

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

IRRIGATION SYSTEM, SUBIRRIGATION - INTERIM

(No. and Acre)
Code 754

PURPOSE

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

- To efficiently and uniformly apply irrigation water.
- To provide adequate soil moisture from a controlled water table for optimum plant growth.
- To control excessive water loss or erosion.
- To protect water quality.



DEFINITION

A planned irrigation system in which all necessary facilities are installed for applying irrigation water to the water table through the use of subsurface drains, open channels, pipelines, flooding, or microirrigation tubing. The water table supplies moisture to plants by capillary movement through the soil.

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

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to areas where the following conditions are present:

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. Benefits justify installation of the system.
5. The water supply must be sufficient in quantity and quality for the crops to be grown.
6. Soil depth and permeability will permit effective operation of the system.

Saline or sodic soil conditions can be maintained at an acceptable level for efficient production of crops.

The site has an adequate outlet or one can be provided for removal of excess rainfall from the system.

CRITERIA**Criteria Applicable To Subirrigation Methods**

Planned work shall comply with all Federal, state, and local laws, rules and regulations. Plans to utilize water resources may need to be permitted by the appropriate water management district in accordance with Chapter 40-2 and Chapter 40-4 Florida Administrative Code (F.A.C.).

Subirrigation systems shall be designed with the necessary drainage practices for the removal of excess surface and subsurface water so that the water table does not remain in the root zone long enough to cause crop damage. Main or lateral drainage ditches, field ditches, subsurface drains, and mole drains shall meet the requirements of NRCS conservation practice standard Surface Drainage, Main or Laterals, Code 608, Surface Drainage, Field Ditch, Code 607, Subsurface Drain, Code 606, and Mole Drain, Code 482, respectively.

An irrigation water management (IWM) plan shall be developed for each subirrigation system. IWM plans shall be prepared in accordance with

NRCS Florida conservation practice standard, Irrigation Water Management, Code 449.

Capacity. The capacity of the subirrigation system and its components shall be adequate to meet the peak consumptive use requirements of the crops to be grown plus seepage losses. The minimum total capacity shall be based on the system application efficiency. The design application efficiency, E, shall not exceed the values in Table 1. To allow flexibility in irrigation management, the recommended capacity of the system should be equal to or greater than twice the crop peak consumptive use rate.

Table 1 - Design Application Efficiencies, E, for Various Subirrigation Systems

Type of Subirrigation System	E (%)
Crown Flood (with tailwater recovery)	80
Fully Enclosed	85
Open Channels (Backup)	55
Semi-Enclosed (Flow-through)	65
Underground Conduits	85
Ebb and Flow	90
Capillary Mat	90

The system capacity may need to be increased for areas where:

1. it is desired to prevent significant fluctuation of the water table during the 3 or 4 hours of maximum water use (peak consumptive use) at midday,
2. more than normal seepage and peripheral losses occur,
3. where the water table is allowed to fluctuate and
4. where the irrigation stream is applied for short durations of time (pulsed).

When various subirrigation systems will be used on the same field, the system capacity must be adequate for the subirrigation method requiring the highest rate of water delivery. Likewise, if crops with different peak consumptive use requirements are to be grown, the system capacity shall be based on the crop having the highest peak consumptive use rate.

All subirrigation conveyance facilities and other structures shall be of sufficient size to permit the

delivery of required quantities of irrigation water without overtopping.

Water table elevation. Systems shall be designed to maintain the water table at or within predetermined water table elevations below the ground surface at all points in the design area such that the required irrigation water can be supplied to the root zone by capillary movement.

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 uniform, except for minor depressions.

Erosion control. The design of subirrigation systems must provide for conveying and distributing irrigation water without causing damaging soil erosion. All unlined ditches shall be located on non-erosive 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 pipe drops, chutes, or erosion resistant ditch linings. Where needed, ditches shall be protected from bank erosion by a vegetative cover.

Stormwater runoff. Irrigation system designs shall include facilities of adequate capacity for the safe removal of stormwater runoff from the field surface. Ditches constructed for this purpose must be on non-erosive gradients or be stabilized by lining or structural measures if erosion is a hazard. If field elevations do not permit the disposal of stormwater by gravity flow, the design shall provide for the installation of pumping plants and other needed appurtenant structures to remove excess rainfall within a time frame that will not cause crop damage. Structures shall be sized for the designed flow conditions, shall provide for a freeboard consistent with their size, and according to the NRCS conservation practice standard, Structure for Water Control, Code 587.

