KS652.0980 State supplement - irrigation water management

(a) General information

This section contains additional technical information required for irrigation-water-management-related topics and additional guidance for irrigation scheduling and irrigation system evaluation procedures.

(b) Soil-plant-water balance

Section 562.0902(b)(1)(iv) provides direction for utilizing this tool to evaluate the soil-water content. Refer to Table KS9-5 for assistance with interpretation of the values shown on the tensiometer dial.

Section 562.0902(b)(1)(v) and Table KS9-3 provide interpretations of readings from a typical electrical resistance meter. Refer to Table KS9-5 for resistance ranges using an ohmmeter rather than the resistance meter provided by suppliers.

(c) Irrigation scheduling

There are numerous irrigation scheduling procedures. The checkbook method consists of maintaining a water balance (budget) where rainfall and irrigation water applied is a deposit (credit) to the checkbook, and evapotranspiration (ET) is a debit. The checkbook method has been performed manually by farmers in the past so a computer is not required to utilize this procedure for tracking crop water use.

Computer programs are available for tracking daily crop consumptive use. Personnel at the Kansas State University (KSU) Department of Biological and Agricultural Engineering have developed an irrigation scheduling program, KanSched. The program is an independently executable program that is available at www.oznet.ksu.edu/mil. The Common Computing Environment (CCE) version can be downloaded by an Office of the Chief Information Officer (OCIO) Information Technology Services (ITS) Technical Support Division (TSD) team specialist for use on Natural Resources Conservation Service (NRCS) computers.

The executable program has "Help" buttons that allow one to get critical dates (10 percent cover, 70 to 80 percent cover, maturation) computed for the field and soil moisture information which the program will enter directly into the input data sheet. The Budget sheet of the .exe program will let a person organize fields into a designated group. ET data can be entered into the Quick Budget Update option for all fields that are attached to a designated group. This program is very easy to use after receiving about two hours of initial training on the program.

Kansas State Research and Extension agents and Kansas NRCS staff are utilizing the KanSched program as a tool for assisting farmers with the checkbook method for irrigation scheduling. Should the producer choose to use other checkbook programs for maintaining a water budget, we will try to assist them with implementation of the desired program. Two such programs (which are CCE-certified) are Cropflex that was developed at Colorado State University and SPAW+ (Soil-Plant-Air-Water) that was developed at Washington State University. Some of the input data for these two programs may not be readily available, and special training could be required to learn how to properly utilize them.

KanSched program training is available from some Kansas State Research and Extension staff and the Kansas NRCS lead engineer handling irrigation activities.

(1) Considerations for checkbook programs for maintaining a water budget

(i) **Rainfall**--The effective rain is the rain that returns the soil water moisture back to 100 percent whereas the rain would be the total rainfall for the day and could be greater than the volume necessary to return the deficit to zero. The first 0.2 inch of any day's rainfall is considered not available to the crop use as a result of interception by the plant leaves and evaporation from the soil surface.

If the computer program does not adjust the effective rain by reducing the value entered by 0.2 inch, then the rainfall value to be entered for the day should be reduced by 0.2 inch.

(ii) **Soil water chart**--This graphically displays the water budget during the season.

- The upper (top) line is Field Capacity (maximum volume of water that the soil can hold once gravitational water passed through the soil within the designated root zone).
- The middle (dashed) line is the Management Allowed Depletion (MAD) that is the allowable depletion below field capacity where additional water uptake could create identifiable reduction in plant development and crop yield.
- The lower (bottom) line is the Permanent Wilting Point (PWP) whereby the plant is unable to survive any longer.

(iii) **Crop coefficient**--Crop coefficient values are listed in Tables KS9-1, KS9-2, KS9-3, and KS9-4 either for Grass Reference (ET_o) or Alfalfa Reference (ET_r). The ET_r value is 120 percent (1.20) greater than the ET_o value. The maximum crop coefficient (Kc) for the other crops should not exceed 1.00 of the ET_r value any time during the season. At some sites (such as the Garden City KSU Experiment Station), ET values are available for specific crops (such as corn), and the reference value would be 1.00 for all three entries.

