful concentrations of salt and/or sodium in a soil (sometimes referred to as leaching).

## PURPOSE

To permit desirable plants to grow.

## CONDITIONS WHERE PRACTICE APPLIES

On land where the accumulation of salt at or near the surface limits the growth of desirable plants.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on infiltration, deep percolation, and ground water recharge. Consider the variability (volume and timing) of the leaching fraction, the need for additional irrigation water, and the impact of drainage if installed as an associated practice.

### Water Quality

1. Effects on irrigation induced erosion, sedimentation, and soluble and sediment-attached substances in irrigation tailwater.
2. Effects of leaching on the volume of toxic salts and soluble nutrients and pesticides removed from the root zone. Identify the ultimate residence of the chemicals and the surface and ground water impact of drainage if installed as an associated practice.

## SPECIFICATIONS GUIDE

Methods of reducing concentrations and time.

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# TREE/SHRUB ESTABLISHMENT

(Acre)  
CODE 612

## DEFINITION

To establish woody plants by planting or seeding.

## PURPOSE

- To establish woody plants for forest products.
- Provide erosion control for landscaping and energy conservation.
- To reduce air pollution for uptake of soil and water borne chemicals and nutrients.
- Beautify an area.
- Protect a watershed.
- Provide wildlife habitat.

## CONDITIONS WHERE PRACTICE APPLIES

On any areas where woody plants are suited.

## CRITERIA

Species will be adapted to soil-site conditions.

Species will be suitable for the planned purpose.

Planting or seeding rates will be adequate to accomplish the planned purpose.

Planting dates, and care in handling and planting of the seed or seedlings will ensure that planted materials have an acceptable rate of survival.

Only viable, high quality, and adapted planting stock or seed will be used.

Site preparation shall be sufficient for establishment and growth of selected species.

Adequate seed or advanced reproduction needs to be present or provided for when using natural regeneration to establish a stand.

Timing and use of equipment will be appropriate for the site and soil conditions.

The acceptability and timing of coppice regeneration shall be based on species, age, and diameter.

The planting will be protected from adverse impacts such as livestock damage or fire.

## CONSIDERATIONS

When underplanting, trees should be planted sufficiently in advance of overstory removal to ensure full establishment.

Prescribed burning may be required for natural regeneration of serotinous cone species and for site preparation for other species.

All planting stock and seed should be purchased from nurseries that are known to be using locally adapted seed, seedlings or cuttings. Priority will be given to plant materials that have been selected and tested in tree improvement programs. All plant materials should comply with the minimum standards established by the American Nurseryman Standards Institute.

Plans for landscape and beautification plantings should consider foliage color, color and season of flowering, and mature plant height.

Where multiple species are available to accomplish the establishment objective, consideration should be given to selecting the species which best meets wildlife needs.

Tree arrangement and spacing should allow for access lanes.

Residual chemical carryover should be considered prior to planting.

## **PLANS AND SPECIFICATIONS**

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

Adapted tree species for the purposes outlined, spacing, planting methods, cultural practices and maintenance requirements that are applicable; and variations in methods and species between interplanting, underplanting, and planting in open areas. Separate specifications can be prepared for each of these planting methods.

## **OPERATION AND MAINTENANCE**

Competing vegetation will be controlled until the woody plants are established.

Replanting will be required when survival is inadequate.

Trees and shrubs will be protected from fire, insects, disease, and animals until established.

Supplemental watering may be desirable to ensure adequate survival.

Damaging pests will be monitored and controlled.

Periodic applications of nutrients may be needed to maintain plant vigor.

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# TREE/SHRUB PRUNING

(Acre)  
CODE 660A

## DEFINITION

Removing all or parts of selected branches from trees and shrubs.

## PURPOSES

- Improve the intended function of the plant.
- Improve appearance of trees or shrubs.
- Improve the quality of the wood product.
- Reduce a safety hazard.

## CONDITIONS WHERE PRACTICE APPLIES

On crop trees of high-value species (e.g. trees grown for select lumber, veneer or Christmas trees); on trees where removing all or parts of branches enhances the beauty and/or safety of an area; and to remove hazardous or diseased portions of trees.

## CRITERIA

Prune trees according to the following steps:

1. Locate the branch bark ridge
2. Find **A** (outside edge of branch bark ridge).
3. Find **B** (swelling where branch meets branch collar. If **B** is difficult to determine drop a line from **A**: the angle **XAC** is equal to the angle **XAB** (see figure 1). Stub the branch to be pruned using a first cut from below and a second cut from above.
4. Make the final cut on line **AB**.
5. Do not cut behind the branch bark ridge.
6. Do not leave stubs.
7. Do not cut into the branch collar.

Timing of shearing, branch removal and corrective pruning of high value tree species will be described to accomplish the intended purpose.

## CONSIDERATIONS

The timing of pruning should consider the nesting and breeding requirements of arboreal species. In urban areas special considerations need to be given for safety hazards.

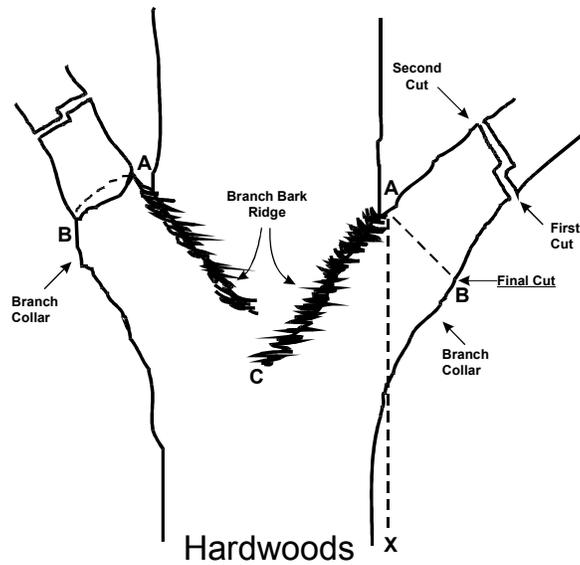


Figure 1. — Hardwood pruning (see figure 2 for conifer pruning).

## PLANS AND SPECIFICATIONS

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation. Species, site limitations, methods, equipment, season of year, and guides to pruning for the applicable purpose shall be considered.

## OPERATION AND MAINTENANCE

Reinspection and re pruning as needed for the prescribed purposes.

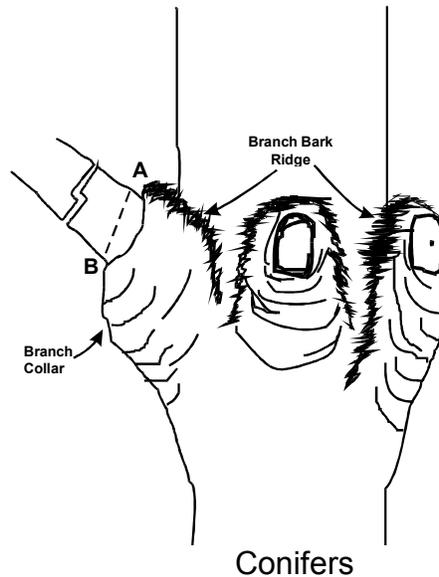


Figure 2. — Conifer pruning.

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# **TROUGH OR TANK**

(No.)  
CODE 614

## **DEFINITION**

A trough or tank, with needed devices for water control and waste water disposal, installed to provide drinking water for livestock.

## **SCOPE**

This standard applies to all troughs or tanks installed to provide livestock watering facilities that are supplied by streams, springs, wells, ponds, or other sources.

## **PURPOSE**

To provide watering facilities for livestock at selected locations that will protect vegetative cover through proper distribution of grazing or through better grassland management for erosion control. Another purpose on some sites is to reduce or eliminate the need for livestock to be in streams, which reduces livestock waste there.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies where there is a need for new or improved watering places to permit the desired level of grassland management, to reduce health hazards for livestock, and to reduce livestock waste in streams.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects on components of the water budget.
2. Effects on downstream flows or aquifers that affect other water uses or users.

### **Water Quality**

1. Effects on erosion and movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.
2. Effects on the visual quality of onsite and downstream water resources.
3. Effects on wetlands and water-related wildlife habitats.

## **DESIGN CRITERIA**

The trough or tank shall have adequate capacity to meet the water requirements of the livestock. This will include the storage volume necessary to carry over between periods of replenishment.

The site should be well drained, or if not, drainage measures will be provided. Areas adjacent to the trough or tank that will be trampled by livestock shall be graveled, paved, or otherwise treated to provide firm footing and reduce erosion.

Automatic water level control and/or overflow facilities shall be provided as appropriate. Valves or pipes shall be protected by shields or covers to prevent damage by livestock. Overflow shall be piped to a desirable point of release. The trough and outlet pipes will be protected from freezing and ice damage if this is a potential problem. Freeze-proof troughs or electric heaters may be used at some sites. Roofs can be placed over the trough to provide shade and reduce loss of water by evaporation.

The quality and durability of all materials shall be in keeping with the planned useful life of the installation. Common construction materials are reinforced concrete, steel, and wood.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing troughs and tanks shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

## **OPERATION AND MAINTENANCE**

Check periodically to see if any type of debris has fallen into the trough which may restrict the inflow or outflow system. Check tank for leaks or cracks and repair immediately if any cracks or wall separations are found. Check the automatic water level device to insure that it is operating properly. Make certain that that area adjacent to the trough is well protected with gravel, paving, or good cover. Be sure that the outlet pipe has a free outlet and is not causing any serious erosion problems.

If the trough has not been designed to prevent damage from freezing, it should be prepared for winter weather. This may include a measure such as adding material in the storage area to take up expansion.

Algae and iron sludges sometimes are problems in watering facilities. Chemicals such as copper sulfate and chlorine have been used. Local rules and regulations are to be followed when recommending chemicals.

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# UNDERGROUND OUTLET

(Ft)  
CODE 620

## DEFINITION

A conduit installed beneath the surface of the ground to collect surface water and convey it to a suitable outlet.

## SCOPE

This standard applies to underground conduits designed to dispose of excess surface water. It does not apply to trickle tubes or to principal spillways in ponds or in Subsurface Drains (606).

## PURPOSE

To dispose of excess water from terraces, diversions, subsurface drains, surface drains, trickle tubes or principal spillways from dams (outside the dam area only), or other concentrations without causing damage by erosion or flooding.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies where: (1) excess surface water needs to be disposed of; (2) a buried outlet is needed for Diversions (362), Terraces (600), or similar practices; (3) an underground outlet can be installed that will safely dispose of excess water; and (4) surface outlets are impractical because of stability problems, climatic conditions, land use, or equipment traffic.

## PLANNING CONSIDERATIONS

1. Consider effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Consider effects on the volume of downstream flow that might cause undesirable environmental, social, or economic effects.
3. Evaluate potential use for water management.
4. Consider effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.
5. Consider effects on the visual quality of downstream water resources.
6. Consider sediment-attached and construction-related effects on the quality of downstream water courses.
7. Consider effects on wetlands or water-related wildlife habitats.

## DESIGN CRITERIA

**Capacity.** The underground outlet shall be designed, alone or in combination with other practices, with adequate capacity to insure that the terrace, diversion, or other practices function according to the standard for the specific practice. For example, an underground outlet can be used in combination with a grassed waterway or a surface drain to carry part of the design flow. The capacity of the underground outlet for natural basins shall be adequate for the intended purpose without causing excessive damage to crops, vegetation, or improvements.

**Inlet.** An inlet can be a collection box, a perforated riser, or other appropriate device. Its capacity shall be adequate to provide the maximum design flow in the conduit. Flow-control devices shall be installed as necessary. Perforated risers must be of durable material, structurally sound and resistant to damage by rodents or other animals. If burning of vegetation is likely to create a fire hazard, the inlet shall be fire resistant. Blind inlets can be used where they are effective. Collection boxes must be large enough to facilitate maintenance and cleaning operations. The inlet must have an appropriate trash guard to insure that trash or other debris entering the inlet passes through the conduit without plugging. It must also have an animal guard to prevent the entry of rodents or other animals.

Pressure-relief wells shall be designed and installed as needed to control pressure. If junction boxes and other structures are needed, they shall be designed and installed in a manner that facilitates cleaning and other maintenance activities.

**Hydraulics.** Underground outlets shall be continuous conduits, tubing, or tile. Joints shall be hydraulically smooth, and the materials and methods used shall be recommended by the manufacturer. If a pressure system is used, joints shall be adequate to withstand the design pressure, including surges and vacuum. The maximum velocity must not exceed the safe velocity for the conduit materials and installation.

Lines shall be adequate to carry the design flow when the outlet and all inlets are operating at design capacity. Capacity shall be based on the pipe size or on other flow control devices to prevent water from the upper inlets from discharging through the lower inlets. The minimum conduit diameter shall be 3 inches.

Materials shall meet or exceed the design requirements against leakage and shall withstand internal pressure or vacuum and external loading. Plastic, concrete, aluminum, and steel shall meet the requirements specified in the applicable ASTM standard. All materials specified for Subsurface Drains (606) can be used for underground outlets. Conduits, however, can be perforated or nonperforated, depending on the design requirements.

**Outlet.** The outlet shall be sufficiently stable for all anticipated flow conditions. It shall be designed for the maximum anticipated water surface at design flow. A continuous section of closed conduit or a headwall can be used at the outlet. If a closed conduit is used, it shall be durable and strong enough to withstand all anticipated loads, including those caused by ice. If fire is a hazard, the outlet shall be fire resistant. All outlets near ponds, outlet channels, or streams where water is normally present must have animal guards to prevent the entry of rodents or other animals. Animal guards must be hinged to allow passage of debris.

**Protection.** Before the outlet is installed, all disturbed areas shall be reshaped and regraded so that they blend with the surrounding land features and conditions. Visual resources must be given the same consideration as other design features. Areas that are not to be farmed or covered by structural works shall be established to vegetation or otherwise protected from erosion as soon as practicable after construction.

**Maintenance.** Underground outlets shall be maintained by keeping inlets, trash guards, and collection boxes and structures clean and free of materials that can reduce the flow. All leaks shall be repaired promptly to insure proper functioning of the conduit. Animal guards must be inspected periodically and maintained in proper working order.

## PLANS AND SPECIFICATIONS

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

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# UPLAND WILDLIFE HABITAT MANAGEMENT

(acre)  
CODE 645

## DEFINITION

Creating, restoring, maintaining or enhancing areas for food, cover, and water for upland wildlife and species which use upland habitat for a portion of their life cycle.

## PURPOSE

- Provide a variety of food for the desired kinds of wildlife species;
- Provide a variety of cover types for the desired kinds of wildlife species, examples include nesting, fawning, loafing, resting, escape, travel lanes, and thermal;
- Provide drinking water for the desired kinds of wildlife species.
- Arrange habitat elements in proper amounts and locations to benefit desired species.
- Manage the wildlife habitat to achieve a viable wildlife population within the species home range.