Where needed for erosion control, grade stabilization structures shall be used to convey runoff from the field surface into the outlet ditch. Grade stabilization structures shall meet the requirements of NRCS conservation practice standard, Grade Stabilization Structure, Code 410.

Water control. Subirrigation systems shall include structures such as division boxes, culverts, and flashboard risers, as appropriate, to

control and regulate the water for efficient application and management of irrigation water.

Seepage losses. Designs shall provide for minimizing seepage losses. Irrigation supply 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 reduce seepage losses.

Pump and power unit. The pump capacity and the power unit shall be adequate to provide the required capacity when being pumped against maximum total dynamic head. Pumps shall be in conformance with NRCS FL conservation practice standard Pumping Plant, Code 533.

Additional Criteria For Subirrigation System, Underground Conduits

Laterals (Underground Conduits).

Underground conduits shall meet the material requirements and installation requirements of NRCS conservation practice standard Subsurface Drain, Code 606.

The recommended maximum length of conduits shall be 1300 feet.

Capacity. The capacity of the conduit shall be equal to or greater than the required drainage coefficient or the required irrigation requirement, whichever is greater.

Spacing of mains and laterals. The spacing of main lines and laterals shall be as needed to adequately raise the water table from the lowest expected level to the planned level within 24 hours for the area served or the drainage spacing, whichever is controlling. The maximum spacing of laterals to achieve uniform distribution of irrigation water will be determined by one or more of the following:

1. DRAINMOD computer model analysis.
2. Using the average spacing recommendation from the Florida Drainage guide, specifically for water-table control systems.
3. Comparing the subject site to existing systems with similar soils and crops, where the adequacy of the existing system is known.
4. Small trial areas, where insufficient existing data are available for certain soils.

5. Ellipse equation.

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 shall be 4 inches.

Water table elevation. The water table elevation shall be controlled to allow no more than 0.5 foot variation in the water table elevation along the entire length of the underground conduit. Unless justified by individual field conditions, structures shall be located at not more than 0.5 foot vertical intervals in the water surface in the underground conduit systems. The required capacity for structural measures shall be provided with a maximum head loss of 0.5 foot or less depending on vertical intervals of structures and head available.

Filter and filter material. Because of the water movement into and out of the conduits in the laterals with fluctuating hydraulic heads, the potential for siltation may be greater than in regular drainage laterals. Suitable filters shall be used where needed to prevent siltation. Determining the need for a filter or selecting a filter is critical.

Properly graded sand and gravel filters, as defined in NRCS conservation practice standard Subsurface Drain, Code 606, can be used as filters around conduits. For fine-textured, poorly graded sands, a geotextile filter material 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 woven 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 NRCS conservation practice standard Subsurface Drain, Code 606, for envelope material requirements.

Additional Criteria For Subirrigation System, Open Channels

Mains and laterals. Main and lateral ditches shall meet the requirements of either NRCS conservation practice standard, Irrigation Canal or Lateral, Code 320 and Irrigation Field Ditch, Code 388 or Surface Drainage Main or Lateral, Code 608 and Surface Drainage Field Ditch, Code 607 whichever is controlling. Pipelines may be used to supply the irrigation water to the laterals in lieu of open channels. Pipelines used to deliver irrigation water to the laterals shall meet the requirements of NRCS conservation practice standard, Irrigation Water Conveyance, Pipeline, Code 430.

Spacing of mains, laterals, and field ditches. The spacing of main, laterals, and field ditches shall be as needed to:

1. adequately raise the water table from the lowest expected level to the planned level within a reasonable time in order to maintain adequate soil moisture in the root zone for the crop and area served, and
2. meet the drainage requirements for the crop and area served.

The maximum spacing of laterals and field ditches to achieve uniform distribution of irrigation water shall be determined by one or more of the following:

1. DRAINMOD computer program analysis.
2. Using the drainage spacing recommendation from the Florida Drainage Guide.
3. Comparing the subject site to existing systems with similar soils and crops, where the adequacy of the existing system is known.
4. Small trial areas, where insufficient existing data are available for certain soils.
5. Ellipse equation.