(iv) **Weather stations**--The state hydrologist is maintaining daily ET values for the available weather stations on the KSU Web site.

(2) Detailed explanation of data input and budget spreadsheets

(i) Plant root depth in inches at start date for water budget - Use a minimum of 4 inches or 2 inches below ground for each inch of plant height above ground if starting after emergence date.

(ii) Total mature plant root zone depth in inches (ranges between 12 and 48 inches)

NOTE: Dates should be changed during the season to reflect actual conditions, and the values shown on the Budget spreadsheet will be adjusted accordingly.

(iii) Net Irrigation (this is the depth applied after adjusting for the gross irrigation value) - For a center pivot, this would typically be the first day for the circle.

(iv) Measured soil moisture availability can be entered to correct the calculated soil water availability shown for that day. For example, the calculated soil water availability may show 82.3 percent, but the measured soil moisture was about 75 percent. Likewise, if the measured soil moisture was about 88 percent, then the calculated moisture deficit would be reduced for that day.

Table KS9-1 KanSched Input Data for Winter Wheat

Crop			Grass Reference (ET_o)	Alfalfa Reference (ET_r)
Winter Wheat (fall - before dormancy)	Root depth at start date	18 inches		
	Managed root zone depth	18 inches		
	Date crop canopy cover exceeds 10% of field area	Approximately 15 days after emergence		
	Date crop canopy cover exceeds 70% of ground area	Approximately 30 days after emergence		
	Date of initial maturation	Approximately 45 days after emergence		
	End of growing season	12/01/year		
	Initial Kc		0.25	0.20
	Maximum Kc		0.50	0.40
	Final Kc		0.25	0.20
Winter Wheat (spring - after dormancy)	Root depth at start date	18 inches		
	Managed root zone depth	36 inches		
	Emergence date	Day breaking dormancy		
	Date crop canopy cover exceeds 10% of field area	15 days after breaking dormancy		
	Date crop canopy cover exceeds 70% of ground area	heading/flowering *(use 40 days later for first attempt)		
	Date of initial maturation	30 days after heading		
	End of growing season	14 days before harvest		
	Initial Kc		0.25	0.20
	Maximum Kc		1.20	1.00
	Final Kc		0.25	0.20

* Date given for initial input for KanSched - will need to adjust date based on actual day each season

Table KS9-2 KanSched Input Data for Alfalfa

Crop			Grass Reference (ET_o)	Alfalfa Reference (ET_r)
Alfalfa (breaking dormancy)	Root depth at start date	Up to 48 inches		
	Managed root zone depth	Up to 48 inches		
	Emergence date	Breaking dormancy		
	Date crop canopy cover exceeds 10% of field area	1st day after breaking dormancy		
	Date crop canopy cover exceeds 70% of ground area	10 inch height *(Use 15 days later for first attempt)		
	Date of initial maturation	Day before cutting		
	End of growing season	Day of cutting		
	Initial Kc		0.30	0.25
	Maximum Kc		1.20	1.00
	Final Kc		1.20	1.00
Alfalfa (following cutting)	Root depth at start date	Up to 48 inches		
	Managed root zone depth	Up to 48 inches		
	Emergence date	Cutting date		
	Date crop canopy cover exceeds 10% of field area	1st day after cutting		
	Date crop canopy cover exceeds 70% of ground area	10 inch height *(Use 15 days later for first attempt)		
	Date of initial maturation	Day before cutting		
	End of growing season	Day of cutting		
	Initial Kc		0.30	0.25
	Maximum Kc		1.20	1.00
	Final Kc		1.20	1.00

* Date given for initial input for KanSched - will need to adjust date based on actual day each season

