NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE
DITCH AND CANAL LINING, PLAIN CONCRETE

(Ft.)

CODE 428A

DEFINITION

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral.

PURPOSE

- Improve management of irrigation water
- Prevent waterlogging of land
- Maintain water quality
- Prevent erosion
- 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 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.

Plain 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 deterioration of concrete.

CRITERIA

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

General. Plain concrete linings installed under the practice standard shall be limited to ditches or canals with:

- a bottom width not greater than 6 feet,
- flow capacity equal to or less than100 cubic feet per second, and
- design velocity equal to or less than 15 feet per second.

Materials. On sites where sulfate concentrations exist, concrete linings may be used only if they are made using special sulfate-resistant cement in accordance with those shown in Table 1.

Fly ash can be used to replace up to 15 percent (%) of the cement, by weight when other pozzolans are not used.

Air-entrainment admixture is required to improve workability and reduce damage due to freeze-thaw cycles. In-place, air content shall be in the range of 4 to 7% of the volume of concrete.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Table 1. Cement Requirements for Concrete Exposed to Sulfates

Water-soluble sulfate (SO_4) percent by weight	Sulfate (as SO_4) in water parts per million	Cement type ASTM C150 or C595
$SO_4 \geq 0$	$SO_4 \geq 0$	Any
$SO_4 \geq 0.10$	$SO_4 \geq 150$	II, IP(MS), IS(MS), P(MS), I(PM)(MS), I(SM)(MS)
$SO_4 \geq 0.2$	$SO_4 \geq 1500$	V
$SO_4 > 2.00$	$SO_4 \geq 10000$	V plus pozzolan*

* Pozzolan known or shown to improve sulfate resistance in concrete with Type V cement

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 or overtopping. Design capacity shall be based on the following, whichever is greater:

1. The capacity shall be enough to deliver water needed for irrigation to meet design peak consumptive use of crops.
2. The capacity shall be enough to provide an adequate irrigation system for all methods of irrigation planned.

For design purposes, the capacity 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 0.015.

Velocity. To avoid unstable surge flows, restrict design velocities in excess of 1.7 times the critical velocity to straight reaches that discharge into ditch sections or structures designed to reduce the velocity to less than critical velocity. 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 gates, turnouts, siphon tubes or by similar means shall be less than supercritical and sufficiently low to permit operation of the planned takeout structure or device.

Freeboard. The required freeboard varies according to the ditch or canal, velocity of water, horizontal and vertical alignment, the amount of storm or wastewater that may be intercepted, and the change in water surface elevation that may occur when any control structure is operating. The depth of freeboard provided, above the calculated water surface, shall be no less than:

0.1He for rectangular sections,
0.2He for trapezoidal sections,

except when the proposed channel bottom slope, S_o falls between $0.7S_c$ and $1.3S_c$, then the freeboard provided, above the calculated water surface shall be no less than

$$0.2He + 0.25d_c[1 - 11.1((S_o/S_c) - 1)^2]$$

He -= specific energy head = $d + (v^2/64.32)$,
d = calculated depth of flow, ft.,
v = mean velocity, ft/sec,
d_c = critical depth, ft.,
S_c = critical slope, ft/ft,
S_o = channel bottom slope, ft/ft.

In all cases, the minimum freeboard for any lined ditch or canal shall be 3 inches (in.) of lining above the design water surface.

Minimum freeboard requirement is based on assumption that the finished channel bottom elevation will vary no more than 0.1 ft from design elevations. If a construction deviation greater than 0.1 ft is permitted, the minimum freeboard shall be increased.

Additional freeboard shall be provided if required by velocity, depth of flow, alignment, obstruction, curves, and other site conditions.

Superelevation. Curves shall be designed to limit superelevation to one foot above the calculated depth of flow or 10% of the water surface width, whichever is the least.