## CONDITIONS WHERE PRACTICE APPLIES

On all landscapes that are suitable for the kinds of wildlife habitat that are needed within the range of the desired species or the natural community under consideration.

## CRITERIA

### General Criteria Applicable to all Purposes

- Habitat development and management necessary, to achieve the purpose(s), shall be based on a wildlife habitat appraisal or suitable habitat evaluation. The appraisal or evaluation procedure shall be used to determine a habitat suitability for either individual fields, home range areas, habitat type or natural community as well as to provide an overall evaluation for the entire property or operating unit.

Habitat Appraisal or Habitat Evaluation:

- The evaluation will result in a quality rating or habitat suitability index (hsi). This will consider the type, amount, and distribution of habitat elements required. The quality rating or hsi will be compared to the quality criteria in Section III of the FOTG.
- If the evaluation indicates a level below the acceptable quality, alternatives will be recommended that will result in the necessary changes in habitat elements or their management to bring the rating up to the minimal acceptable or above.
- If the evaluation is at the minimum or above, alternatives will be recommended that will result in the necessary management to preserve, maintain or improve the existing habitat in its present state or toward optimum conditions

## Habitat Elements

- The following habitat elements will be considered when assessing wildlife habitat. Not all may apply to every habitat type.
  1. Food
    - a. Type
    - b. Amount
  2. Cover
    - a. Type
    - b. Amount
  3. Water
    - a. quality
    - b. quantity
    - c. accessibility
    - d. seasonal availability
  4. Interspersion and Distance to
    - a. crops
    - b. grasses and or legumes
    - c. shrubs
    - d. trees
    - e. water
    - f. openings
  5. Migration
    - a. routes
    - b. season of use
    - c. corridors

## Development and Management of Wildlife Habitat:

- As indicated by the wildlife habitat evaluation, certain habitat elements may be weak or missing. For the desired species, identify the types, amount, and distribution of habitat elements and management actions necessary to achieve the management objectives.
- The amount and kinds of habitat elements planned, their location and management shall be identified in a management plan.
- The use of native plant materials shall be encouraged.
- Vegetative manipulations to restore plant and/or animal diversity shall be accomplished by prescribed burning or mechanical, biological or chemical methods, or a combination of the four.
- Where feasible prescribed burning shall be utilized instead of mowing.
- Livestock grazing or haying shall be conducted to maintain or improve vegetation structure and composition so as to improve the desired wildlife habitat.
- Management measures shall be provided to control invasive species and noxious weeds.
- To protect forbs and legumes that benefit native pollinators and other wildlife and provide insect food sources for grassland nesting birds, spraying or other control of noxious weeds shall be done on a "spot" basis.

## CONSIDERATIONS

Wildlife population control (hunting to reduce numbers) which is the responsibility of state and federal wildlife agencies and the landowner may be necessary to protect and maintain certain habitats.

Consider that manipulations of habitat may impact more than the desired kinds of wildlife. These possible effects shall be evaluated and taken into consideration during the planning process.

This practice may be used to promote the conservation of declining species, including threatened and endangered species.

Consider the problems of habitat fragmentation when using this practice, create large blocks of habitat verses increased edge which leads to predation and parasitism by some species such as cowbirds.

Consider habitat linkages and habitat corridors when developing upland wildlife habitat.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for this practice shall be prepared for each site. Plans and specifications shall be recorded using approved specifications sheets, job sheets, technical notes, or narrative documentation in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

The purpose of operation, maintenance, and management is to insure that the practice functions as intended over time.

A plan for operation and maintenance of upland wildlife habitat at a minimum shall include monitoring and management of structural and vegetative measures.

Timing of haying and livestock grazing will avoid periods when upland wildlife are nesting, fawning, etc. and will allow the establishment, development, and management of upland vegetation for the intended purpose.

Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible.

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# **USE EXCLUSION**

(Acre)  
CODE 472

## **DEFINITION**

Excluding animals, people or vehicles from an area.

## **PURPOSES**

To protect, maintain, or improve the quantity and quality of the plant, animal, soil, air, water, and aesthetics resources and human health and safety.

## **CONDITIONS WHERE PRACTICE APPLIES**

In areas where vegetative establishment and maintenance, soil condition, water or air quality, wildlife or aesthetic values are in need of protection. This practice is also applicable in areas where human and animal health and safety hazards are present.

## **CRITERIA**

Barriers must be adequate to prevent use by targeted vehicles, animals or people.

Barrier life expectancy must be adequate for the intended purpose.

Timing and exclusion periods must be described to accomplish intended purposes.

## **CONSIDERATIONS**

All areas should consider existing or potential liability to the planning agency or the landuser based on safety, health and public relations.

Barriers may consist of both natural and artificial structures such as logs, vegetation, earth fill, boulders, fences, gates or signs.

## **PLANS AND SPECIFICATIONS**

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Barriers will be periodically inspected and remedial repairs will be performed as needed.

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# **VERTICAL DRAIN**

(No.)  
CODE 630

## **DEFINITION**

A well, pipe, pit, or bore in porous, underground strata into which drainage water can be discharged.

## **PURPOSE**

To provide an outlet for drainage water from a surface or subsurface drainage system.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice is applicable in locations where the underlying strata can receive, transmit, or store the design drainage flow and other drainage outlets are not available and cannot be provided at a reasonable cost. The practice is applicable only in locations where a determination has been made that it is not contrary to state laws or regulations, and that it will not cause pollution of underground waters.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effect on the aquifer recharge.
2. Effect on the water table.
3. The effect on the volume of downstream flow to downstream users and uses.

### **Water Quality**

1. The potential hazard to ground water quality from the discharge of drainage water containing dissolved substances.
2. The potential for land use changes that may impair aquifer quality.

## **DESIGN CRITERIA**

The number and size of vertical drains shall be adequate to discharge the design drainage flow into the underlying stratum or strata. The number, size, and location of the drains shall be based on a field determination of the depth, permeability, porosity, thickness, and extent of the strata. The minimum diameter of shallow uncased wells shall be 24 in. and of deep cased wells, 4 in.

A suitable filter system, desilting basin, or other means for removing sediment from the water before it enters the well shall be provided.

Well casings shall be of adequate strength and longevity to serve planned needs.

## **PLANS AND SPECIFICATIONS**

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

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# WASTE MANAGEMENT SYSTEM

(No.)  
CODE 312

## DEFINITION

A planned system in which all necessary components are installed for managing liquid and solid waste, including runoff from concentrated waste areas, in a manner that does not degrade air, soil, or water resources.

## SCOPE

This standard establishes the minimum acceptable requirements for planning and operating waste management systems. It does not apply to the design and installation of the system components.

## PURPOSE

To manage waste in rural areas in a manner that prevents or minimizes degradation of air, soil, and water resources and protects public health and safety. Such systems are planned to preclude discharge of pollutants to surface or ground water and to recycle waste through soil and plants to the fullest extent practicable.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies where: (1) waste is generated by agricultural production or processing; (2) waste from municipal and industrial treatment plants is used in agricultural production; (3) all practice components necessary to make a complete system are specified; and (4) soil, water, and plant resources are adequate to properly manage the waste.

## PLANNING

**General.** Waste, as used in this standard, includes both liquid and solid waste, waste water used in processing, and polluted runoff such as that from a feedlot.

A waste management system for a given enterprise shall include the components necessary to properly manage waste and prevent degradation of air, water, soil and plant resources. A system may consist of a single component, such as a diversion, or may consist of several components. Components shall not be installed until an overall waste management system has been planned.

**Components.** Components of complete waste management systems may include, but are not limited to, the following:

- Debris basins
- Pond sealings or linings
- Dikes
- Subsurface drains
- Diversions
- Surface drains
- Fencing
- Waste storage ponds

- Grassed waterways or outlets
- Waste storage structures
- Irrigation systems
- Waste treatment lagoons
- Irrigation water conveyance
- Waste utilization

Design criteria for individual components shall be according to standards in the National Handbook of Conservation Practices. The criteria for the design of components not included in this handbook shall be consistent with sound engineering principles.

## **PLANNING CONSIDERATIONS**

1. Waste should be used to the fullest extent possible by recycling it through soil and plants. If very little land is available, such practices as lagoons and oxidation ditches may be needed.
2. Clean water should be excluded from concentrated waste areas to the fullest extent practical.
3. Manure shall be collected and safely spread on land, treated, or stored until it can be safely spread. Adequate storage must be provided to allow spreading during favorable weather and at times compatible with crop management and available labor.
4. Polluted runoff and seepage from concentrated waste areas shall be intercepted and directed to storage or treatment facilities for future disposal or be directly applied to land in an acceptable manner.
5. Waste water from processing shall be collected and directly applied, stored, or treated before using it.
6. Adequate drainage, erosion, control, and other soil and water management practices shall be incorporated to prevent system-related problems.
7. The overall system shall include sufficient land for proper use or disposal of waste at locations, times, rates and volumes that maintain desirable water, soil, plant, and other environmental conditions. Appropriate waste-handling equipment shall be available for effective operation of the system.
8. The system should be outside major viewsheds to conserve visual resources. Vegetative screens and other methods should be provided, as appropriate, to improve visual conditions.

### **Water Quantity**

1. Effects on the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, on farm uses and ground water recharge.
2. Variability of effects often seasonal and weather variations.
3. Effects of vegetation on soil moisture.
4. Effects of snow catch and melt on water budget components.
5. Effects of increasing organic matter on water holding capacity of the soil.
6. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.

### **Water Quality**

1. Effects of both growing and decaying vegetation or nutrients balance in the root zone.
2. Effects on erosion and the movement of sediment, pathogens, organic material, and soluble and sediment-attached substances carried by runoff.
3. Effects of use and management of nutrients and pesticides on surface and ground water quality.
4. Effects on the visual quality onsite and of downstream water.

5. Sediment-attached and construction-related effects on the quality of onsite downstream water courses and impoundments.
6. Effects on the movement of dissolved substances below the root zone and toward ground water, especially for on-farm water supply for human and livestock.
7. Effects on wetlands and water-related wildlife habitats.

**Sequence of installation.** System components shall be planned and installed in a sequence that insures that each will function as intended without being hazardous to others or to the overall system.

**Safety.** Safety features and devices shall be included in waste management systems, as appropriate, to protect animals and humans from drowning, dangerous gases, and other hazards. Fencing shall be provided, as necessary, to prevent livestock and others from using facilities for other purposes.

## **SYSTEM OPERATION**

The owner or operator shall be responsible for operating and maintaining the system. An operation plan shall be prepared for this use. It should provide specific details concerning the operation of each component and should include:

1. Timing, rates, volumes, and locations for application of waste and, if appropriate, approximate number of trips for hauling equipment and an estimate of the time required.
2. Minimum and maximum operation levels for storage and treatment practices and other operations specific to the practice, such as estimated frequency of solids removal.
3. Safety warnings, particularly where there is danger of drowning or exposure to poisonous or explosive gases.
4. Maintenance requirements for each of the practices.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for waste management systems shall be in keeping with this standard and standards for individual system components.

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# WASTE STORAGE FACILITY

(No.)  
CODE 313

## DEFINITION

A waste storage impoundment made by constructing an embankment and/or excavating a pit or dugout, or by fabricating a structure.

## PURPOSE

To temporarily store wastes such as manure, wastewater, and contaminated runoff as a storage function component of an agricultural waste management system.

## CONDITIONS WHERE PRACTICE APPLIES

- where the storage facility is a component of a planned agricultural waste management system
- where temporary storage is needed for organic wastes generated by agricultural production or processing
- where the storage facility can be constructed, operated and maintained without polluting air or water resources
- where site conditions are suitable for construction of the facility
- to facilities utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.
- to fabricated structures including tanks, stacking facilities, and pond appurtenances.

## CRITERIA

### General Criteria Applying to All Waste Storage Facilities.

**Laws and regulations.** Waste storage facilities must be planned, designed, and constructed to meet all federal, state, and local laws and regulations.

**Location.** To minimize the potential for contamination of streams, waste storage facilities should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year flood event, or larger if required by laws, rules, and regulations. Waste storage facilities shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values.

**Storage period.** The storage period is the maximum length of time anticipated between emptying events. The minimum storage period shall be based on the timing required for environmentally safe waste utilization considering the climate, crops, soil, equipment, and local, state, and federal regulations.

**Design storage volume.** The design storage volume equal to the required storage volume, shall consist of the total of the following as appropriate:

1. Manure, wastewater, and other wastes accumulated during the storage period

2. Normal precipitation less evaporation on the surface area (at the design storage volume level) of the facility during the storage period
3. Normal runoff from the facility's drainage area during the storage period
4. 25-year, 24-hour precipitation on the surface (at the required design storage volume level) of the facility
5. 25-year, 24-hour runoff from the facility's drainage area
6. Residual solids after liquids have been removed. A minimum of 6 inches shall be provided for tanks
7. Additional storage as may be required to meet management goals or regulatory requirements

**Inlet.** Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage and ultraviolet ray deterioration while incorporating erosion protection as necessary.

**Emptying Component.** Some type of component shall be provided for emptying storage facilities. It may be a facility such as a gate, pipe, dock, wet well, pumping platform, retaining wall, or ramp. Features to protect against erosion, tampering, and accidental release shall be incorporated as necessary.

**Accumulated solids removal.** Provision shall be made for periodic removal of accumulated solids to preserve storage capacity. The anticipated method for doing this must be considered in planning, particularly in determining the configuration of ponds and type of seal, if any.

**Safety.** Design shall include appropriate safety features to minimize the hazards of the facility. Ramps used to empty liquids shall have a slope of 4 horizontal to 1 vertical or flatter. Those used to empty slurry, semi-solid, or solid waste shall have a slope of 10 horizontal to 1 vertical or flatter unless special traction surfaces are provided. Warning signs, fences, ladders, ropes, bars, rails, and other devices shall be provided, as appropriate, to ensure the safety of humans and livestock. Ventilation and warning signs must be provided for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation. Pipelines shall be provided with a water-sealed trap and vent, or similar device, if there is a potential, based on design configuration, for gases to enter buildings or other confined spaces. Ponds and uncovered fabricated structures for liquid or slurry waste with walls less than 5 feet above ground surface shall be fenced and warning signs posted to prevent children and others from using them for other than their intended purpose.

**Erosion protection.** Embankments and disturbed areas surrounding the facility shall be treated to control erosion.

**Liners.** Liners shall meet or exceed the criteria in NRCS Practice Standard 521, Pond Sealing or Lining.

#### **Additional Criteria for Waste Storage Ponds**

**Soil and foundation.** The pond shall be located in soils with an acceptable permeability that meets all applicable regulation, or the pond shall be lined. Information and guidance on controlling seepage from waste impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The pond shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless features of special design are incorporated that address buoyant forces, pond seepage rate and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains, if feasible, to meet this requirement.