Table KS9-3 KanSched Input Data for Cut Grass

Crop			Grass Reference (ET_o)	Alfalfa Reference (ET_r)
Grass (following dormancy)	Root depth at start date	Up to 36 inches		
	Managed root zone depth	Up to 36 inches		
	Emergence date	Day of green-up		
	Date crop canopy cover exceeds 10% of field area	Day after green-up		
	Date crop canopy cover exceeds 70% of root area	10 inch height *(Use 20 days later for first attempt)		
	Date of initial maturation	Day before cutting		
	End of growing season	Day of cutting		
	Initial Kc		0.50	0.40
	Maximum Kc		1.10	0.90
	Final Kc		1.10	0.90
Cut Grass (after first cutting)	Root depth at start date	Up to 36 inches		
	Managed root zone depth	Up to 36 inches		
	Emergence date	Day of cutting		
	Date crop canopy cover exceeds 10% of field area	Day after cutting		
	Date crop canopy cover exceeds 70% of root area	10 inch height		
	Date of Initial Maturation	Day before cutting		
	End of growing season	Day of next cutting		
	Initial Kc		0.50	0.40
	Maximum Kc		1.10	0.90
	Final Kc		1.10	0.90

* Date given for initial input for KanSched - will need to adjust date based on actual day each season

Table KS9-4 KanSched Input Data for Grazed Grass

Crop			Grass Reference (ET_o)	Alfalfa Reference (ET_r)
Grazed Grass (following dormancy)	Root depth at start date	Up to 36 inches		
	Managed root zone depth	Up to 36 inches		
	Emergence date	Day of green-up		
	Date crop canopy cover exceeds 10% of field area	Day after green-up		
	Date crop canopy cover exceeds 70% of root area	Day of 10 inch height if ungrazed *(Use 20 days later for first attempt)		
	Date of initial maturation	Day before end of grazing		
	End of growing season	Last day of grazing		
	Initial Kc		0.50	0.40
	Maximum Kc		0.90	0.75
	Final Kc		0.90	0.75
Grazed Grass (after first grazing)	Root depth at start date	Up to 36 inches		
	Managed root zone depth	Up to 36 inches		
	Emergence date	Day grazing stops		
	Date crop canopy cover exceeds 10% of field area	Day after grazing stops		
	Date crop canopy cover exceeds 70% of root area	Day of 10 inch height if ungrazed *(Use 20 days later for first attempt)		
	Date of initial maturation	11/30/year		
	End of growing season	12/01/year		
	Initial Kc		0.90	0.75
	Maximum Kc		0.90	0.75
	Final Kc		0.90	0.75

* Date given for initial input for KanSched - will need to adjust date based on actual day each season

(d) Irrigation system evaluation procedures

(1) Surface irrigation systems evaluations

The Surface Irrigation Model, SRFR, which was explained in Section KS652.0605(b), can be used to perform an irrigation system evaluation for any surface irrigation system. The information required for the system design for SRFR would be the actual data gathered from the system operation such as flow rate, time of concentration, etc. The efficiency obtained would be the actual efficiency, rather than a hypothetical or design potential.

(2) Center pivot system evaluation

Center Pivot Evaluation and Design (CPeD) is a Windows NT-CCE or Windows 3.1 or greater program for assessment of center pivot performance. The program simulates the water distribution under a center pivot from various commercial nozzles as well as performs an evaluation from catch can data. Using the option of catch can data entry, a system evaluation can be performed.

(3) Microirrigation system evaluation

Section 652.0904(g)(8) provides guidance for large microirrigation systems. For windbreaks and other systems consisting of just a few lines, the following is an acceptable method for field evaluation of microirrigation systems:

(i) Determine the lateral line from the plan sheet--Form KS-ENG-428(JS)--which represents the maximum operating condition when the system is being used. This is usually the most limiting factor as related to the proper functioning of the system. Ordinarily it will be the longest lateral with the most emitters and the least downhill elevation head when the system is operating.