The minimum depth of lining around curves in trapezoidal channels shall be calculated as

d + S + freeboard

S, the maximum height of water surface above the normal depth of flow, shall be computed according to the following formula:

For subcritical velocity:

$$S = \frac{v^2(b + 2zd)}{2(gR - 2zv^2)}$$

S = maximum height of water surface above the normal depth of flow, ft.,

v = average velocity, ft/sec,
b = lining bottom width, ft.,
z = co-tangent of bank slope,
d = calculated normal flow depth, ft.,
g = 32.16,
R = radius of curve to centerline, ft.

Water surface elevations. All lined ditches and canals shall be designed so that 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 necessary head, backwater effect must be considered in computing freeboard requirements.

The required elevation of the water surface above the field surface varies with the type of takeout structure or device used and the amounts of water to be delivered. A minimum head of 4 in. shall be provided. Where head is greater than 6 in. with erosive soils, exit velocity from gates, turnouts or siphon tubes may require devices to reduce excess energy head.

Lining thickness. 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 thickness to be used. Minimum thickness for plain concrete linings in rectangular sections shall be 3½ in. For trapezoidal or parabolic sections, minimum thickness shall be in accordance with Table 2.

Table 2. — Minimum required thickness for plain concrete ditch and canal linings

Design velocity[1] (ft/s)	Minimum thickness by construction method and site condition (in.)	
	Type 1	Type 2
Less than 9.0	2.0	3.0
9.0–12.0	2.5	3.0
12.0–15.0	3.0	3.0

[1]Velocities in short chute sections shall not be considered design velocity.

Type 1 – Precision excavation with slip form concrete placement for soil condition in well drained, non-expansive, and not susceptible to frost heave (silts).

Type 2 – Non-precision excavation with hand place concrete for all soil conditions.

Ditch or canal side slopes. Plain concrete linings are generally used in ditches and canals that have either a trapezoidal or parabolic cross section.

They may be used in rectangular sections if the sidewall height is not greater than 1½ ft. Side slopes for usual construction methods shall not be steeper than shown below:

Hand-placed, formed concrete:
Height of lining less than 1½ ft …….Vertical

Hand-placed, screeded concrete:
Height of lining less than 2½ ft ....3/4H to 1V*
Height of lining more than 2½ ft …..1H to 1V

Slip form concrete:
Height of lining less than 3 ft .....1H to 1V
Height of lining more than 3 ft ….1¼H to 1V

*H – Horizontal, V – Vertical

Ditch or canal banks. Ditch and canal banks shall be constructed 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 ensure stability of fills and to prevent excessive deposition in cut sections.

When using siphon tubes, minimum berm or bank width of 12 in. shall be provided at the top of the lining on both sides of the finished ditch. All other canals and laterals shall have a minimum berm or bank width of 18 in. at top of lining.

If the bank or berm is to be used as a roadway, the minimum top width shall be adequate for the purpose. Minimum recommended roadway width for straight sections is 12 ft.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability. A minimum slope is 2H to 1V is recommended. Where vegetation will be maintained by mowing, the minimum slope shall be 3H to 1V.

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 applicable NRCS Conservation Practice Standard requirements for the type of structure used.

CONSIDERATIONS

Effects of downstream flows or aquifers that would affect other water usages or users.

Potential changes in growth and transpiration of vegetation located next to the conveyance because of elimination of leakage from the system.

Effects on the movement of dissolved substances into the groundwater.

Effects on the visual quality of water resources.

Consider the addition of fiber reinforcement to increase durability and reduce the potential for minor cracking.

PLANS AND SPECIFICATIONS

Plans and specifications for installing plain 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.

OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan shall be developed for plain concrete irrigation ditch and canal linings. The plan should document needed actions to ensure that practices perform adequately throughout their expected life.

O&M requirements shall be determined as part of the design. Any requirements should be documented as brief statements in the plans, the specifications, or the conservation plan narrative, or as a separate O&M plan. Typical O&M may include sediment/debris removal, patching of cracked concrete, and replacement of deteriorated linings.