**Maximum Operating Level.** The maximum operating level for waste storage ponds shall be the pond level that provides for the required volume less the volume contribution of precipitation and

runoff from the 25-year, 24-hour storm event plus the volume allowance for residual solids after liquids have been removed. A permanent marker or recorder shall be installed at this maximum operating level to indicate when drawdown should begin. The marker or recorder shall be referenced and explained in the O&M plan.

**Outlet.** No outlet shall automatically release storage from the required design volume. Manually operated outlets shall be of permanent type designed to resist corrosion and plugging.

**Embankments.** The minimum elevation of the top of the settled embankment shall be 1 foot above the waste storage pond's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall be not less than 5 percent. The minimum top widths are shown in Table 1. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

Table 1 – Minimum Top Widths

Total embankment Height, ft.	Top Width, ft.
15 or less	8
15 – 20	10
20 – 25	12
25 – 30	14
30 – 35	15

**Excavations.** Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

#### **Additional Criteria for Fabricated Structures**

**Foundation.** The foundations of fabricated waste storage structures shall be proportioned to safely support all superimposed loads without excessive movement or settlement. Where a non-uniform foundation cannot be avoided or applied loads may create highly variable foundation loads, settlement should be calculated from site-specific soil test data. Index tests of site soil may allow correlation with similar soils for which test data is available. If no test data is available, presumptive bearing strength values for assessing actual bearing pressures may be obtained from Table 2 or another nationally recognized building code. In using presumptive bearing values, adequate detailing and articulation shall be provided to avoid distressing movements in the structure.

Foundations consisting of bedrock with joints, fractures, or solution channels shall be treated or a separation distance provided consisting of a minimum of 1 foot of impermeable soil between the floor slab and the bedrock or an alternative that will achieve equal protection.

Table 2 - Presumptive Allowable Bearing Stress Values<sup>1</sup>

Foundation Description	Allowable Stress
Crystalline Bedrock	12000 psf
Sedimentary Rock	6000 psf
Sandy Gravel or Gravel	5000 psf
Sand, Silty Sand, Clayey Sand, Silty Gravel, Clayey Gravel	3000 psf
Clay, Sandy Clay, Silty Clay, Clayey Silt	2000 psf
<sup>1</sup> Basic Building Code, 12th Edition, 1993, Building Officials and Code Administrators, Inc. (BOCA)	

**Liquid tightness.** Applications such as tanks, that require liquid tightness shall be designed and constructed in accordance with standard engineering and industry practice appropriate for the construction materials used to achieve this objective.

**Structural loadings.** Waste storage structures shall be designed to withstand all anticipated loads including internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, water pressure due to seasonal high water table, and frost or ice pressure and load combinations in compliance with this standard and applicable local building codes.

The lateral earth pressures should be calculated from soil strength values determined from the results of appropriate soil tests. Lateral earth pressures can be calculated using the procedures in TR-74. If soil strength tests are not available, the presumptive lateral earth pressure values indicated in Table 3 shall be used.

TABLE 3 - LATERAL EARTH PRESSURE VALUES<sup>1</sup>

Soil		Equivalent fluid pressure (lb/ft <sup>2</sup> /ft of depth)			
		Above seasonal high water table <sup>2</sup>		Below seasonal high water table <sup>3</sup>	
Description <sup>4</sup>	Unified Classification <sup>4</sup>	Free-standing walls	Frame tanks	Free-standing walls	Frame tanks
Clean gravel, sand or sand-gravel mixtures (maximum 5% fines) <sup>5</sup>	GP, GW, SP, SW	30	50	80	90
Gravel, sand, silt and clay mixtures (less than 50% fines) Coarse sands with silt and and/or clay (less than 50% fines)	All gravel sand dual symbol classifications and GM, GC, SC, SM, SC-SM	35	60	80	100
Low-plasticity silts and clays with some sand and/or gravel (50% or more fines) Fine sands with silt and/or clay (less than 50% fines)	CL, ML, CL-ML SC, SM, SC-SM	45	75	90	105
Low to medium plasticity silts and clays with little sand and/or gravel (50% or more fines)	CL, ML, CL-ML	65	85	95	110
High plasticity silts and clays (liquid limit more than 50) <sup>6</sup>	CH, MH	-	-	-	-

<sup>1</sup> For lightly compacted soils (85% to 90% maximum standard density.) Includes compaction by use of typical farm equipment.  
<sup>2</sup> Also below seasonal high water table if adequate drainage is provided.  
<sup>3</sup> Includes hydrostatic pressure.  
<sup>4</sup> All definitions and procedures in accordance with ASTM D 2488 and D 653.  
<sup>5</sup> Generally, only washed materials are in this category  
<sup>6</sup> Not recommended. Requires special design if used.

Lateral earth pressures based upon equivalent fluid assumptions shall be assigned according to the following conditions:

- **Rigid frame or restrained wall.** Use the values shown in Table 3 under the column “Frame tanks,” which gives pressures comparable to the at-rest condition.
- **Flexible or yielding wall.** Use the values shown in Table 3 under the column “Free-standing walls,” which gives pressures comparable to the active condition. Walls in this category are designed on the basis of gravity for stability or are designed as a cantilever having a base wall thickness to height of backfill ratio not more than 0.085.

Internal lateral pressure used for design shall be  $65 \text{ lb/ft}^2$  where the stored waste is not protected from precipitation. A value of  $60 \text{ lb/ft}^2$  may be used where the stored waste is protected from precipitation and will not become saturated. Lesser values may be used if supported by measurement of actual pressures of the waste to be stored. If heavy equipment will be operated near the wall, an additional two feet of soil surcharge shall be considered in the wall analysis.

Tank covers shall be designed to withstand both dead and live loads. The live load values for covers contained in ASAE EP378.3, Floor and Suspended Loads on Agricultural Structures Due to Use, and in ASAE EP 393.2, Manure Storages, shall be the minimum used. The actual axle load for tank wagons having more than a 2,000 gallon capacity shall be used.

If the facility is to have a roof, snow and wind loads shall be as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads. If the facility is to serve as part of a foundation or support for a building, the total load shall be considered in the structural design.

**Structural design.** The structural design shall consider all items that will influence the performance of the structure, including loading assumptions, material properties and construction quality. Design assumptions and construction requirements shall be indicated on standard plans.

Tanks may be designed with or without covers. Covers, beams, or braces that are integral to structural performance must be indicated on the construction drawings. The openings in covered tanks shall be designed to accommodate equipment for loading, agitating, and emptying. These openings shall be equipped with grills or secure covers for safety, and for odor and vector control.

All structures shall be underlain by free draining material or shall have a footing located below the anticipated frost depth. Fabricated structures shall be designed according to the criteria in the following references as appropriate:

- Steel: “Manual of Steel Construction”, American Institute of Steel Construction.
- Timber: “National Design Specifications for Wood Construction”, American Forest and Paper Association.
- Concrete: “Building Code Requirements for Reinforced Concrete, ACI 318”, American Concrete Institute.
- Masonry: “Building Code Requirements for Masonry Structures, ACI 530”, American Concrete Institute.

**Slabs on grade.** Slab design shall consider the required performance and the critical applied loads along with both the subgrade material and material resistance of the concrete slab. Where applied point loads are minimal and liquid-tightness is not required, such as barnyard and feedlot slabs subject only to precipitation, and the subgrade is uniform and dense, the minimum slab thickness shall be 4 inches with a maximum joint spacing of 10 feet. Joint spacing can be increased if steel reinforcing is added based on subgrade drag theory.

For applications where liquid-tightness is required such as floor slabs of storage tanks, the minimum thickness for uniform foundations shall be 5 inches and shall contain distributed reinforcing steel. The required area of such reinforcing steel shall be based on subgrade drag theory as discussed in industry guidelines such as American Concrete Institute, ACI 360, “Design of Slabs-on-Grade”.

When heavy equipment loads are to be resisted and/or where a non-uniform foundation cannot be avoided, an appropriate design procedure incorporating a subgrade resistance parameter(s) such as ACI 360 shall be used.

## CONSIDERATIONS

Waste storage facilities should be located as close to the source of waste and polluted runoff as practicable.

Non-polluted runoff should be excluded from the structure to the fullest extent possible except where its storage is advantageous to the operation of the agricultural waste management system.

Freeboard for waste storage tanks should be considered.

Solid/liquid separation of runoff or wastewater entering pond facilities should be considered to minimize the frequency of accumulated solids removal and to facilitate pumping and application of the stored waste.

Due consideration should be given to environmental concerns, economics, the overall waste management system plan, and safety and health factors.

### **Considerations for minimizing the potential for and impacts of sudden breach of embankment or accidental release from the required volume.**

Features, safeguards, and/or management measures to minimize the risk of failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 4 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 4 may be significantly affected:

1. An auxiliary (emergency) spillway
2. Additional freeboard
3. Storage for wet year rather than normal year precipitation
4. Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes
5. Secondary containment

Table 4 - Potential Impact Categories from Breach of Embankment or Accidental Release

- |   |
|---|
| <ol style="list-style-type: none"><li>1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries</li><li>2. Critical habitat for threatened and endangered species.</li><li>3. Riparian areas</li><li>4. Farmstead, or other areas of habitation</li><li>5. Off-farm property</li><li>6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.</li></ol> |
|---|

The following options should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table 4 may be significantly affected:

1. Outlet gate locks or locked gate housing
2. Secondary containment
3. Alarm system

4. Another means of emptying the required volume

#### **Considerations for minimizing the potential of waste storage pond liner failure.**

Sites with categories listed in Table 5 should be avoided unless no reasonable alternative exists. Under those circumstances, consideration should be given to providing an additional measure of safety from pond seepage when any of the potential impact categories listed in Table 5 may be significantly affected.

Table 5 - Potential Impact Categories for Liner Failure

<ol style="list-style-type: none"><li>1. Any underlying aquifer is at a shallow depth and not confined</li><li>2. The vadose zone is rock</li><li>3. The aquifer is a domestic water supply or ecologically vital water supply</li><li>4. The site is located in an area of solutionized bedrock such as limestone or gypsum.</li></ol>
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Should any of the potential impact categories listed in Table 5 be affected, consideration should be given to the following:

1. A clay liner designed in accordance with procedures of AWMFH Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than  $1 \times 10^{-6}$  cm/sec
2. A flexible membrane liner over a clay liner
3. A geosynthetic clay liner (GCL) flexible membrane liner
4. A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness

#### **Considerations for minimizing the impact of odors.**

An anaerobic lagoon instead of a waste storage pond should be considered for sites located in rural areas where odors are a concern. This should be especially considered where odors would affect neighboring farms having enterprises that do not cause odors and/or neighbors who earn a living off-farm. The recommended loading rate for anaerobic lagoons at sites where odors must be minimized is one-half the values given in AWMFH Figure 10-22.

For sites located near urban areas practices such as the following should be considered to reduce odor emissions:

1. Covering the storage facility with a suitable cover.
2. Using naturally aerated or mechanically aerated lagoons.
3. Using composting in conjunction with a solid waste system rather than a liquid or slurry system.
4. Using a methane digester and capture system.

### **PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

### **OPERATION AND MAINTENANCE**

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design.

The plan shall contain the operational requirements for emptying the storage facility. This shall include the requirement that waste shall be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan. In addition, for ponds, the plan shall include an explanation of the permanent marker or recorder installed to indicate the maximum operating level. The plan shall include a strategy for removal and disposition of waste with least environmental damage during the normal storage period to the extent necessary to insure the pond's safe operation. This strategy is for the removal of the contribution of unusual storm events that may cause the pond to fill to capacity prematurely with subsequent design inflow and usual precipitation prior to the end of the normal storage period. Development of an emergency action plan should be considered for waste storage facilities where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.

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# WASTE TREATMENT LAGOON

(No.)  
CODE 359

## DEFINITION

A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout.

## PURPOSE

To biologically treat waste, such as manure and wastewater, and thereby reduce pollution potential by serving as a treatment component of a waste management system.

## CONDITIONS WHERE PRACTICE APPLIES

- Where the lagoon is a component of a planned agricultural waste management system.
- Where treatment is needed for organic wastes generated by agricultural production or processing.
- On any site where the lagoon can be constructed, operated and maintained without polluting air or water resources.
- to lagoons utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.

## CRITERIA

### General Criteria for All Lagoons

**Laws and Regulations.** All Federal, state, and local laws, rules, and regulations governing the construction and use of waste treatment lagoons must be followed.

**Location.** To minimize the potential for contamination of streams, lagoons should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year flood event, or larger if required by laws, rules, and regulations. Lagoons shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values.

Lagoons should be located so they have as little drainage area as possible. If a lagoon has a drainage area, the volume of normal runoff during the treatment period and 25-year, 24-hour storm event runoff shall be included in the required volume of the lagoon.

**Soils and foundation.** The lagoon shall be located in soils with an acceptable permeability that meets all applicable regulations, or the lagoon shall be lined. Information and guidance on controlling seepage from waste impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The lagoon shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless special design features are incorporated that address buoyant forces, lagoon

seepage rates, and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains to meet this requirement.

**Flexible membranes.** Flexible membrane liners shall meet or exceed the requirements of flexible membrane linings specified in NRCS Practice Standard 521, Pond Sealing or Lining, Flexible Membrane Lining

**Required volume.** The lagoon shall have the capability of storing the following volumes:

- Volume of accumulated sludge for the period between sludge removal events;
- Minimum treatment volume (anaerobic lagoons only);
- Volume of manure, wastewater, and other wastes accumulated during the treatment period;
- Depth of normal precipitation less evaporation on the surface area (at the required volume level) of the lagoon during the treatment period;
- Depth of the 25-year, 24-hour storm precipitation on the surface area (at the required volume level) of the lagoon.

**Treatment period.** The treatment period is the detention time between drawdown events. It shall be the greater of either 60 days; or the time required to provide the storage that allows environmentally safe utilization of waste considering the climate, crops, soil, and equipment requirements; or as required by local, state, and Federal regulations.

**Waste loading.** Daily waste loading shall be based on the maximum daily loading considering all waste sources that will be treated by the lagoon. Reliable local information or laboratory test data should be used if available. If local information is not available, Chapter 4 of the AWMFH may be used for estimating waste loading.

**Embankments.** The minimum elevation of the top of the settled embankment shall be 1 foot above the lagoon's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall be not less than 5 percent. The minimum top widths are shown in Table 1. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

Table 1 – Minimum Top Widths

Top Width, Height, ft.	Total embankment ft.
15 or less	8
15 – 20	10
20 – 25	12
25 – 30	14
30 – 35	15

**Excavations.** Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

**Inlet.** Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage, and ultraviolet ray deterioration, while incorporating erosion protection as necessary. Inlets shall be provided with a water-sealed trap and vent, or similar device if there is a potential, based on design configuration, for gases to enter buildings or other confined spaces.

**Outlet.** Outlets from the required volume shall be designed to resist corrosion and plugging. No outlet shall automatically discharge from the required volume of the lagoon.