Field ditches. The capacity of field ditches shall be equal to or greater than the required drainage coefficient or the required irrigation requirement, whichever is greater. Field ditches shall be constructed on non-erosive grades. Changes in grade should be gradual without drastic changes

The minimum constructed depth shall be 1.25 feet. Greater depths are normally desirable to improve drainage on flat slopes.

The length of ditches supplying irrigation water should normally be 1300 feet or less when water is supplied from one end. Longer irrigation supply ditches may be used provided a uniform water table elevation can be maintained when irrigating and/or draining.

Water table elevation. The water table shall be managed between planned elevations by appropriately locating water control structures. Structures shall be located such that the natural ground elevation for the irrigated area controlled by the structure does not vary more than 1.0 foot. A variation of 0.5 foot in natural ground elevation is desirable. Unless justified by individual field conditions, the natural ground elevation shall not vary more than 0.5 foot along any irrigating field ditch.

The required capacity of structures shall be provided with a maximum head loss of 0.5 foot depending on vertical intervals of structures and head available.

Additional Criteria Subirrigation System, Fully Enclosed

Pipelines. The design of irrigation pipeline mains and manifolds shall ensure that the required quantities of water are conveyed to all lateral lines at the design pressure. Pipelines shall meet the requirements of NRCS conservation practice standard, Irrigation Water Conveyance, Pipeline, Code 430.

Laterals. Microirrigation (drip) tubing installed to convey irrigation water shall meet NRCS conservation practice standard, Irrigation System, Microirrigation, Code 441.

The maximum length of tubing shall be based on the friction loss so as to maintain uniform application of irrigation water.

Spacing of laterals (tubing). The spacing of laterals shall be as needed to uniformly supply irrigation water to the design area.

Size of tubing. Tubing must be sized to provide an emission uniformity (EU) of not less than 80 percent for irrigation units operated simultaneously.

Filters. A filtration system shall be provided at the system inlet. Under clean conditions, filters should be designed for a head loss of 5 psi or less. Manufacturer's recommendations and data should be used to design sand separators.

The filter element, strainer, or filtration media must be sized to prevent the passage of solids in sizes or quantities which would obstruct the emitter openings. Recommendations of the emitter manufacturer shall be used in selecting the filtration system. However, filtration systems shall be designed to remove solids equal to or larger than one-fourth the diameter of the emitter opening 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 must remain within the manufacturer's specification and shall not cause unacceptable emission uniformity.

Filter/strainer systems designed for continuous flushing should have backwash rates not exceeding 1.0% of the system flow rate. These systems must not exceed the manufacturer's specified operational head loss across the filter/strainer.

Chemical water treatment. Proper maintenance and water treatment must be followed in accordance with clogging prevention guidelines based upon emitter and water quality characteristics. ASAE EP405.1 contains guidelines for chemical water treatment.

System flushing. Fittings which can be readily operated shall be installed above ground at the ends of all mains and laterals to facilitate flushing. A minimum flow velocity of 2 ft/sec is recommended for adequate flushing.

Additional Criteria for Subirrigation System, Flow Through

Pipelines. The design of main and lateral irrigation pipelines shall ensure that the quantities of water required are conveyed to all irrigation field ditches at sufficient pressure and flow rate. Pipelines shall meet the requirements of NRCS conservation practice standard, Irrigation Water Conveyance, Pipeline, Code 430.

Field ditches. Field ditches shall meet the requirements of NRCS conservation practice standard Surface Drainage, Field Ditch, Code 607. The required capacity and velocity shall meet the most stringent requirement of either drainage or irrigation.

The average grade of field ditches in the direction of irrigation should not exceed 0.0055 ft/ft with the maximum grade not to exceed 0.01 ft/ft in any segment of channel. Changes in grade should be gradual without drastic changes. A minimum grade of 0.0005 ft/ft is desirable to ensure drainage. Cross slopes shall be limited to the channel grade unless the size of field ditches is such that "break throughs" from rainfall runoff are prevented. The maximum cross slope shall not exceed 1.00 foot per 100 feet.

The minimum constructed depth should be 0.5 foot or greater below normal ground. Greater depths are normally desirable to improve drainage on flat slopes. Depths may be increased through bedding the crop.

The length of the field ditch should normally not exceed 1300 feet when irrigation water is supplied from one end. Long irrigation field ditches increase the difficulty of maintaining a uniform water table elevation.