(ii) On windbreaks, checking the lateral line representing the maximum condition will usually be sufficient for the average size system. On orchards and vineyards, a random sample of 10 percent of the lateral lines will be adequate. On all systems, a visual check should be made on an additional 10 percent of the other lateral lines. Visual checks should also be made of the major component parts of the system (pressure gauges, line valves, filters, etc.) to ensure there are no obvious problems that need attention.

(iii) Place catch cans or containers under 6 emitters along the lateral line selected for checking. They should be placed at random locations along the line. Generally, more satisfactory results are obtained if the first 1 or 2 and the last 2 or 3 emitters are not used. High or low elevations along the line should be included in the checking.

(iv) Time the flow into the catch cans or containers for a minimum of 15 minutes. A stopwatch with a second hand should be used for timing.

(v) Record the amount of water caught if the catch can or container is calibrated. If not, pour the water into a graduated cylinder or other measuring vessel. Use the following conversion factors (depending on the units the water is measured in) to convert the measured quantities to emitter flow rate in gallons per hour (gph).

Conversion Factors	
Measured Units	F Factor
Milliliters	0.01585
Fluid Ounces	0.469
Gallons	60
gph = Amount Measured / Time (minutes) x F	

(vi) The emitter discharge (in gph) should check within ±15 percent of the average flow of the 6 emitters. Either the highest or lowest flow rate may be thrown out if the total amount of the 6 emitters does not average out to within 15 percent.

See Figure KS9-1 for a sample of Form KS-ENG-395. From the sample:

Total for the 6 emitters is 6.21 gph

$$\text{Average gph} = \frac{6.21}{6} = 1.04 \text{ gph}$$

Upper Tolerance Limit = 1.04 x 1.15 = 1.19 gph
Lower Tolerance Limit = 1.04 x 0.85 = 0.88 gph

In this case, the emitter at Station 3+74 exceeds the maximum. By omitting this emitter, the average flow rate for the other 5 emitters would be 1.00 gph. The upper limit would be 1.15 gph, and the lower limit would be 0.85 gph. The 5 emitters would then meet the required tolerance.

(vii) In cases where the flow rates do not meet the tolerances, the following items should be checked:

- Double check at the hydrant or water source and make sure the system is operating at the design pressure. Remove one of the pressure gauges and use a different gauge to check the pressure.

  This should be done if there is any question as to the accuracy of the ones being used properly.

- Be sure line valves are set correctly and functioning.

- Take pressure checks at the 6 emitter locations to make sure there are no blockages in the lateral line. One method of measuring pressure is to remove the emitter and insert a pitot tube with pressure gauge or a special fitting can be fabricated for this purpose. (Determine the designed operating pressure at these locations by referring to the system plan.)

- Check the next most critical lateral line and see if it meets the design requirements. If it checks all right, then it can be assumed the remainder of the lateral lines are functioning properly.

- Emitters that are obviously defective should be replaced, and a new test should be run.

- In extreme cases, it may be necessary to run a supplemental lateral line and bypass the trouble spot in the line if it can be located.

- If there is any question as to emitter clogging, the clogging agent should be definitely identified before any corrective action is taken.

Figure KS9-1 Sample of Form KS-ENG-395, Trickle Irrigation System Evaluation

USDA
NRCS

KS-ENG-395
Rev. 5/03

Trickle Irrigation System Evaluation

Name: Example | Ident. No.:
Legal Desc.: NE 1/4 5-5-5 | County: Wichita
Evaluation by: S. C. Tech | Date: 5/6/03
Checked by: D. Cons | Date: 5/6/03

System Installation Date: 5/2/03 | Water Source: House well

Total System Q: 285 gph | Pressure at Source: 30 psi

Pipe Diameter:
Main 3/4 in. PE Type | Manifold 3/4 in. PE Type | Lateral(s) 1/2 in. PE Type

Emitter: Type Pressure comp. | Q 1.0 gph | Manufacturer and Model Global-STTF *

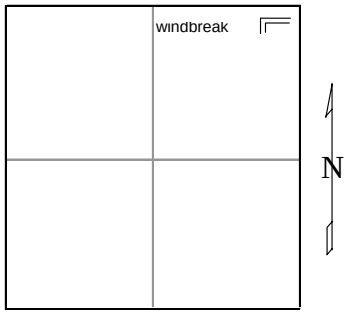
Maximum Condition: Lateral No. 1 | Pipe Dia. 1/2 in.