**Facility for drawdown.** Measures that facilitate safe drawdown of the liquid level in the lagoon shall be provided. Access areas and ramps used to withdraw waste shall have slopes that facilitate a safe operating environment. Docks, wells, pumping platforms, retaining walls, etc. shall permit drawdown without causing erosion or damage to liners.

**Sludge removal.** Provision shall be made for periodic removal of accumulated sludge to preserve the treatment capacity of the lagoon.

**Erosion Protection.** Embankments and disturbed areas surrounding the lagoon shall be treated to control erosion. This includes the inside slopes of the lagoon as needed to protect the integrity of the liner.

**Safety.** Design shall include appropriate safety features to minimize the hazards of the lagoon. The lagoon shall be fenced around the perimeter and warning signs posted to prevent children and others from using it for other than its intended purpose.

### **Additional Criteria for Anaerobic Lagoons**

**Loading rate.** Anaerobic lagoons shall be designed to have a minimum treatment volume based on Volatile Solids (VS) loading per unit of volume. The maximum loading rate shall be as indicated in AWMFH Figure 10-22 or according to state regulatory requirements, whichever is more stringent.

**Operating levels.** The maximum operating level shall be the lagoon level that provides the required volume less the 25-year, 24-hour storm event precipitation on the surface of the lagoon. The maximum drawdown level shall be the lagoon level that provides volume for the required minimum treatment volume plus the volume of accumulated sludge between sludge removal events. Permanent markers shall be installed at these elevations. The proper operating range of the lagoon is above the maximum drawdown level and below the maximum operating level. These markers shall be referenced and described in the O&M plan.

**Depth Requirements.** The minimum depth at maximum drawdown shall be 6 feet. If subsurface conditions prevent practicable construction to accommodate the minimum depth at maximum drawdown, a lesser depth may be used, if the volume requirements are met.

### **Additional Criteria for Naturally Aerobic Lagoons**

**Loading rate.** Naturally aerobic lagoons shall be designed to have a minimum treatment surface area as determined on the basis of daily BOD<sub>5</sub> loading per unit of lagoon surface. The required minimum treatment surface area shall be the surface area at maximum drawdown. The maximum loading rate shall be as indicated by AWMFH Figure 10-25 or according to state regulatory requirements, whichever is more stringent.

**Operating levels.** The maximum operating level shall be the lagoon level that provides the required volume less the 25-year, 24-hour storm event on the lagoon surface. The maximum drawdown level shall be the lagoon level that provides volume for the volume of manure, wastewater, and clean water accumulated during the treatment period plus the volume of accumulated sludge between sludge removal events. Permanent markers shall be installed at these elevations. The proper operating range of the lagoon is above the maximum drawdown level and below the maximum operating level. These markers shall be referenced and described in the O&M plan.

**Depth requirements.** The minimum depth at maximum drawdown shall be 2 feet. The maximum liquid level shall be 5 feet.

## **Additional Criteria for Mechanically Aerated Lagoons**

**Loading rate.** Mechanically aerated waste treatment lagoons' treatment function shall be designed on the basis of daily BOD<sub>5</sub> loading and aeration equipment manufacturer's performance data for oxygen transfer and mixing. Aeration equipment shall provide a minimum of 1 pound of oxygen for each pound of daily BOD<sub>5</sub> loading.

**Operating levels.** The maximum operating level shall be the lagoon level that provides the required lagoon volume less the 25-year, 24-hour storm event precipitation and shall not exceed the site and aeration equipment limitations. A permanent marker or recorder shall be installed at this elevation. The proper operating range of the lagoon is below this elevation and above the minimum treatment elevation established by the manufacturer of the aeration equipment. This marker shall be referenced and described in the O&M plan.

## **CONSIDERATIONS**

### **General**

Lagoons should be located as close to the source of waste as possible. Solid/liquid separation treatment should be considered between the waste source and the lagoon to reduce loading.

The configuration of the lagoon should be based on the method of sludge removal and method of sealing.

Due consideration should be given to economics, the overall waste management system plan, and safety and health factors.

### **Considerations for minimizing the potential for and impacts of sudden breach of embankment or accidental release from the required volume**

Features, safeguards, and/or management measures to minimize the risk of embankment failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 2 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 2 may be significantly affected:

- An auxiliary (emergency) spillway
- Additional freeboard
- Storage volume for the wet year rather than normal year precipitation
- Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes
- Secondary containment
- Water level indicators or recorders

**Table 2- Potential Impact Categories from Breach of Embankment or Accidental Release**

1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries
2. Critical habitat for threatened and endangered species
3. Riparian areas
4. Farmstead, or other areas of habitation
5. Off-farm property
6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places

The following should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table 2 may be significantly affected:

- Outlet gate locks or locked gate housing
- Secondary containment
- Alarm system
- Another means of emptying the required volume

**Considerations for minimizing the potential of lagoon liner seepage**

Consideration should be given to providing an additional measure of safety from lagoon seepage when any of the potential impact categories listed in Table 3 may be affected.

Should any of the potential impact categories listed in Table 3 be affected, consideration should be given to the following:

- A clay liner designed in accordance with procedures of AWMFH, Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than  $1 \times 10^{-6}$  cm/sec.
- A flexible membrane liner
- A geosynthetic clay liner (GCL) flexible membrane liner
- A concrete liner designed in accordance with slabs on grade criteria in NRCS Practice Standard 313, Waste Storage Facility, for fabricated structures requiring water tightness.

**Table 3 - Potential Impact Categories for Liner Seepage**

1. Any underlying aquifer is at a shallow depth and not confined
2. The vadose zone is rock
3. The aquifer is a domestic water supply or ecologically vital water supply
4. The site is located in an area of carbonate rock (limestone or dolomite)

**Considerations for minimizing the impact of odors**

For sites located where odors are a concern, the following should be considered:

- Reduce loading rates of anaerobic lagoons to at least one half the values of AWMFH Figure 10-22.
- Covering the lagoon with a suitable cover.
- Using naturally aerated or mechanically aerated lagoons.
- Using composting in conjunction with a solid waste system rather than a liquid or slurry system.
- Using an anaerobic digester and biogas capture system.

**PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

**OPERATION AND MAINTENANCE**

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for design. The plan shall contain the operational requirements for drawdown and the role of permanent markers. This shall include

the requirement that waste be removed from the lagoon and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan. In addition, the plan shall include a strategy for removal and disposition of waste with least environmental damage during the normal treatment period to the extent necessary to insure the lagoon's safe operation. This strategy shall also include the removal of unusual storm events.

Development of an emergency action plan should be considered for lagoons where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.

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# WASTE UTILIZATION

(Acre)  
CODE 633

## DEFINITION

Using agricultural wastes such as manure and wastewater or other organic residues.

## PURPOSES

- Protect water quality
- Provide fertility for crop, forage, fiber production and forest products
- Improve or maintain soil structure;
- Provide feedstock for livestock
- Provide a source of energy

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies where agricultural wastes including animal manure and contaminated water from livestock and poultry operations; solids and wastewater from municipal treatment plants; and agricultural processing residues are generated, and/or utilized.

## CRITERIA

### General criteria applicable to all purposes

All federal, state and local laws, rules and regulations governing waste management, pollution abatement, health and safety shall be strictly adhered to. The owner or operator shall be responsible for securing any and all required permits or approvals related to waste utilization, and for operating and maintaining any components in accordance with applicable laws and regulations.

Use of agricultural wastes shall be based on at least one analysis of the material during the time it is to be used. In the case of daily spreading, the waste shall be sampled and analyzed at least once each year. As a minimum the waste analysis should identify nutrient and specific ion concentrations. Where the metal content of municipal wastewater, sludge, septage, and other agricultural waste is of a concern, the analysis shall also include determining the concentration of metals in the material.

Where agricultural wastes are to be spread on land not owned or controlled by the producer, the waste management plan, as a minimum, shall document the amount of waste to be transferred and who will be responsible for the environmentally acceptable use of the waste. Records of the use of wastes shall be kept a minimum of five years as discussed in OPERATION AND MAINTENANCE, below.

### Additional criteria to protect water quality

All agricultural waste shall be utilized in a manner that minimizes the opportunity for contamination of surface and ground water supplies.

Agricultural waste shall not be land-applied on soils that are frequently flooded, as defined by the National Cooperative Soil Survey, during the period when flooding is expected.

When liquid wastes are applied, the application rate shall not exceed the infiltration rate of the soil, and the amount of waste applied shall not exceed the moisture holding capacity of the soil profile at the time of application. Wastes shall not be applied to frozen or snow-covered ground.

**Additional criteria for providing fertility for crop, forage, fiber production and forest products**

Where agricultural wastes are utilized to provide fertility for crop, forage, fiber production, and forest products, the practice standard Nutrient Management (590) shall be followed.

Where municipal wastewater and solids are applied to agricultural lands as a nutrient source, the single application or lifetime limits of heavy metals shall not be exceeded. The concentration of salts shall not exceed the level that will impair seed germination or plant growth.

**Additional criteria for improving or maintaining soil structure**

Wastes shall be applied at rates not to exceed the crop nutrient requirements or salt concentrations as stated above, and shall be applied at times the waste material can be incorporated by appropriate means into the soil within 72 hours of application.

**Additional criteria for providing feedstock for livestock**

Agricultural wastes to be used for feedstock shall be handled in a manner to minimize contamination and preserve its feed value. Chicken litter stored for this purpose shall be covered. A qualified animal nutritionist shall develop rations which utilize wastes.

**Additional criteria for providing a source of energy**

Use of agricultural waste for energy production shall be an integral part of the overall waste management system.

All energy producing components of the system shall be included in the waste management plan and provisions for utilization of residues of energy production identified.

Where the residues of energy production are to be land-applied for crop nutrient use or soil conditioning, the criteria listed above shall apply.

**CONSIDERATIONS**

The effect of Waste Utilization on the water budget should be considered, particularly where a shallow ground water table is present or in areas prone to runoff. Limit waste application to the volume of liquid that can be stored in the root zone.

Minimize the impact of odors of land-applied wastes by making application at times when temperatures are cool and when wind direction is away from neighbors.

Agricultural wastes contain pathogens and other disease-causing organisms. Wastes should be utilized in a manner that minimizes their disease potential.

Priority areas for land application of wastes should be on gentle slopes located as far as possible from waterways. When wastes are applied on more sloping land or land adjacent to waterways, other conservation practices should be installed to reduce the potential for offsite transport of waste.

It is preferable to apply wastes on pastures and hayland soon after cutting or grazing before re-growth has occurred.

Reduce nitrogen volatilization losses associated with the land application of some waste by incorporation within 24 hours.

Minimize environmental impact of land-applied waste by limiting the quantity of waste applied to the rates determined using the practice standard Nutrient Management (590) for all waste utilization.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for Waste Utilization shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The waste management plan is to account for the utilization or other disposal of all animal wastes produced, and all waste application areas shall be clearly indicated on a plan map.

## **OPERATION AND MAINTENANCE**

Records shall be kept for a period of five years or longer, and include when appropriate:

- Quantity of manure and other agricultural waste produced and their nutrient content
- Soil test results
- Dates and amounts of waste application where land applied, and the dates and amounts of waste removed from the system due to feeding, energy production, or export from the operation
- Waste application methods
- Crops grown and yields (both yield goals and measured yield)
- Other tests, such as determining the nutrient content of the harvested product
- Calibration of application equipment.

The operation and maintenance plan shall include the dates of periodic inspections and maintenance of equipment and facilities used in waste utilization. The plan should include what is to be inspected or maintained, and a general time frame for making necessary repairs.

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# **WATER AND SEDIMENT CONTROL BASIN**

(No.)  
CODE 638

## **DEFINITION**

An earth embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin.

## **SCOPE**

This standard applies to planning, designing, and constructing water and sediment control basins. It does not apply to diversions (362), grade stabilization structures (410), or sediment basins (350).

## **PURPOSE**

To improve farmability of sloping land, reduce watercourse and gully erosion, trap sediment, reduce and manage onsite and downstream runoff, and improve downstream water quality.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to sites where:

1. The topography is generally irregular.
2. Watercourse and gully erosion are a problem.
3. Sheet and rill erosion are controlled by other conservation practices.
4. Runoff and sediment damage land and improvements.
5. Soil and site conditions are suitable.
6. Adequate outlets are available or can be provided.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effect on the water budget, especially on volumes and rates of runoff, infiltration, and evaporation.
2. Ability to increase deep percolation below the root zone and, where possible, ground water recharge.
3. Potential for a change in rates of plant growth and transpiration because of changes in the amount of soil water storage.
4. Effects on the trapping or distribution of snow.

### **Water Quality**

1. Potential to trap sediment and sediment-attached substances carried by runoff.
2. Potential change in the flow of dissolved substances such as nitrates or pesticides into downstream water courses.
3. Potential movement of dissolved substances to ground water.
4. Effects on downstream water temperature.
5. Effects on the visual quality of downstream water resources.

## DESIGN CRITERIA

Water and sediment control basins can be part of the treatment needed to protect the soil resource base. In addition, practices such as terraces, contouring, a conservation cropping system, conservation tillage, and crop residue management shall also be used to control erosion.

Water and sediment control basins shall not be used in place of terraces. When a ridge and channel extend beyond the detention basing or level embankment, terraces shall be designed. The resource management system must reduce soil loss in the interval above and below the basin to prevent excessive maintenance and operation problems.

**Spacing.** Water and sediment control basins shall generally be spaced at terrace intervals. The grade of the watercourse between basins shall be considered, and the spacing shall be set to prevent watercourse or gully erosion. The drainage of each basin shall be limited so duration of flooding, infiltration, or seepage does not damage crops or create other problems.

The system of basins and row arrangements shall be parallel when possible and spaced to accommodate farm machinery widths. Consideration shall be given to embankment slope lengths, top width, and inlet location when determining spacing.

**Alignment.** The embankment orientation and row direction shall be approximately perpendicular to the land slope to permit contouring as near as possible. The arrangement should permit farmability without excessive shoulder point rows or sharp curves. Field boundaries and row length should also be considered when determining basin location and row direction.

**Cross section.** Embankment slopes shall not be steeper than two horizontal to one vertical. The effective top width and height shall be at least as wide as shown in the following.

Fill height (ft)	Effective top width (ft)
0 - 5	3
5 - 10	6
10 - 15	8

The constructed height of the embankment shall be at least 5 percent greater than the designed height to allow for settlement. The maximum settled height shall be 15 ft measured from the natural ground at the centerline of the embankment. Slopes may be vegetated or may be flattened to permit cropping.

**Capacity.** The basin shall be large enough to control the runoff during a 10-year, 24-hour-frequency storm without overtopping. The capacity of basins designed to provide flood protection or to function with other structures may be larger and shall be adequate to control the runoff from a storm of a frequency consistent with the potential hazard. The basin also shall have the capacity to store the anticipated 10-year sediment accumulation, unless provisions are made for periodic sediment removal from the basin to maintain the design capacity.

