NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, SURFACE AND SUBSURFACE

(Ac.)

CODE 443

DEFINITION

A system in which all necessary earthwork, multi-outlet pipelines, and water control structures have been installed for distribution of water by surface means (such as furrows, borders, and contour levees) or by subsurface means through water table control.

PURPOSES

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

- Efficiently convey and distribute irrigation water to the surface point of application without causing excessive water loss, erosion, or water quality impairment.
- Efficiently convey and distribute irrigation water to the subsurface point of application without causing excessive water loss or water quality impairment.
- Apply chemicals and/or nutrients as part of a surface irrigation system in a manner which protects water quality.
- Reduce energy use.

CONDITIONS WHERE PRACTICE APPLIES

Areas must be suitable for irrigation and the water supplies must be adequate in quantity and quality to make irrigation practical for the planned crops to be grown and the planned application methods to be used.

This standard does not apply to detailed design criteria and construction specifications for individual water control or conveyance structures or appurtenances.

Site conditions for a subsurface irrigation system shall be such that a water table can be created and maintained to supply water to the crop root zone.

Subsurface irrigation under this standard applies to irrigation through water table control by adding water at water control structures and using perforated pipe or tubing (usually 3 inches or greater in diameter) or to operation of ditch structures to raise the water table.

This standard does not apply to irrigation systems employing subsurface line source emitters on buried drip tapes or tubing which is addressed in Conservation Practice Standard (CPS) 441, Irrigation System, Microirrigation.

CRITERIA

General Criteria Applicable to All Purposes

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

The criteria for the design of components not addressed in Natural Resources Conservation Service (NRCS) conservation practice standards shall be consistent with sound engineering principles.

Conservation irrigation methods. All irrigation systems 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 irrigated area.

All farm irrigation system designs shall be based on the use of sound irrigation water application methods that are suited to site conditions (combination of soil and slope) and crops to be grown. Adapted methods are those methods that will provide efficient use of water without destructive soil erosion or degradation of water quality. Refer to Section KS652.0605 in the National Engineering Handbook Part 652 (NEH 652), *Irrigation Guide*.

Capacity. The irrigation system shall have adequate capacity to meet the intended purpose(s).

If more than one irrigation method will be used on the same field, the system capacity shall be adequate for the method or methods when operated simultaneously, requiring the highest water delivery rate.

All structures and water delivery components shall be designed for maximum flow conditions expected and shall have adequate capacity and/or freeboard.

Water control. Farm irrigation systems shall include necessary structures required for water control such as measuring devices, division boxes, checks, turnouts, pipelines, lined ditches, valves, pumps, and gates to control and regulate water for efficient application.

Additional Criteria Applicable to Surface Irrigation Systems

Design of physical components shall be in accordance with Conservation Practice Standard (CPS) 430, Irrigation Pipeline; CPS 320, Irrigation Canal or Lateral; CPS 388, Irrigation Field Ditch; CPS 587, Structure for Water Control; CPS 533, Pumping Plant; and other pertinent conservation practice standards.

Capacity. The system shall have either (1) a design capacity adequate to meet water demands of all crops to be irrigated in the design area or (2) enough capacity to meet the requirements of water application 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 and any leaching requirements.

Design application rate. The design rate of application shall be within a range established by the minimum practical application rate for local climatic conditions and the maximum rate consistent with the intake rate of the soil and conservation practices used on the land.

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 inches shall be provided.

Location of delivery ditches or aboveground, multi-outlet distribution pipelines. Delivery 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 such that irrigation run lengths are not longer than the maximums specified in Section KS652.0605 in NEH 652 or those determined by field evaluation. If more than 1 crop is to be grown or more than 1 method of irrigation is used, the ditch or distribution pipeline spacing shall not exceed the allowable run length determined for the limiting crop or method.

Irrigation water management. An "Irrigation Water Management Plan" that meets the requirements of CPS 449, Irrigation Water Management, shall be developed for use with this practice.

Aboveground, multi-outlet distribution pipeline.

Working pressure. The maximum working pressure for all aboveground, multi-outlet distribution pipe except for poly irrigation tubing shall be 10 pounds per square inch or 23 feet of head. Appropriate head control appurtenances shall be installed to reduce maximum working pressure to acceptable levels.