Station	Amount Measured	Units	Time (minutes) 1/	Factor F	Calculated (gph)
2+24	950	Milliliters	15	0.01585	1.00
2+72	970	Milliliters	15	0.01585	1.02
3+26	1000	Milliliters	15	0.01585	1.06
3+74	1150	Milliliters	15	0.01585	1.22
4+28	920	Milliliters	15	0.01585	0.97
4+82	890	Milliliters	15	0.01585	0.94
				Total	6.21
				Average gph	1.04

Upper Tolerance Limit = 1.19 gph

Lower Tolerance Limit = 0.88 gph

1/ Minimum of 15 minutes



Location Map Scale 1" = 1320'

Conversion Factors	
Measured Units	F Factor
Milliliters	0.01585
Fluid Ounces	0.469
Gallons	60
gph = Amount Measured / Time (minutes) x F	

Remarks: * Emitters manufactured by Global Irrigation Co., Whittier, CA

At Station 3+74, 1.22 gph is above the +15% tolerance listed. These and other emitters observed visually are successfully watering all the trees and shrubs. Replace emitters that appear to be underwatering or providing an excessive amount of water.

Table KS9-5 Interpretation of Tensiometer Readings

Dial Reading*		
Inches of Mercury	Centibars	Interpretation
Saturated 3	0 10	Near saturated soil often occurs for a day or two following irrigation. There is a danger of waterlogged soils, a high water table, poor soil aeration, or the tensiometer may have broken tension if readings persist.
Field Capacity 6 9	11 20 30	Field Capacity - Irrigations discontinued in this range to prevent waste by deep percolation and leaching of nutrients below the root zone. Sandy soils will be at field capacity for the lower range, with clayey soils at field capacity in the upper range.
Irrigation Range 12 15 18	 40 50 60	Usual range for starting irrigations - Soil aeration is assured in this range. In general, irrigations start at readings of 30 to 40 in sandy textured soils (loamy sands and sandy loams). Irrigations usually start from 40 to 50 on loamy soils (very fine sandy loams and silt loams). On clay soils (silty clay loams, silty clays, etc.), irrigations usually start from 50 to 60. Starting irrigations in this range ensures maintaining readily available soil water at all times.
Dry 21 24	 70 80	This is the stress range; however, the crop is not necessarily damaged or yield reduced. Some soil water is available to the plant, but it is getting dangerously low for maximum production. Top range of accuracy of tensiometer - Readings above this range are possible, but the tensiometer will break tension between 80 and 85 centibars.

* Indicative of soil conditions where the tensiometer is located.
Judgment should be used to correlate these readings to general crop conditions in the field.

Table KS9-6 Interpretation of Readings on Electrical Resistance Meters

	Electrical Resistance		
	Ohms	Meter Reading*	Interpretation
Nearly Saturated	Less than 200	200 to 800	Nearly staturated soil often occurs for a few hours following irrigation. There is a danger of water-logged soils, a high water table, or poor soil aeration if readings persist for several days.
Field Capacity	300 to 500	180 to 270	Field Capacity - Irrigations discontinued in this range to prevent waste by deep percolation and leaching of nutrients below the root zone.
Irrigation Range	3200 to 7000	120 to 80	Usual range for starting irrigations - Soil aeration is assured in this range. Starting irrigations in this range ensures maintaining readily available soil water at all times.
Dry	Above 7000	Less than 80	This is the stress range; however, the crop is not necessarily damaged or yield reduced. Some soil water is available to the plant, but it is getting dangerously low for maximum production.

* Indicative of soil conditions where the electrical resistance block is located.
Judgment should be used to correlate these readings to general crop conditions in the field.