The basins shall have the ends closed to the elevation needed for the design capacity. A maximum of 0.31 m (1 ft) of freeboard may be added to the design height to provide for an emergency spillway around one or both ends of the basin. The emergency spillway must not contribute runoff to a lower basin in series that does not have an emergency spillway.

**Outlets.** Water and sediment control basins shall have underground outlets or soil infiltration outlets that meet the requirements for terraces (600) and underground outlets.

**Vegetation.** Slopes and distributed areas that are not to be farmed shall be established to suitable erosion-resistant vegetation. Environmental quantity and quantity and wildlife food and habitat shall be considered in selecting the species of vegetation. If soil or climatic conditions preclude the use of vegetative cover and protection is needed, an organic or gravel mulch may be used. Seedbed preparation, fertilizing, seeding, and mulching shall be in accordance with the technical guides.

## **MAINTENANCE.**

A maintenance job sheet or maintenance plan shall be provided for each resource management system and practice. The maintenance plans for the water and sediment control basin shall include maintenance requirements for the embankment, design, capacity, vegetative cover, and the outlet. Maintenance should include inspection of inlets for clogging and embankment failure after each large storm. Failures should be corrected as soon as possible to prevent major damages.

The sediment and design capacity shall be maintained by cleaning the basin or by raising the embankment height. Excavated material spread on the cropland shall be placed to maintain fertility and enhance topography. Fill material for increasing the embankment height shall be obtained in a manner that enhances topography and maintains productivity of the cropland. The vegetation shall be maintained to prevent sheet and rill erosion or gullyng of the embankment. Trees and woody cover generally create problems on embankments and should be controlled.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for installing water and sediment control basins shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# WATER-HARVESTING CATCHMENT

(No.)  
CODE 636

## DEFINITION

A facility for collecting and storing precipitation.

## SCOPE

This standard applies to the sealing of watersheds or contributing areas to increase, collect, and store runoff water for future use. It also applies to simple curbs and diversions constructed to collect and store runoff from such high runoff areas as rock outcrops or existing paved or impervious areas.

## PURPOSE

To provide water for livestock, fish and wildlife recreation, or other purposes.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas where there is a need for additional water. The contributing area must have a potential to furnish the quantity and quality of water required for the intended use.

## PLANNING CONSIDERATIONS

### Water Quantity

1. Effects of trapping or catching of water on surface and ground water. Factors include changes in evaporation, timing of releases from the catchment, and the impact of the type of catchment on surface water versus ground water decreases.

### Water Quality

1. Potential improvement in surface water quality resulting from flow reduction's contribution to reducing erosion and sediment yield. Consider the size of the harvest area and the impact of associated structures, such as sediment traps.
2. Effects of reduced dilution water on water quality factors such as dissolved substances, waste assimilation capacity, and dissolved oxygen.
3. Effects of loss of ground water dilution and the reduction of input of dissolved salts and chemicals on ground water quality.

## DESIGN CRITERIA

Each water-harvesting catchment must be designed according to a plan suited to the water requirements and the site conditions. The following points shall be considered in designing water-harvesting catchments:

1. Quality and quantity of water required for the planned use.
2. Probability of filling the storage area or basin.
3. Area of apron needed for the required water yield.

4. Materials and method required to insure that the apron is smooth and impervious. Earth, treated earth, wax, rubber, plastic, asphalt, concrete, steel, and other such suitable materials are acceptable for this purpose.
5. Provisions for diverting foreign runoff from the he catchment area to prevent damage and excessive sedimentation.
6. Provisions for protecting the apron from damage by runoff in excess of that needed to maintain the design capacity of the conveyance system. An overflow pipe or an emergency spillway can be used.
7. Need for a sediment trap between the apron and the storage basin.
8. A storage basin that is adequate in size, impermeability, and durability for the required water. Earth basins and tanks of steel, concrete, Butyl rubber and similar facilities are acceptable. Earth dams must have at lest 1 ft of freeboard above design high water. All storage basins must be protected from 10-year-frequency storms. An overflow device must be installed in all storage basins.
9. Need for evaporation repressants, such as rock filling and floating covers.
10. Adequate protection to prevent damage from weather, animals, vandals, wildlife, and traffic. Fencing may be necessary.
11. Provisions for maintaining the apron, the conveyance system, the overflow device, and the storage basin.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for water-harvesting catchments shall be in keeping with this standard and shall describe the requirements for installing the practice to achieve its intended purpose.

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# **WATER TABLE CONTROL**

(Acre)  
CODE 641

## **DEFINITION**

Water table control through proper use of subsurface drains, water control structures, and water conveyance facilities for the efficient removal of drainage water and distribution of irrigation water.

## **SCOPE**

This standard applies to underground conduits installed to a planned spacing, depth, and grade and to the related facilities and structures needed to regulate water table depths for efficient crop production.

## **PURPOSE**

To improve the soil environment for vegetative growth by regulating the water table to remove excess runoff and subsurface water, facilitate leaching of saline and alkali soil, and regulate or manage ground water for subirrigation.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to areas where:

1. A high water table exists, either natural or induced.
2. The topography is relatively smooth, uniform, and flat to gently sloping.
3. Subsurface conditions are such that a water table can be maintained without excessive water loss.
4. An adequate water supply is available.
5. Benefits of subirrigation, in addition to controlling ground water and surface runoff, justify installation of the system.
6. Soil depth and permeability will permit effective operation of the control system.
7. Saline or sodic soil conditions can be maintained at an acceptable level for efficient production of crops.
8. A suitable outlet exists.
9. Improvement of off-site water quality is needed and may be provided by controlling the water table.

## **PLANNING CONSIDERATIONS**

### **Water Quantity**

1. Effects the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Effects on the movement of dissolved substances below the root zone and to ground water.
3. Potential effects on wetlands or water related wildlife habitats.
4. Effects of pesticides and nutrient use on surface and ground water quality.

## **Water Quality**

1. Effects on erosion and the movement of sediment, pathogens, organic material and soluble and sediment-attached substances carried by runoff.
2. Effects on the movement of dissolved substances below the root zone and to ground water.
3. Potential effects on wetlands or water-related wildlife habitats.
4. Effects of pesticide and nutrient use on surface and ground water quality.

## **DESIGN CRITERIA**

### **GENERAL**

Design are to be made in accordance with all other pertinent Engineering Standards such as Subsurface Drain (606); Mole Drain (482); Surface Drainage, Field Ditch (607); Surface Drainage, Main or Lateral (608); Structure for Water Control (587); Irrigation System, Surface and Subsurface (443); Irrigation Field Ditch (388); Irrigation Canal or Lateral (320); Irrigation Water Conveyance (428); and the additional special design criteria contained in this standard.

### **CAPACITY**

The overall facilities designed and all component parts shall have the capacity to deliver or remove the flow of water required for irrigation or drainage, whichever is greater.

#### **1. Drainage capacity**

Combined capacity of the surface and subsurface facilities shall be adequate to satisfy the appropriate drainage coefficient for the crops to be grown.

Where it is necessary to admit surface water through surface inlets to the drain, an adjustment in the required capacity of the drain should be made if needed to compensate for increased inflow soon after rainfall.

#### **2. Irrigation capacity**

The facilities should be sized to supply the peak period consumptive use rate for the crops to be grown. Local consumptive use tables or irrigation guides should be consulted.

### **LAND PREPARATION**

Excessive irregularities in the land surface should be removed whenever practical by leveling or smoothing so that grades in the direction of the rows are level or continuous, except for minor depressions. Otherwise, surface inlets shall be provided in the depressions for surface water removal. Silt traps should be provided, as needed, depending on the type of surface inlet. From a maintenance standpoint, it advisable to have as few surface inlets as practical.

### **PLAN**

A plan based on soils, topography, and crops to be grown shall be prepared. The plan shall show the location elevations, spacing, size, and grade of all conduits, control structures, and outlet channels.

### **GRADE OF MAIN AND LATERALS**

The grade of mains may be level or constantly sloping toward the outlet and may be either open ditches or closed conduits. Laterals should be planned on grades as nearly parallel to the ground

surface as possible and sloping towards the normal outlet. The grade of laterals should generally be in accordance with the conservation practice standard for Subsurface Drain (606). Lateral grades may be reduced to 0.05 percent if essential for effective water table control and precautions are taken to minimize sedimentation problems.

### **LENGTH OF LATERALS**

Providing adequate capacity for drainage and irrigation should be considered in planning lateral length. Lateral length may be restricted by the requirements for lateral depth relative to desired water-table elevations at the upper end of individual laterals. Laterals should normally not exceed 1,200 feet.

### **DEPTH OF LATERALS**

The subsurface drain should be deeper than the maximum and minimum levels of the desired water table throughout the length of the lateral. It is desirable to place laterals within the soil layer having the highest hydraulic conductivity.

### **SPACING OF MAINS AND LATERALS**

The spacing of main lines and open supply or drainage ditches should be as needed to enable lateral lines to adequately serve the field area. The maximum spacing of laterals to achieve uniform distribution of irrigation water will be determined by one or more of the following:

1. DRAINMOD program, analysis.
2. Using the average spacing recommendation from the local drainage guide, specifically for water-table control systems.
3. Comparing the subject site to existing systems is known.
4. Small trial areas, where insufficient existing data are available for certain soils.

### **SIZE OF CONDUITS**

Conduits must be sized to provide the desired flow, allowing for friction losses and the hydraulic gradients anticipated, for both drainage and subirrigation. The minimum size of conduits is 4 inches.

### **FILTER AND FILTER MATERIALS.**

Because of the water movement into and out of the conduits in water-table control lateral with fluctuating hydraulic heads, the potential for situation may be greater than in regular drainage laterals. Suitable filters should be used where needed to prevent siltation (for guidance see Engineering Field Manual p. 14-70). Determining the need for a filter or selecting a filter is critical.

Generally, only properly graded sand and gravel filters, as defined in the subsurface drain standard (606), should be used as filters around conduits in water-table control systems. For coarser textures, well-graded sands, filters may not be necessary. For fine-textures, poorly graded sands, a geotextile filter may be used. If geotextile filters are to be used in any other soils, they should be tested to prove they will function satisfactorily. These tests should be made against the soils in which the filters will be installed. These tests are necessary unless sufficient field installations are available in similar soils to indicate that these geotextile filters have not clogged under similar water-table control conditions. In soils where iron oxide problems are known to exist and a filter is needed, a knitted geotextile material or sand gravel filter should be used.

## **ENVELOPES AND ENVELOPE MATERIAL**

Envelopes shall be used around subsurface drains if needed for proper bedding of the conduit or to improve the characteristics of flow of ground water into the conduit. See Subsurface Drain standard (606) for envelope material requirements.

## **WATER CONTROL STRUCTURES**

Water control structures should be installed as necessary to insure the water table is held within 1.0 ft of the desired elevation.

Water control structures should be sized to provide the required drainage flow over the flashboard or otherwise throughout the control structure with a maximum head of 0.5 ft for normal operations. In all cases, the drainage flow elevations should be controlled so that crop damages do not occur as a result of an extended period of saturation in the root zone. Structures should be designed so that control can be quickly removed when return to the drainage mode is desired.

## **OPERATION AND MAINTENANCE**

An operation and maintenance plan should be provided to inform the owner of operation and maintenance needs.

### **1. Operation**

Operation of the facilities should be that prolonged saturation of the root zone does not occur. For very shallow rooted crops, such as vegetables, the best method of operation may be to raise the ground water to near 12 inches of the ground surface for a short period until the surface layer of the soil reaches its water-holding capacity. Once this condition is reached, the water table is then allowed to recede by evapotranspiration to some determined level until the crop needs to be irrigated again. Additional water is then applied and the cycle is repeated. This procedure allows air to move into the soil and plant root zone for optimum root development.

For deeper rooted crops, it is customary to maintain the water control structures at a predetermined level for the various crop stages; thus, variations in the water table will result only from rainfall and differing consumptive use rates during any particular crop stage. Water control structures should be designed so that adjustments may be easily made to facilitate removal of large storm discharges. Trafficability in the spring and during harvest can also be facilitated by timely lowering of the water table. Flashboard type structures normally allow for adequate management of the water table.

### **2. Maintenance**

Maintenance items should be addressed as appropriate for the materials and system used.

## **SPECIFICATIONS GUIDE**

Plans and specifications for installing water table control facilities shall be in keeping with this standard and shall describe the requirements for applying all components of the facility to achieve its intended purpose. Incorporate, by reference, appropriate conservation practice standards and specifications required to install the facility.

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# WATER WELL

(No.)  
CODE 642

## DEFINITION

A hole drilled, dug, driven, bored, jetted or otherwise constructed to an aquifer.

## PURPOSE

To provide water for livestock, wildlife, irrigation, human, and other uses.

To provide for general water needs of farming/ranching operations.

To facilitate proper use of vegetation on rangeland, pastures, and wildlife areas.

## CONDITION WHERE PRACTICE APPLIES

On all land uses where the underground supply of water is sufficient in quantity and quality for the intended purpose.

This practice standard applies only to production wells. Specifically excluded are any types of wells installed solely for monitoring or observation purposes; injection wells; and piezometers. The standard does not apply to pumps installed in wells; above ground installations, such as pumping plants, pipelines, and tanks; temporary test wells; and decommissioning of wells (ASTM D 5299).

## CRITERIA

**Suitability of Site:** The availability of ground water for its intended use at the site shall be determined by using reliable local experience and reviewing all available relevant geologic maps and reports; well records maintained by state and federal agencies; and design, construction, and maintenance records of nearby wells. An appropriate level of investigation, including test well drilling, is conducted on-site, as needed, prior to well construction to determine site-specific hydrogeologic conditions.

The site shall be suitable for safe operation of the drilling equipment.

**Well Head Protection:** Wells shall be located at safe distances from potential sources of pollution, including unsealed abandoned wells. The allowable distance shall be based on consideration of site-specific hydrogeologic factors and shall comply with requirements of all applicable state or local regulations or construction codes.

Surface runoff and drainage that might reach the wellhead from areas used by livestock shall be diverted.

Wells shall be located a safe distance from both overhead and underground utility lines and other safety hazards.

**Borehole:** Drilled, jetted, bored, and driven wells shall be sufficiently round, straight, and of adequate diameter, to permit satisfactory installation of inlet, well casing, filter pack, and annular seal, and passage of tremie pipe (including couplings), if used.

**Use of Casing:** Casing shall be installed to seal out undesirable surface or shallow ground water and to support the side of the hole through unstable earth materials. The intake portion of a well through stable geologic formations may not require casing.

**Casing Diameter:** Casing diameter shall be sized to permit satisfactory installation and efficient operation of the pump, and large enough to assure that uphole velocity is 5 feet per second or less, to protect against excessive head loss.

**Materials:** Casings may be of steel, iron, stainless steel, copper alloys, plastic, fiberglass, concrete, or other material of equivalent strength and durability consistent with the intended use of the water and the maximum anticipated differential head between the inside and outside of the casing.