For poly irrigation tubing, manufacturer's recommendations for maximum allowable working pressure shall be followed. If the manufacturer's recommendations are not available, the hoop stress formula in Chapter 52 in National Engineering Handbook Part 636, *Structural Engineering*, shall be used to determine maximum working pressure, using a Factor of Safety of 1.5.

Friction losses. For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation using roughness coefficients of C = 130 for aluminum pipe and C = 150 for plastic or poly irrigation tubing.

Flow velocity. Velocity in the pipeline when operating at system capacity shall not exceed 7 feet per second unless appropriate surge protection is provided.

Capacity. The design capacity of the pipeline 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 capacity at design working pressure to deliver required flow to a point at least 4 inches above the field surface.

Head requirement. The working head shall not be less than 0.5 foot above outlet gates unless a detailed design or manufacturer's literature indicates a lower head is adequate to deliver required water to the field.

Where either design working head exceeds 5 feet or stream flows are erosive, an effective method of energy dissipation shall be installed at each gate, or permanent vegetation shall be established and maintained along the pipeline to provide erosion control.

Flushing. A suitable outlet shall be installed at the end of the pipeline for flushing the line free of sediment or other foreign material.

Materials. Pipe shall be aluminum or plastic material certified for aboveground use. All fittings and couplers shall equal or exceed the pressure rating of the pipe with which they will be used. They shall be made of material which is recommended by the manufacturer for use with the pipe

Pipe and appurtenances shall be furnished with a coupling system which is compatible with the selected pipe material.

Rubber gaskets shall be according to the manufacturer's standard design dimensions and tolerances for the pipe material selected. They shall be of such size and shape that, after assembly, adequate compressive force is provided against the spigot and socket to provide a positive seal. The gasket shall be a continuous elastomeric ring and shall be the sole element depended upon to make the joint flexible and watertight.

Minimum wall thickness for aluminum gated pipe shall be 0.050 inch for 6 through 10 inches in diameter and 0.058 inch for 12-inch diameter pipe.

Corrosion protection shall be provided for aluminum pipe when:

- Conveying water with a copper content exceeding 0.02 part per million.
- In contact with soil having a resistivity of less than 500 ohm-centimeters.
- In contact with soil having a pH less than 4 or greater than 9.

Minimum wall thickness of polyvinyl-chloride-(PVC)-gated pipe (including consideration of any standard manufacturing tolerances) shall not be less than 0.09 inch. The pressure rating of the pipe shall be 22 pounds per square inch or greater (prior to gate installation).

Minimum wall thickness of poly irrigation tubing shall be 6 mil (0.006 inch).

Related structures. An open ditch supply shall include a permanent water control structure as the inlet to multi-outlet pipe.

When the water supply for poly irrigation tubing is greater than 0.5 foot above the ground, a PVC or aluminum fitting shall be used to convey water between the supply outlet and the poly irrigation tubing at ground level.

Erosion control. The design of farm irrigation systems shall provide for conveying and distributing irrigation water without causing damaging soil erosion. All unlined ditches shall have non-erosive gradients. If water is conveyed on slopes steep enough to cause excessive flow velocities, the irrigation system design shall provide for the installation of structural erosion control measures such as pipe drops, chutes, buried pipelines, or erosion-resistant ditch linings. Polyacrylamide may be utilized for erosion control according to CPS 450, Anionic Polyacrylamide (PAM) Application, in lieu of or in combination with structural measures.

Seepage control. If site conditions require conveyance of water across excessively permeable areas, the irrigation system design shall provide for pipelines, flumes, or lined ditches as needed to prevent excessive seepage losses.

Tailwater and excess runoff removal. Irrigation system designs shall include facilities of adequate capacity for the safe removal of irrigation tailwater and stormwater runoff from the field surface. If erosion is a hazard, collection facilities (ditches) constructed for this purpose shall be on non-erosive gradients or be stabilized by lining or structural measures. If field elevations do not permit the safe disposal of tailwater or excess water by gravity flow, the design shall provide for installation of pumping plants and other needed appurtenant structures. Ditches shall be protected from bank erosion.