The maximum allowable non-erosive irrigation stream size shall be determined by the empirical formula,

$$Q = \frac{10}{S}$$

Where

Q = maximum allowable stream in gpm

S = slope of channel in feet per 100 feet.

The irrigation stream should be controlled to the extent practical to minimize irrigation tailwater loss unless the water will be collected and reused as irrigation water.

Water table elevation. The irrigation field ditches shall be located and constructed such that the water table depth below natural ground does not vary more than 0.5 foot for the entire length of the ditch.

Spacing of field ditches. The spacing of irrigation field ditches shall be as needed to adequately raise the water table from the lowest expected level to the planned level within 24 hours for the area served or the drainage spacing required for the crop, whichever is controlling.

The maximum spacing of irrigation field ditches to achieve uniform distribution of irrigation water shall be determined by one or more of the following:

1. DRAINMOD computer model analysis.
2. Using the drainage spacing recommendation from the Florida Drainage Guide
3. Comparing the subject site to existing systems with similar soils and crops, where the adequacy of the existing system is known.
4. Small trial areas, where insufficient existing data are available for certain soils.
5. Ellipse equation.

Additional Criteria For Subirrigation System, Crown Flood

Crown flood irrigation is applicable only to bedded citrus and to soils suitable for production of citrus. The soil profile should have sufficient soil depth of adequate permeability to allow construction of a bed which can be drained to the extent that at least a 30-inch drained zone, measured from the crown of the bed, can be established and maintained to allow for root system development.

Reuse of tailwater is essential for efficient water use. This can be accomplished with tailwater recovery irrigation systems or irrigation tailwater may be returned to a delivery system where it may be reused for successive irrigation cycles in the surrounding area. Tailwater recovery systems shall meet NRCS conservation practice standard Irrigation System, Tailwater Recovery, Code 447.

Capacity. The capacity of a crown flood irrigation system and its components should be adequate to raise the water level to near the base of the trees in a 24-hour period and shall not exceed 36 hours.

Irrigation water disposal facilities shall provide for the safe removal of excess irrigation water and should be designed to remove the water in 24 hours and shall not exceed 36 hours.

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 standards.

Bedding. Beds shall be constructed with an approximate level grade and crowned to provide for drainage from centerline of the bed into the

furrows. It is normally desirable to have a 30-inch minimum settled height of beds above the bottom of furrow and/or above a soil horizon which will perch a water table. The ground elevation at the base of trees should not vary more than 0.5 foot and shall not vary more than 0.75 foot within an area that will be flooded simultaneously. Spacing of beds shall be in conformance with NRCS conservation practice standard Bedding, Code 310.

Furrows shall provide positive drainage and the width between furrows shall not exceed 60 feet.

Location of delivery ditches or pipelines.

Ditches or pipelines used shall be located so that irrigation water can be applied uniformly over the entire field without causing erosion.

Additional Criteria For Subirrigation System, Ebb and Flow or Capillary Mat

Measures shall be taken to collect and recycle nutrient-laden irrigation water used in subirrigation systems to prevent discharge of contaminants to the environment. In fully enclosed greenhouse systems, water shall be 100 percent recycled. Containerized plants shall be placed in bins that are impermeable.

Chlorination or other water treatment methods shall be used where disease spreading problems are a known concern.

Precautions shall be taken to ensure that bin overflow water is routed back to the sump. Sumps shall be sized to hold the complete irrigation volume of the largest bin that the sump serves.

Additional Criteria To Protect Water Quality

To reduce phosphorus discharge, subirrigation systems installed in organic soils shall be operated to maintain the water table as high as possible for the crop being grown and with as minimal of fluctuation as possible.

Structures shall be designed to provide for storage of rainfall and reduce offsite discharge of drainage water.

CONSIDERATIONS

Irrigation land leveling or land smoothing is needed when the irrigated area contains significant depressions which will pond water or the ground elevation will not permit uniform irrigation water distribution. Irrigation land

leveling should meet NRCS conservation practice standard Irrigation Land Leveling, Code 464. Land smoothing should meet NRCS conservation practice standard Land Smoothing, Code 466.

Irrigation land leveling will improve surface drainage, improve the availability of nutrients, uniformity of crop production, and uniformity and efficiency of irrigation.

Plants may need to be grown on raised beds to provide the drained root zone necessary to prevent crop damage where surface and subsurface drainage is a problem.