Steel well casings shall meet or exceed requirements specified in ASTM A 589. Steel pipe manufactured for other purposes may be used if the quality of the pipe meets or exceeds requirements specified in ASTM A 589.

Only steel pipe casings shall be used in driven wells.

To prevent galvanic corrosion, dissimilar metals shall not be joined.

Plastic casings made of acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), or styrene-rubber (SR) shall conform to material, dimensional and quality requirements specified in ASTM F 480.

If the water is to be used for human consumption, plastic pipe shall be approved by the National Sanitation Foundation.

Plastic pipe manufactured for water or irrigation pipelines may be used if the quality equals or exceeds requirements specified in ASTM F 480.

Filament-wound fiberglass casings (glass-fiber-reinforced-thermosetting-resin pipe, RTRP) may be used if material meets requirements specified in ASTM D 2996. Tests for long-term cyclic pressure strength, long-term static pressure strength, and short-term rupture strength as required in ASTM D 2996 are not needed because the pipe is to be used for well casing. Joints shall meet requirements specified in section 3.8, ASTM F 480.

Fiberglass pressure pipe, (also called reinforced plastic mortar pipe, RPMP, or fiberglass pipe with aggregate) shall meet or exceed requirements specified in ASTM D 3517.

**Casing Strength:** Well casing wall thickness shall be sufficient to withstand all anticipated static and dynamic pressures imposed on the casing during installation, well development, and use.

**Joint Strength:** Joints for well casings shall have adequate strength to carry the load due to the casing length and still be watertight, or shall be mechanically supported during installation to maintain joint integrity. Such mechanically supported casings shall terminate on firm material that can adequately support the casing weight.

**Screen:** Well screen shall be installed in any earth material likely to produce silt or sand. Well screens may be constructed of commercially manufactured screen sections, well points, or field-perforated sections.

Perforation by any method is allowable provided proper slot size and entrance velocity limits can be met. The length and open area of the screen shall be sized to limit entrance velocity of water into the well to less than or equal to 0.1 foot per second.

Depth of the aquifer below ground surface and the thickness of aquifer to be penetrated by the well shall govern the position of the screen in the well.

Maximum drawdown shall not be permitted below the top of the highest screen or pump intake.

**Seals (Packers):** Telescoped screen assemblies shall be provided with one or more sand-tight seals between the top of the telescoped screen assembly and casing.

**Filter Pack:** Installation of a filter pack around the well screen shall be considered under the following conditions: presence of a poorly graded, fine sand aquifer; presence of a highly variable aquifer, such as alternating sand and clay layers; presence of a poorly cemented sandstone or similar aquifer; a requirement for maximum yield from a low-yielding aquifer; and holes drilled by reverse circulation.

**Prepacked Well Screens:** For heaving or caving sands, silty or fine-grained aquifers, and for horizontal or angled wells, a commercial prepacked well screen may be substituted for a conventionally installed (by tremie) filter pack.

**Installation:** Casing shall extend from above the ground surface down through unstable earth materials to an elevation of at least 2 feet into stable material or to the top of the screen.

All wells shall be cased to a sufficient height (minimum of 12 inches) above the ground surface to prevent entry of surface and near-surface water.

Casing for artesian aquifers shall be sealed into overlying, impermeable formations in such a manner as to retain confining pressure.

If a zone is penetrated that is determined or suspected to contain water of quality unsuitable for the intended use, the zone shall be sealed to prevent infiltration of the poor-quality water into the well and the developed portion of the aquifer.

**Well Development:** Wells to be completed without a filter pack in unconsolidated granular aquifers shall be developed following guidance provided in ASTM D 5521, Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers.

The method shall be selected based on geologic character of the aquifer, type of drilling rig, and type of screen.

**Aquifer Development:** For massive, unfractured rock formations unresponsive to well development procedures, the use of aquifer stimulation techniques may be considered to improve well efficiency and specific capacity. Techniques may include dry ice, acidizing, explosives, or hydrofracturing, depending on the composition and structure of the formation.

**Grouting and Sealing:** The annulus surrounding the permanent well casing at the upper terminus of the well shall be filled with expansive hydraulic cement (ASTM C 845), shrinkage-compensating concrete, bentonite-based grout, clay, or other material with similar sealing properties. The length of the grout seal shall be no less than 10 feet and not less than the minimum specified in state or locally applicable construction codes.

If the water is intended for human consumption, the casing shall be surrounded at the ground surface by a 4-inch thick concrete slab extending at least 2 feet in all directions.

A positive seal (grouted in place) or packer shall be provided between the casing and the less pervious material overlying the aquifer of artesian wells, and in all aquifers where co-mingling of waters is undesirable.

**Access Port:** An access port with a minimum diameter of 0.5 inch shall be installed to allow for unobstructed measurement of depth of the water surface, or for a pressure gage for measuring shut-in pressure of a flowing well. Access ports and pressure gages or other openings in the cover shall be sealed or capped to prevent entrance of surface water or foreign material into the well. Removable caps are acceptable as access ports.

**Disinfection:** Wells shall be disinfected immediately following their construction or repair to neutralize any contamination from equipment, material, or surface drainage introduced during construction. The disinfection process shall comply with all local or state requirements.

**Water Quality Testing:** Sampling and testing shall comply with all applicable federal, state, and local requirements. These requirements vary according to the water quality parameters associated with the intended use(s) of the water.

## **CONSIDERATIONS**

The potential for adverse interference with existing nearby production wells needs to be evaluated in planning.

The potential for ground water overdraft and the long-term safe yield of the aquifer needs to be considered in planning.

If practicable, wells should be located in higher ground and up gradient from sources of contamination or flooding.

Potential effects of installation and operation of the well on cultural, historical, archeological, or scientific resources at or near the site need to be considered in planning.

## **PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared for specific field sites in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended uses.

## **OPERATION AND MAINTENANCE**

A plan for maintenance of a well shall be prepared. The well construction records shall be kept on file with the maintenance plan by the owner/operator. As a minimum, the plan shall include a statement of identified problems, corrective action taken, date, and specific capacity (yield per unit drawdown) of well before and after corrective action was taken.

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# **WATERSPREADING**

(Acre)  
CODE 640

## **DEFINITION**

Diverting or collecting runoff from natural channels, gullies, or streams with a system of dams, dikes, ditches, or other means, and spreading it over relatively flat areas.

## **SCOPE**

Waterspreading systems are suited to locations where the topography and climatic conditions are such that the additional moisture can be expected to improve plant growth. Areas that have an average annual precipitation of 8 to 25 inches benefit from waterspreading. Waterspreading differs from irrigation in that applications are timed by the availability of natural runoff flow rather than scheduled to meet plant needs. This standard does not apply to Surface and Subsurface Irrigation Systems (443).

## **PURPOSE**

To supplement natural precipitation in areas where plants can effectively use additional moisture.

## **CONDITIONS WHERE PRACTICE APPLIES**

Waterspreading systems apply to areas where:

1. Soils have suitable intake rates and adequate water-holding capacities for the crops to be grown.
2. Soils are suitable for production of feed, forage, or grain crops.
3. The topography is suitable for the diversion or collection and spreading of water to achieve the desired result.
4. Runoff or streamflow is available at the time of the year and in a volume sufficient to increase plant growth.
5. Flows can be collected or diverted and spread and exceed water returned without causing excessive erosion.
6. Fish and wildlife will not be significantly affected adversely.
7. Grazing of the spreading area can be controlled.

## **PLANNING CONSIDERATIONS**

1. Consider nonstructural measures, including brush removal, fencing, and seeding, before planning a waterspreading system.
2. Do not install a waterspreading system on highly erodible soils or in areas where the hazard of erosion is high.
3. Include erosion control at the diversion works, within the spreading area, and at the outlet facilities as an integral part of the waterspreading system.
4. Manage livestock use of the spreading areas to prevent compaction when soils are wet and to prevent range degradation by overuse.

## Water Quantity

1. Significant reduction of surface water quantity. Factors include the volume of water diverted, and volume of return flows.
2. Potential increase in soil moisture and ground water quantity. Assess additional surface area covered by diverted water, soil infiltration rates, diverted flow time, and evapotranspiration volume.

## Water Quality

1. The reduction in sediment and adsorbed and dissolved nutrients and pesticides in surface waters. Consider soluble chemicals infiltrating in the water spread areas, the percentage of fine soil practices in the suspended sediment, and the amount of soil disturbance during construction.
2. Degradation of return flows by chemicals transported from the spreading area. Consider rate and volume of return flows, chemicals used, time of chemical application in comparison to predictable storm events, and the nature of sediments transported.
3. Potential ground water degradation from applied chemicals caused by increased infiltration. Important factors include available soil moisture storage, evapotranspiration, type and amounts of chemicals used, and saline geology.
4. Potential visual impacts of decrease sediment in return flows and the lack of streamflow below the water spreading area.

## DESIGN CRITERIA

**Drainage area.** The contributing area, or ratio of watershed area to benefited area for a “dependable” water supply, must be such that the volume of divertable flow needed for the design water application can be expected on an average of 8 years in 10. Systems with less than this amount, classed as “questionable,” must necessarily be simple and inexpensive and must furnish at least the volume that can be expected 1 year in 2.

**Diversion works.** The diversion works should be automatic, requiring no manual control to divert the stream onto the spreading areas, except on watercourses that have expected flow durations of more than 24 hours. The diversion must be capable of safely bypassing the peak flood flow. Suitable controls should be provided so that only the desired rate of flow enters the conveyance system. Where significant sediment is present in flood flows, a low-flow bypass must be installed to exclude bedload from the system. The inlet control must be adjustable to exclude flow from the spreading areas when crops are to be harvested mechanically. The diverted flow must not cause undue maintenance problems in the diversion works or the spreading area.

**Conveyance system.** The conveyance system shall have the capacity to safely convey the design flow from the diversion works to the spreading area.

**Spreading area.** Ditches, dikes, diversion, conduits, and similar structures will be arranged and located to spread diffused flow over the land surface or to pond water over the land, depending on the type of system selected. All slopes will be stable and graded to the slope necessary for management and harvesting operation. Land leveling, land forming, land smoothing, obstruction removal, and similar practices may be performed for more uniform distribution of water and increased operation efficiency. All component practices installed as part of the overall system will comply with the SCS standard for that practices.

If the water is to be spread over the area as diffused flow, the depth of application should be the approximate depth of water that the soil will absorb in the period equal to the estimated flow

duration. For soils that have rapid or very rapid permeability, this depth may be more than is needed to fill that root zone.

If the water is to be impounded on the spreading area, the depth of application should approximately equal the available moisture capacity of the soil profile for the effective root zone of the plants to be grown. Rapidly permeable soils are generally unsatisfactory for impoundment systems. The system should be designed and managed to minimize deep percolation.

**Water impounding dike.** The maximum depth of water impounded against dikes will be 3 ft except across channels, sloughs, swales, or gullies less than 40 ft wide, where up to 5 ft of depth will be allowed. Water depth greater than this requires embankment design according to the standard for Ponds (378).

Minimum top width of dikes at design top elevation will be 3 ft. Side slopes of dikes will not be steeper than two horizontal to one vertical. They should be flatter as needed for stability and for mowing or operating other farm equipment.

The foundation of all dikes must be stripped of vegetation or other unsuitable material before placement of fill material. A cutoff will be installed when necessary for stability or to prevent seepage. The dike must be constructed high enough to allow at least 5% for settlement.

**Outlet works.** A provision must be made for returning excess water from the system to the stream channel or other parts of the system without causing excessive erosion and in time to prevent crop damage by ponded water. The flow line of gated conduits used for this purpose should be below ground level to improve flow characteristics.

Dikes with a total water storage capacity less than the 10-year, 24-hour runoff volume from the contributing area must have at least one outlet or treating area must have at least one outlet or overflow section that is at least 1.0 ft below the design top elevation. This may be a vegetated spillway, stable rock, weir overflow structure, pipe outlet, or some combination of these. Total capacity of the outlet must exceed the design inflow to the impoundment with a freeboard of not less than 0.3 ft. The design inflow is the maximum diverted rate of flow, or the 10-year, 24-hour peak flow from the contributing area, whichever is less.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for waterspreading shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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# WELL DECOMMISSIONING

(NO.)  
CODE 351

## DEFINITION

The sealing and permanent closure of a water well no longer in use.

## PURPOSES

This practice serves to:

- Prevent entry of vermin, debris, or other foreign substances into the well or well bore hole;
- Eliminate the physical hazard of an open hole to people, animals, and farm machinery;
- Prevent entry of contaminated surface water into well and migration of contaminants into unsaturated (vadose) zone or saturated zone
- Prevent the commingling of chemically or physically different ground waters between separate water bearing zones.

## CONDITIONS WHERE PRACTICE APPLIES

This practice applies to any drilled, dug, driven, bored, or otherwise constructed vertical water well determined to have no further beneficial use.

This practice does not apply to wells that were used for waste disposal, or if evidence of contamination still exists. This practice does not apply to wells that contain contaminant levels that exceed state or federal water quality standards. Treatment of contamination source(s) is required before a well is decommissioned.

## CRITERIA

**General criteria for design parameters, acceptable installation processes, or minimum performance requirements applicable to all purposes named above:**

All planned work shall comply with General Manual Title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local laws and regulations. ASTM Standard Guide D5299 provides information on properties of common well sealing materials.

**Data collection** - All available data for the well shall be collected and reviewed from as-built construction and maintenance records; i.e., well log, the materials schedule, length, and diameter of casing, total well depth, type of liners and screens, and related information. The existing conditions of the well shall be documented as shown in the "Plans and Specifications" section.

**Well preparation** - The well shall be cleared of all pumping equipment, valves, pipelines, casing liners, debris, and other foreign material.

**Casing** - The well casing should be removed if possible. Where the well casing cannot be removed, and an open annular space exists between the outside of the casing and the well bore, then the annular space must be sealed, using sealing materials described in this standard. Sealing materials can be directed into the annular space as grout. As alternative the casing

may be ripped or perforated to ensure that sealing materials completely fill the casing and any annular space. Also see "Surface Seal" part of this standard.

**Disinfection** - Before sealing, the well water shall be brought to a 100 ppm chlorine concentration or other solution specified by local or state requirements.

**Sealing materials** - All materials used for sealing any portion of the well shall have a hydraulic conductivity equivalent to or less than that of the lowest hydraulic conductivity of the geologic materials being sealed. Properties of sealing materials shall conform to characteristics listed in ASTM D5299, part 6.3 Plugging Materials.

**Fill materials** - When allowed by state regulations, fill materials, such as sand, pea gravel, sand-gravel mix, crushed stone, or agricultural lime can be used to plug the well provided that zones of sealing materials (conforming to ASTM D5299, part 6.3) are placed no less than one foot thick each at intervals no greater than 10 feet within the column. Fill materials shall be clean and free of organic or other foreign matter. The gradation shall be such that bridging will not occur during placement.