If excess water will be reused for irrigation, the irrigation system design shall provide for collection facilities so that water does not flow directly from furrows or borders into irrigation head ditches. Tailwater systems shall be installed according to CPS 447, Irrigation System, Tailwater Recovery.

Additional Criteria Applicable to Subsurface Irrigation Systems

Subsurface irrigation systems shall be designed to maintain the water table at or between predetermined elevations below the ground surface at all points in the application area.

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 most limiting crop to be grown.

Design of physical components shall be in accordance with CPS 606, Subsurface Drain; CPS 587; CPS 533; and other pertinent conservation practice standards.

Soils. Site conditions shall be such that water can move laterally from open ditches or irrigation tiles to form and maintain a water table at the design depth as specified in the irrigation water management plan. Subsurface irrigation shall not be employed unless the irrigated area has a slowly permeable water restrictive layer.

Soil survey information for the irrigated area can be used in preliminary planning. Final design shall be based on on-site lateral hydraulic conductivity measurements or average lateral hydraulic conductivity determined from laboratory tests of each soil layer.

Lateral spacing. Laterals shall be equally spaced in each subunit. Maximum spacing of irrigation tiles or open ditches shall be no more than one-half the lateral or ditch spacing specified in local drainage guides or no more than one-half the lateral or ditch spacing computed using procedures found in Chapter 14 in National Engineering Handbook Part 650 (NEH 650), *Engineering Field Handbook*, or Chapter 10 in National Engineering Handbook Part 624 (NEH 624), *Drainage*.

Water control. Within each managed subunit, the water level control structure shall be of sufficient size to allow adequate flow to meet water requirements of that subunit. The control structures should be set on elevation intervals not to exceed 1 foot.

Water level control structures must be covered or otherwise protected to prevent accidental entry by animals, livestock, machinery, or humans.

Irrigation water management. An “Irrigation Water Management Plan” that meets the requirements of CPS 449, Irrigation Water Management, shall be developed for use with this practice.

Additional Criteria Applicable to Application of Chemicals and/or Nutrients with a Surface Irrigation System

The installation and operation of an irrigation system for the purpose of chemical and/or nutrient application shall comply with all federal, state, and local laws, rules, and regulations. This includes backflow and anti-siphon prevention measures to protect surface and groundwater sources. Additionally, surface waters shall be protected from direct application and runoff.

Design of physical components shall be in accordance with CPS 430; 634, Waste Transfer; CPS 587; CPS 533; and other pertinent conservation practice standards.

Capacity. The system shall have a design capacity adequate to supply the specified amount of chemical and/or nutrients to the design area in the specified operating period.

Nutrient and pest management. Chemicals, fertilizers, wastewater, and liquid manure shall be applied in accordance with appropriate CPS 590, Nutrient Management; CPS 595, Integrated Pest Management; and/or CPS 633, Waste Recycling.

Additional Criteria Applicable to Reduce Energy Use

Provide analysis to demonstrate reduction of energy use from practice implementation.

Reduction of energy use is calculated as average annual or seasonal energy reduction compared to previous operating conditions.

CONSIDERATIONS

When planning this practice, the following items should be considered:

- Effects of soluble salts, nutrients, and /or pesticides on surface and groundwater quality.
- Effects of saturated water levels on such soil nutrient processes as plant nitrogen use or denitrification and root development.
- Effects on the soil biota which will alter nutrient cycling carbon utilization. Water-logged and tillage-dominated soils become bacteria-driven systems which denitrify and ineffectively use carbon.
- Effects on aquatic and wildlife communities, wetlands, or water-related wildlife habitats (including effects upon pollinator foraging and nesting habitats).
- When planning and designing surface and subsurface irrigation systems, soil texture, intake, slope, and depth are important soil properties which influence installation, performance, and soil limitations related to intake rate, seepage, corrosivity, and soil compaction. Designers should refer to soil survey information for the irrigated area during preliminary planning and conduct on-site soil investigations prior to final design.