Consideration should be given to eliminate irrigation runoff to no more than 10 percent of the amount applied. Tailwater recovery systems should be installed to collect and reuse irrigation water when management or structural practices will not prevent excessive irrigation runoff.

Fully enclosed subirrigation systems may eliminate irrigation runoff compared to other methods of subirrigation.

Depending on the water table management strategy, subirrigation systems may increase outflow rates during wet periods because water table elevations at the beginning of rainfall events will be elevated compared to conventional drainage. Runoff from rainfall can be reduced by managing the water table at the lowest depth that will allow for a sufficient rate of upflux to the crop. This depth will vary during the crop growing season.

Subsurface drainage systems tend to reduce peak flows from stormwater compared to surface drainage on similar soils.

Water table observation wells are recommended to monitor the ground water level.

Where fully enclosed subirrigation systems are used, burying the tube below the cultivation depth can provide for use on a continual basis and eliminates the seasonal requirements of installation, retrieval, and disposal. For the deep burial systems, proper maintenance and water treatment must be followed in accordance with clogging prevention guidelines based upon emitter and water quality characteristics.

Water table control to maintain relatively high field water table levels tends to increase the proportion of surface runoff in total outflow. This will normally result in higher concentrations of phosphorus and sediment in the outflow than otherwise occur with conventional drainage. The

higher water table levels tend to increase the potential for denitrification and should result in lower concentrations of nitrate-nitrogen compared to uncontrolled drainage.

Lateral seepage losses can be minimized with good planning and layout. Whenever possible, irrigation supply canals should be located near the center of irrigated fields rather than along the side. Perimeter ditches and outlet canals should also be controlled with structures.

Whenever possible, irrigated field should be laid out in square blocks and adjoining other irrigated fields. This minimizes the length of field boundaries along which seepage can occur.

Water quality is an important consideration when determining whether irrigating with drip emitters or underground conduits is feasible. Well and surface water often contain high concentrations of undesirable minerals (chemicals). Surface water can contain organic debris, algae, moss, bacteria, soil particles, etc. The irrigation water supply should be properly tested to determine its feasibility and treatment needed for use in supplying irrigation water. The ground water should be tested to determine the potential for clogging underground conduits.

Consideration should be given to monitoring recycled irrigation water for weed seed, harmful bacteria and disease. Measures may need to be taken to prevent spreading of these problems.

Ebb and Flow or Capillary Mat subirrigation systems should be considered for use in greenhouse situations. Use of these methods will incur higher initial construction cost and require management skills for disease prevention and other water quality concerns. However, these systems typically require less water and fertilizer compared to overhead irrigation methods since the water is recycled. A single sump may serve as the receptacle of water to be reused for several zones of irrigation.

Due consideration should be given to the economics of the overall irrigation system and water management strategy.

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. The plans shall be based on soils, topography, and crops to be grown and shall show the location, elevations, spacing, size, and grade of all conduits, irrigation supply lines,

ditches, water control structures, and outlet channels.

OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan shall be prepared for use by the owner or others responsible for operating the system. The O&M plan shall provide specific instructions for operating and maintaining the system to ensure that it functions properly for all planned purposes. The O&M plan shall reference the requirements of the IWM plan. The O&M plan shall provide guidance on:

- a system to monitor and observe the water table,
- water table elevations for subirrigation, and
- a record keeping system of observation well readings, irrigation water added, and observed crop response.

The O&M plan shall provide for periodic inspections and prompt repair or replacement of damaged components.

Subirrigation systems shall be operated without causing excessive water loss or degrading water quality.

REFERENCES

- ASAE EP405.1
Chapters 40-2 and 40-4 F.A.C.
DRAINMOD Computer Model, North Carolina State University
Florida Drainage Guide
NRCS Conservation Practice Standards
Bedding, Code 310
Grade Stabilization Structure, Code 410
Irrigation Canal or Lateral, Code 320
Irrigation Field Ditch, Code 388
Irrigation System, Tailwater Recovery, Code 447
Irrigation Land Leveling, Code 464
Irrigation System, Microirrigation, Code 441
Irrigation Water Conveyance, Pipeline, Code 430
Irrigation Water Management, Code 449
Land Smoothing, Code 466
Mole Drain, Code 482
Pumping Plant, Code 533
Structure for Water Control, Code 587.
Subsurface Drain, Code 606
Surface Drainage, Field Ditch, Code 607
Surface Drainage, Main or Lateral, Code 608

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