**Placement of materials** - All materials shall be placed without bridging. For wells greater than 30 inches in diameter, backfill shall be placed in a manner that minimizes segregation and bulking in order to prevent surface subsidence.

**Surface seal** - The casing shall be completely removed from the well or cut off at a depth not less than 3 ft. below ground surface or at the maximum depth of frost penetration, whichever is greater. Local frost heave and fracturing hazards shall be considered in the design of the surface seal. An interval not less than 3 ft. Below the cut-off casing shall be sealed with sealing materials. These materials may be an extension of the sealing materials used below this depth.

The interval between the ground surface and the top of the cut-off casing shall be filled with soil materials that achieve an in-place hydraulic conductivity equivalent to or less than the surface soil surrounding the well. The ground surface at the sealed well site shall be mounded and graded in a manner that prevents ponding of surface runoff.

**Additional criteria to prevent commingling of ground waters between separate water bearing zones:**

Wells with open annular space around the casing shall be treated in a manner that seals the voided annular space. Methods of treatment include (1) removing the casing or (2) grouting the casing in place.

Casing removal is acceptable when the entire casing can be removed from the well. Casings removed from a collapsing formation shall be grouted concurrent with removal such that the bottom of the casing remains submerged in the grout.

Casings grouted in place shall employ a grouting procedure that will fill the open space. Perforated or ripped casing shall provide sufficient apportioned open area to assure passage of the grout to the annular space. The casing shall be perforated or ripped throughout the entire length of a confining layer.

## **CONSIDERATIONS**

This practice may be part of a ground water protection system that includes water and chemical management practices.

To the extent practicable, an abandoned well should be decommissioned in a manner that restores the original hydrogeologic conditions of the well site and does not preclude the use of the site from future land management practices.

Decommissioning requires special consideration of specific geological, biological, physical, and climatic conditions, the chemical composition of the surrounding soil, rock, and ground water at the well site, and the well's construction practices. All procedures, fill and sealing materials need to be selected according to these considerations.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for decommissioning abandoned water wells shall be consistent with this standard and shall describe the requirements for applying the practice to achieve its intended purposes. A record of the installation of this practice shall be made and shall include the following information:

- Location of the decommissioned well by latitude/longitude, township/range, or other georeference convention, of such precision that it can be readily located in the field, if required, in the future.
- Date of well decommissioning
- Name of landowner
- Total depth of well
- Inside diameter of well bore or casing
- Casing material type or schedule (e.g., standard weight steel, or PVC sch-80)
- Static water level measured from ground surface
- Types of materials used for filling and sealing, quantities used, and depth intervals for emplacement of each type.

## **OPERATION AND MAINTENANCE**

The practice site shall be inspected periodically to ensure that the decommissioned well and the adjacent area have not settled or eroded, or are otherwise adversely disturbed. The well site and adjacent ground surfaces shall be maintained in a manner that prevents ponding of surface runoff on the site.

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# **WETLAND CREATION**

(acre)  
**CODE 658**

## **DEFINITION**

A wetland that has been created on a site location which historically was not a wetland or is a wetland but the site will be converted to a wetland with a different hydrology, vegetation type, or function than naturally occurred on the site.

## **PURPOSE**

To create wetlands that have wetland hydrology, hydrophytic plant communities, hydric soil conditions, and wetland functions and/or values.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to sites where no natural wetland occurred or where a wetland exists, or existed, and the wetland characteristics (hydrology, vegetation, and functions) will be different from what historically occurred.

Upon completion of the practice the site will meet the current NRCS definition of Wetland, if hydric soils exist at the site.

This practice is applicable only if hydrologic conditions can be approximated by modifying drainage and/or artificial flooding of a duration and frequency to create and maintain wetland conditions during an average annual precipitation event. The wetland class/subclass will be specified.

This practice does not apply to: a constructed wetland (656) intended to treat point and non-point sources of water pollution; wetland enhancement (659) intended to rehabilitate a degraded wetland where specific functions and/or values are enhanced beyond original conditions; or wetland restoration (657) intended to rehabilitate a degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to original conditions.

## **CRITERIA**

### **General Criteria**

The landowner shall obtain necessary local, state, and federal permits that apply before the practice is applied.

Water rights and water availability are assured prior to creation if required.

Created wetlands will only be located where the soils, hydrology and vegetation can be modified to meet the current NRCS criteria for wetland.

Establish vegetative buffers on surrounding uplands to reduce sediment and soluble and sediment-attached substances carried by runoff and/or wind.

Document the soil, hydrology and vegetative characteristics of the site and its contributing watershed before alteration.

### **Criteria for Hydric Soil Conditions**

Establish an approximation of the soil microtopography typical for the wetland type(s) being established.

### **Criteria for Wetland Hydrology**

The hydrology of the site is defined as the rate and timing of inflow and outflow, source, duration, frequency, and depth of flooding, ponding or saturation.

The standards and specifications for Dike (356) and Structure for Water Control (587) will be used as appropriate. Refer to the Engineering Field Handbook, Chapters 13, "Wetland Restoration, Enhancement, and Creation," and 6, "Structures," for additional design information. Existing drainage systems will be utilized, removed, or modified as needed to achieve the intended purpose.

### **Criteria for Hydrophytic Vegetation**

Establish hydrophytic vegetation typical for the wetland type(s) being established. Each state will develop specific guidelines that consider soil, seed sources, and species.

Preference shall be given to native wetland plants with localized genetic material. Plant materials collected or grown from material collected within a 200 mile radius from the site is considered local.

Where natural colonization of selected species will realistically dominate within 5 years, then natural regeneration can be left to occur.

Adequate substrate material and site preparation necessary for proper establishment of the selected plant species shall be included in the design.

Each state will develop specific guidelines that consider soil, seed sources, and species.

If the targeted hydrophytic vegetation is predominantly herbaceous, several species adapted to the site will be established. Herbaceous vegetation may be established by a variety of methods including: mechanical or aerial seeding, topsoiling, organic mats, etc., over the entire site, or a portion of the site and at densities and depths appropriate.

Forested wetland establishment will include a minimum of three species, where appropriate. Seedling preparation and planting will follow the criteria of Conservation Practice 612, Tree Planting.

Seed planting rates and site preparation will meet the criteria of Conservation Practice 652, Woodland Direct Seeding. Seed viability will be checked immediately prior to planting.

### **Criteria for Wetland Functions**

A functional assessment (Hydrogeomorphic approach or similar method) shall be performed on the site prior to creation.

Created wetland goals and objectives should include targeted natural wetland functions for the wetland type and the site location.

## **CONSIDERATIONS**

Consider effect of volumes and rates of runoff, infiltration, evaporation, and transpiration on the water budget.

Consider the potential for a change in rates of plant growth and transpiration because of changes in the volume of available soil water.

Consider effects on downstream flows or aquifers that would affect other water uses or users.

Consider effects on wetlands or water-related resources and wildlife habitats that would be associated with the practice.

Considering positioning site(s) adjacent to existing wetlands to increase wetland system complexity and diversity, decrease habitat fragmentation, and ensure colonization of the site by wetland flora and fauna.

Consider linking wetlands by corridors wherever appropriate to enhance the wetland's use and colonization by the flora and fauna.

The nutrient and pesticide tolerance of the species planned should be considered where known nutrient and pesticide contamination exists.

Consider effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

Embankments and excavated slopes should be located and shaped in a manner that is compatible with the existing landscape.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other documentation. Requirements for the operation and maintenance of the practice shall be incorporated into site specifications.

## **OPERATION AND MAINTENANCE**

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

Any use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals shall not compromise the intended purpose. Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible;

Timing and level setting of water control structures required for the establishment of desired hydrologic conditions or for management of vegetation;

Inspection schedule for embankments and structures for damage assessment;

Depth of sediment accumulation to be allowed before removal is required;

Management needed to maintain vegetation, including control of unwanted vegetation;

Haying and livestock grazing will be managed to protect and enhance established and emerging vegetation.

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# **WETLAND ENHANCEMENT**

(acre)  
**CODE 659**

## **DEFINITION**

The modification or rehabilitation of an existing or degraded wetland, where specific functions and/or values are modified for the purpose of meeting specific project objectives. Some functions may remain unchanged while others may be degraded.

## **PURPOSE**

To modify the hydrologic condition, hydrophytic plant communities, and/or other biological habitat components of a wetland for the purpose of favoring specific wetland functions or values. For example; managing site hydrology for waterfowl or amphibian use, or managing plant community composition for native wetland hay production.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies on any degraded or existing wetland where the objective is to specifically enhance a selected wetland function(s) and/or value(s).

Enhancement should not significantly change the primary wetland functions provided at the site. Upon completion of the enhancement the site will meet the current NRCS soils, hydrology, and vegetation criteria of a Wetland.

This practice does not apply to: a constructed wetland (656) intended to treat point and non-point sources of water pollution; wetland restoration (657) intended to rehabilitate a degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to original conditions; or wetland creation (658) for creating a wetland on a site location which historically was not a wetland or on a site which was formerly a wetland but will be replaced with a wetland type not naturally occurring on the site.

## **CRITERIA**

### **General Criteria**

The landowner shall obtain necessary local, state, and federal permits that apply before wetland enhancement.

Water rights are assured prior to enhancement if required.

The design will not back water on neighboring land without an easement.

Document the soil, hydrology, and vegetative characteristics of the site and its contributing watershed before alteration .

The potential for occurrence of threatened or endangered species shall be evaluated for each site proposed for enhancement. Sites containing threatened or endangered species will not be enhanced under this standard unless it can be demonstrated that the impact will benefit the species at risk.

If the presence of hazardous waste materials in the sediment or fill is suspected, soil samples will be collected and analyzed for the presence of hazardous waste as defined by local, state, or federal authorities. Sites containing hazardous waste will not be enhanced under this standard.

#### **Criteria for Hydrology Enhancement**

The hydrology of the site (defined as the rate and timing of inflow and outflow, source, duration, frequency, and depth of flooding, ponding or saturation) is modified to meet the project objectives. An adequate source of water must be available to meet designs for increased hydrology.

The standards and specifications for Dike (356) and Structure for Water Control (587) will be used as appropriate. Refer to the Engineering Field Handbook, Chapters 13, "Wetland Restoration, Enhancement, and Creation," and 6, "Structures," for additional design information. Existing drainage systems will be utilized, removed, or modified as needed to achieve the intended purpose.

#### **Criteria for Vegetation Enhancement**

Where possible, native plant materials shall be used; however, introduced or cultivated plant species can be used to meet specific project objectives. Introduced species may become invasive or detrimental and caution must be exercised.

When using native species, preference shall be given to native wetland plants with localized genetic material. Plant materials collected or grown from material collected within a 200 mile radius from the site is considered local.

In soils where seed banks realistically exist, or where natural colonization of targeted species will dominate within 5 years, then natural regeneration can be allowed. Specific guidelines that consider soil, seed source, and species will be developed by the states.

Adequate substrate material and site preparation necessary for proper establishment of the selected plant species shall be included in the design.

#### **Criteria for Wetland Functions**

A functional assessment (Hydrogeomorphic approach or similar method) shall be performed on the site prior to enhancement.

Project goals and objectives shall minimize adverse impacts to wetland functions not specifically targeted for enhancement.

Where possible, wetland functions not targeted for enhancement should also be maximized.

### **CONSIDERATIONS**

Consider existing wetland functions and/or values that may be adversely impacted.

Consider effect of volumes and rates of runoff, infiltration, evaporation, and transpiration on the water budget.

Consider the potential for a change in rates of plant growth and transpiration because of changes in the volume of available soil water.

Consider effects on downstream flows or aquifers that would affect other water uses or users.

Consider effects on wetlands or water-related resources wildlife habitats that would be associated with the practice.

Consider linking wetlands by corridors wherever appropriate to enhance the wetland's use and colonization by the flora and fauna.

Consider establishing vegetative buffers on surrounding uplands to reduce sediment and soluble and sediment-attached substance carried by runoff and/or wind.

The nutrient and pesticide tolerance of the species planned should be considered where known nutrient and pesticide contamination exists.

Consider effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other documentation. Requirements for the operation and maintenance of the practice shall be incorporated into site specifications.

## **OPERATION AND MAINTENANCE**

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

Any use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals to assure the wetland enhancement function shall not compromise the intended purpose;

Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible;

Timing and level setting of water control structures is required for the establishment of desired hydrologic conditions, for management of vegetation and for optimum wildlife use.

Inspection schedule for embankments and structures for damage assessment;

Depth of sediment accumulation to be allowed before removal is required;

Management needed to maintain vegetation, including control of unwanted vegetation;

Haying and livestock grazing will be managed to protect and enhance established and emerging vegetation.

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# **WETLAND RESTORATION**

(acre)  
**CODE 657**

## **DEFINITION**

A rehabilitation of a drained or degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to the natural condition to the extent practicable.

## **PURPOSE**

To restore hydric soil conditions, hydrologic conditions, hydrophytic plant communities, and wetland functions that occurred on the disturbed wetland site prior to modification to the extent practicable.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies only to sites with hydric soil which were natural wetlands that have been previously degraded hydrologically and/or vegetatively.

Upon completion of the restoration the site will meet the current NRCS soil, hydrology, and vegetation criteria of a wetland.

This practice is applicable only if natural hydrologic conditions can be approximated by modifying drainage and/or artificial flooding of a duration and frequency similar to natural conditions.

If the presence of hazardous waste materials in the sediment or fill is suspected, soil samples will be collected and analyzed for the presence of hazardous waste as defined by local, state, or federal authorities. Sites containing hazardous waste will not be restored under this standard.

This practice does not apply to: a constructed wetland (656) intended to treat point and non-point sources of water pollution; wetland enhancement (659) intended to rehabilitate a degraded wetland where specific functions and/or values are enhanced beyond original conditions; or wetland creation (658) for creating a wetland on a site location which historically was not a wetland or was formerly a wetland but will be replaced with a wetland type not naturally occurring on the site.

## **CRITERIA**

### **General Criteria**

The landowner shall obtain necessary local, state, and federal permits that apply before restoration.

Water rights are assured prior to restoration if required.

Establishing vegetative buffers on surrounding uplands to reduce the movement of sediment and soluble and sediment-attached substances carried by runoff.

The soil, hydrology and vegetative characteristics existing on the site and the contributing watershed shall be documented before restoration of the site begins.

### **Criteria for Hydric Soil Conditions**

Restoration sites will be located on hydric soils.

If the hydric soil is covered by fill, sediment, spoil, or other depositional material, the material covering the hydric soil shall be removed only to the surface of the buried (or original) hydric soil.

Reestablish an approximation of the original soil microtopography.

### **Criteria for Hydrology Restoration**

A permanent water supply should be available approximating the needs of the wetlands. The hydrology of the site is defined as the rate, path, and timing of inflow and outflow; duration, frequency, and depth of flooding, ponding or saturation.

The maximum hydrology and the overall hydraulic variability of the restored site will approximate the conditions that existed before alteration, e.g., dynamic and static water levels, soil saturation.