When designing a surface irrigation system, the following should be considered:

- To improve surface irrigation efficiency, surface tillage should be reduced when possible. The destruction of soil structure caused by physical and chemical disturbance can severely impede the ability of some soils to take in water.
- Impact of salt leaching requirements on system management, capacity, and drainage requirements.
- Effects of erosion and/or movement of sediment and sediment-attached substances carried by runoff (including salinity, nutrients, pesticides, seeds, and vegetative portions of invasive plants).
- Effect of elevated irrigation tailwater temperatures on downstream receiving waters.
- Irrigation system capacity should be determined based on appropriate design application efficiency. Design application efficiency should be no greater than 90 percent for properly designed level surface irrigation systems and a maximum of 80 percent for graded systems. Guidance for selecting design application efficiencies is provided in Chapter 4 in National Engineering Handbook Part 623, *Irrigation*, and in Section KS652.0605(a) in National Engineering Handbook Part 652 (NEH 652), *Irrigation Guide*.
- Design, evaluation, and simulation models WINSRFR and SURFACE can be very useful tools in finalizing surface system designs.

When designing a subsurface irrigation system, the following should be considered:

- Potential benefits of water level control on downstream water quality.
- Potential effects of practice management on lateral seepage.

- Orienting lateral lines along the contours to maximize the area influenced by each water level control structure.
- Soil layers in the water transmission zone (root zone) should have a higher lateral saturated hydraulic conductivity than the vertical saturated hydraulic conductivity of the water restrictive layer. However, if lateral hydraulic conductivity of any single soil layer in the root zone exceeds 10 times that of other layers, lateral seepage may make it difficult to raise the water table to the design depth.
- Irrigation system capacity should be determined based on an appropriate design application efficiency. Design application efficiency should be no greater than 90 percent for soils with minimal lateral losses and a maximum of 75 percent for all other soils.
- Be aware that additional pumping capacity may be needed to raise the water table during drought periods.
- Design procedures and guidance for subsurface irrigation system planning and design are provided in Chapter 10 in NEH 624.
- Potential effects on existing wetlands.

When planning a surface irrigation system that employs an aboveground, multi-outlet, distribution pipeline, the following should be considered:

- Provisions should be made for thrust control at locations subject to pipe movement.
- Good grade control along the pipeline and along the rows is needed to ensure uniform water distribution.
- Consider the water source and potential trash types and amounts when designing or selecting inlet screen types and sizes.
- Plan for disposal of used poly irrigation tubing and encourage recycling.
- Anchor poly irrigation tubing when winds may cause it to move.
- PVC-gated pipe with a wall thickness of less than 0.12 inch will be more flexible, making soil support and uniform pipe grade more important if an irrigation stream contains sand. Sand will tend to settle and accumulate in any gated pipe lows.

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.

OPERATION AND MAINTENANCE

An operation and maintenance plan specific to the facilities installed shall be prepared for use by the landowner or operator responsible for operation and maintenance. The plan should provide specific instructions for operating and maintaining facilities to ensure they function properly. The plan shall include provisions to address the following:

- Periodic cleaning and regrading of tailwater collection facilities to maintain proper drainage, capacity, and functionality.
- Periodic checks and removal of debris as necessary from trash racks and structures to ensure proper operation.
- Periodic removal and planned placement of sediment from traps and/or storage facilities to maintain design capacity and efficiency.
- Inspection and testing of all pipeline and pumping plant components and appurtenances.
- Routine maintenance of all mechanical components in accordance with the manufacturer's recommendations.
- Periodic land smoothing or grading of surface irrigated fields required to maintain the design grade in the direction of flow.

Additionally for a subsurface irrigation, the plan shall include the following as a minimum:

- Water control structure elevation settings by date required to maintain water table at design depth.

- Critical dates and water table target elevations during planned crop growing season.
- Inclusion of specification and locations of all required groundwater observation wells.

REFERENCES

USDA-NRCS, National Engineering Handbook, Part 623, *Irrigation*.

USDA-NRCS, National Engineering Handbook, Part 624, *Drainage*.

USDA-NRCS, National Engineering Handbook, Part 636, *Structural Engineering,* Chapter 52, Structural Design of Flexible Conduits.

USDA-NRCS, National Engineering Handbook, Part 650, *Engineering Field Handbook*, Chapter 14, Water Management (Drainage).

USDA-NRCS, National Engineering Handbook, Part 652, *Irrigation Guide.*