The standards and specifications for Dike (356) and Structure for Water Control (587) will be used as appropriate. Refer to the Engineering Field Handbook, Chapter 13, "Wetland Restoration, Enhancement, and Creation," and Chapter 6, "Structures," for additional design information. Existing drainage systems will be utilized, removed, or modified as needed to achieve the intended purpose.

### **Criteria for Vegetation Restoration**

The vegetation shall be restored as close to the original natural plant community as the restored site conditions will allow. Determination of the original plant community's species and percent composition shall be based upon reference wetlands of the type being restored or suitable technical reference.

Plantings, seeding, or other types of vegetative establishment will be comprised of native species that occur on the wetland type being restored.

Preference shall be given to native wetland plants with localized genetic material. Plant materials collected or grown from material collected within a 200 mile radius from the site is considered local.

In soils where seed banks realistically exist, or where natural colonization of selected native species (identified from reference wetlands) will dominate within 5 years, then natural regeneration can be allowed. Specific guidelines that consider soil, seed source, and species will be developed by the states.

Adequate substrate material and site preparation necessary for proper establishment of the selected plant species shall be included in the design.

On sites which were predominantly herbaceous vegetation prior to modification and planting and/or seeding is necessary, the minimum number of native species to be established shall be based upon the number of ecological sites present. Sites restored to only one ecological site shall be established with at least two species adapted to the site. Sites with two or more ecological sites (i.e., wet meadow, shallow marsh, or slough eco-sites, etc.) shall be established with at least one native species on each ecological site.

Herbaceous vegetation may be established by a variety of methods including: mechanical or aerial seeding, topsoiling, organic mat placement, wetland sod, vegetative sprigs, wetland hay, or etc., over the entire site or a portion of the site and at densities and depths appropriate. Forested wetland plantings and/or seeding will include a minimum of three tree or shrub species on each ecological site (i.e., low flat, bottom ridge eco-sites, etc.), where appropriate. Tree (and shrub) planting will follow the criteria of Conservation Practice 612 - Tree Planting. Seed planting rates and site preparation will meet the criteria of Conservation Practice 652 - Woodland Direct Seeding. Seed viability will be determined prior to planting.

### **Criteria for Wetland Functions**

A functional assessment (Hydrogeomorphic Approach or similar method) shall be performed on the site prior to restoration.

Restoration goals and objectives shall include targeted natural wetland functions for the wetland type and the site location as determined by the functional assessment and reference site data. A post-project assessment will be performed after an adequate period to assess the success if the restoration.

## **CONSIDERATIONS**

Consider effect of volumes and rates of runoff, infiltration, evaporation, and transpiration on the water budget.

Evaluate the potential for a change in rates of plant growth and transpiration because of changes in the volume of available soil water.

Consider effects on downstream flows or aquifers that would affect other water uses or users.

Consider effects on wetlands or water-related resources wildlife habitats that would be associated with the practice.

Consider as a high priority those sites adjacent to existing wetlands as they increase wetland system complexity and diversity, decrease habitat fragmentation, and ensure colonization of the site by wetland flora and fauna.

Consider linking wetlands by corridors wherever appropriate to enhance the wetland's use and colonization by the flora and fauna.

Consider the effects of varying water levels in response to potential climatic events such as wet or dry periods.

Consider changes in salt movement / concentrations in the soil resulting from hydrologic alterations.

The nutrient and pesticide tolerance of the plant species planned should be considered where known nutrient and pesticide contamination exists.

Consider effects of temperature on water resources to prevent undesired effects on aquatic and wildlife communities.

For discharge wetlands, consider upslope water/groundwater source availability.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other documentation. Requirements for the operation and maintenance of the practice shall be incorporated into site specifications.

## **OPERATION AND MAINTENANCE**

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

Any use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals to assure the wetland restoration function shall not compromise the intended purpose;

Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible;

Timing and level setting of water control structures required for the establishment of desired hydrologic conditions or for management of vegetation;

Inspection schedule for embankments and structures for damage assessment;

Depth of sediment accumulation to be allowed before removal is required;

Management needed to maintain vegetation, including control of unwanted vegetation;

Haying and livestock grazing plans will be developed so as to allow the establishment, development, and management of wetland and associated upland vegetation.

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# **WETLAND WILDLIFE HABITAT MANAGEMENT**

(acre)  
**CODE 644**

## **DEFINITION**

Retaining, developing, or managing habitat for wetland wildlife.

## **PURPOSE**

To maintain, develop, or improve habitat for waterfowl, fur-bearers, or other wetland associated flora and fauna.

## **CONDITIONS WHERE PRACTICE APPLIES**

On or adjacent to wetlands, rivers, lakes and other water bodies where wetland associated wildlife habitat can be managed. This practice applies to natural wetlands and water bodies as well as wetlands that may have been previously restored (657), enhanced (659), created (658).

## **CRITERIA**

Identify species management goals and objectives. For the desired species, identify the types, amount, and distribution of habitat elements and the management actions necessary to achieve the management objectives.

Native plant will be used where ever possible.

The landowner shall obtain all necessary local, state and federal permits that apply.

## **CONSIDERATIONS**

Consider effects of movement of dissolved substances on groundwater and on downstream surface waters.

Consider effects of hazardous materials expected or known to occur on the site on wildlife or human use related to wildlife.

Consider effects of management actions on compliance with state and federal hunting regulation (e.g., baiting).

Consider effects of management on non-target fish and wildlife species and Threatened and Endangered Species.

Consider effects of livestock grazing on runoff, infiltration, and wetland vegetation.

Consider using artificial nesting structures that are designed for the region.

Consider locating the management practice adjacent to existing wetlands and other water bodies.

Consider the impact of elevated wildlife uses on adjacent lands (e.g., crop depredation).

Consider effect of volumes and rates of runoff, infiltration, evaporation, and transpiration on the water budget.

Consider effects on downstream flows or aquifers that would affect other water uses or users.

Consider adjacent wetlands or water bodies that contribute to wetland system complexity and diversity, decrease habitat fragmentation, and maximize use of the site by wetland-associated wildlife.

Consider effects on movement of sediment and soluble and sediment-attached substances carried by runoff and/or wind.

## **PLANS AND SPECIFICATIONS**

Document how habitat needs will be provided for the desired kinds of wildlife: required depth of water during the different seasons; types and sizes of structures required; desired native plant species and the means of establishing and maintaining them. Specific information may be provided using appropriate job sheets or written documentation in the conservation plan.

## **OPERATION AND MAINTENANCE**

A plan for operation and maintenance at a minimum should include monitoring and management of structural and vegetative measures and also consider:

Haying and livestock grazing plans will be developed so as to allow the establishment, development, and management of wetland and associated upland vegetation for the intended purpose

Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) shall be implemented where available and feasible.

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# WILDLIFE WATERING FACILITY

(no.)  
CODE 648

## DEFINITION

Develop, improve, or modify watering places and systems for wildlife.

## PURPOSE

- To provide adequate drinking water, during critical periods, for wildlife.
- To create or expand suitable habitat for wildlife.
- To improve water quality and accessibility for wildlife.

## CONDITIONS WHERE THIS PRACTICE APPLIES

In areas where new, additional, or improved watering places are needed to increase the range, distribution, improve the habitat of, or attract wildlife by meeting their water requirements. Where lack of adequate water has been identified as the limiting habitat component.

## CRITERIA

### General Criteria Applicable to All Purposes

- Because each facility is unique to species, habitat, topography, and climate; watering facilities must be planned and installed according to a plan and adapted to the specific site.
- Methods used will be designed to protect the soil resource from erosion
- Design shall be sized to accommodate the expected and/or anticipated consumptive rates of target and non-target species.
- Facilities shall be protected from livestock damage.
- The facility must provide permanent, accessible, dependable, and suitable quality water for the critical period.
- The distribution and spacing of facilities shall be based on topography, required travel distance to water and the home range, territory size, and distribution of the target species.
- Ramps shall be installed in open water troughs and tanks when necessary for access and escape.
- Design shall include appropriate safety features to minimize the hazards of the facility.
- Management measures shall be provided to control invasive species and noxious weeds.
- Facilities shall be designed and installed in compliance with all State and federal laws including water rights and permits if needed.
- Disturbed areas shall be vegetated according to a revegetation plan using native plant materials.

## CONSIDERATIONS

### General Considerations

- Consider the effects on the target species and the ecosystem by concentrated grazing, predation, hunting etc.

- Consider the accessibility of the site for installation and maintenance.
- Consider any effects upon natural springs and associated unique flora and fauna.
- Consider the aesthetics of the installation.

#### **Water Quantity Considerations**

- Consider the effects on downstream flows or groundwater that could affect other water users or associated aquatic sites.

#### **Water Quality Considerations**

- Consider the effects on wetlands or other aquatic sites.
- Consider the existence and maintenance of suitable water quality for the target species.

### **PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

### **OPERATION AND MAINTENANCE**

Facilities shall be checked periodically to insure proper function. Repair and maintain as needed.

Inspect the area adjacent to the facility to make sure the area is well protected with desirable vegetation and not subject to erosion or deposition. Correct as needed.

Facilities not designed to withstand or operate during freezing weather shall be winterized prior to winter conditions.

Periodically monitor water quality to insure acceptable water quality. Maintain as needed.

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# **WINDBREAK/SHELTERBELT ESTABLISHMENT**

(Feet)  
CODE 380

## **DEFINITION**

Linear plantings of single or multiple rows of trees or shrubs established for environmental purposes.

## **PURPOSES**

- Reduce wind erosion.
- Protect growing plants.
- Manage snow.
- Provide shelter for structures and livestock.
- Provide wildlife habitat.
- Provide a tree or shrub product.
- Provide living screens.
- Improve aesthetics.
- Improve irrigation efficiency.

## **CONDITIONS WHERE PRACTICE APPLIES**

On any areas where woody plants are suited.

## **CRITERIA**

### **General Criteria Applicable To All Purposes Named Above**

The location, layout and density of the planting will accomplish the purpose and function intended within a 20 year period.

The maximum design height (H) for the windbreak or shelterbelt shall be the expected height of the tallest row of trees or shrubs at age 20 for the given site.

Species must be suitable and adapted to the soils, climate and purpose.

Site preparation shall be sufficient for establishment and growth of selected species and appropriate for the site.

Only viable, high quality, and adapted planting stock or seed will be used.

The planting shall be done at a time and manner to insure survival and growth of selected species.

The planting will be protected from adverse impacts such as livestock damage or fire.

Avoid planting trees or shrubs where they will interfere with structures or any above or below ground utilities.

Moisture conservation or supplemental watering shall be provided for plant establishment and growth where natural precipitation is too low for the selected species.

### **Additional Criteria To Reduce Wind Erosion; Protect Growing Plants**

The windbreak will be oriented as close to perpendicular to the troublesome wind as possible. The interval between windbreaks shall be determined using current, approved, wind erosion technology to achieve the quality level for the soil or plant resource. The distance sheltered by the barrier shall be 10 times the design height (H).

The wind erosion control system should consider temporary measures to supplement the windbreak until it is fully functional.

### **Additional Criteria To Manage Snow**

The windbreak will be oriented as close to perpendicular to the snow-bearing wind as possible.

For snow distribution, the maximum windbreak density will be 65 percent and the interval between barriers will not exceed 20H.

For snow accumulation, the minimum barrier density will be 50 percent and the windward row will be at least 100 feet from the area to be protected.

Windbreaks will be located so that snow deposition will not adversely impact the area to be protected.

### **Additional Criteria To Provide Shelter For Structures And Livestock**

The planting will be oriented as close to perpendicular to the troublesome wind as possible. For wind protection, the minimum barrier density will be 65 percent and the area to be protected will fall within 10H of the design height.

### **Additional Criteria For Screens**

Noise screens shall be dense, as tall as, and as close to the noise source as practicable.

Visual screens shall be located as close to the observer as possible.

## **CONSIDERATIONS**

Spacing between windbreaks and rows of windbreaks may be adjusted, within limits of the criteria above, to accommodate widths of equipment.

Selection of plants for use in windbreaks should favor species or varieties tolerant to herbicides used in the area.

Plants which may be alternate hosts to undesirable pests should be avoided.

All plantings should compliment natural features.

Where water erosion and/or runoff from melting snow is a hazard, it should be controlled by supporting practices.

Wildlife needs should be considered when selecting tree or shrub species.

Species diversity should be considered to avoid loss of function due to species specific pests.

Consideration should be given to adverse offsite effects.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

- Replacement of dead trees or shrubs will be continued until the barrier is functional.
- Vegetative competition will be controlled.
- Supplemental water will be provided as needed.
- Thin the barrier to maintain its function.
- Damaging pests will be monitored and controlled.
- Periodic applications of nutrients may be needed to maintain plant vigor.

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# **WINDBREAK/SHELTERBELT RENOVATION**

(Feet)  
CODE 650

## **DEFINITION**

Widening, partial replanting, releasing, removing and replacing selected trees and shrubs to improve an existing windbreak or shelterbelt.

## **PURPOSES**

Restoring or enhancing the function of existing windbreaks or shelterbelts.

## **CONDITIONS WHERE PRACTICE APPLIES**

In any windbreak or shelterbelt that is no longer functioning properly for the intended purpose.

## **CRITERIA**

The following criteria will be used individually or in combination to accomplish windbreak or shelterbelt renovation:

Individual trees or shrubs will be identified for thinning to reduce plant competition or alter the density of the planting.

Pruning of trees will be used to remove diseased branches or alter the density of the planting.

Entire or partial rows of trees or shrubs will be identified for removal to release adjacent rows of trees or shrubs.

Identified rows of trees or shrubs in decline will be cut to the ground to allow sprouting (coppice) and improve density and vigor.

When competing herbaceous vegetation is affecting the health of the planting, the trees or shrubs will be released mechanically or chemically to improve the growth and vigor.

Additional rows of trees or shrubs will be added adjacent to or within an existing windbreak/shelterbelt to improve density.

Residual plants will be protected during the renovation.

Comply with applicable laws and regulations, including the state's Best Management Practices (BMPs).

## **CONSIDERATIONS**

Renovation may be accomplished over a period of years.

Debris should be removed from the site and disposed properly if the debris will cause insect, disease, fire, or operability problems.

Consider shade tolerance when selecting species for replanting within or adjacent to an existing windbreak or shelterbelt.  
When rows of a windbreak or shelterbelt are merely extended in length, this is not considered renovation.

Damaging pests will be monitored and controlled.

Wildlife needs should be considered when selecting tree or shrub species.

## **PLANS AND SPECIFICATIONS**

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

## **OPERATION AND MAINTENANCE**

Vegetative competition will be controlled as long as it inhibits the renewed growth and vigor of the windbreak or shelterbelt.

Supplemental water will be provided as needed.

Trees and shrubs will be protected from fire and animals.

Additional thinning, pruning, or coppice management may be needed in the future to maintain function.

The windbreak/shelterbelt will be monitored for potential damaging pests.

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