Irrigation Training Toolbox
Water Management

Planning And Applying Conservation Practices

National Employee Development Center
Natural Resources Conservation Service
Fort Worth, Texas
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LESSON PLAN

COURSE:	Planning and Applying Conservation Practices
LESSON TITLE:	Irrigation Water Management
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OBJECTIVES:	At the end of this session the participants will be able to: (1) List the sources of information available for assistance in planning and designing irrigation systems. (2) Provide simple irrigation water management information to producers. (3) List the types of irrigation systems used in Kansas.
REFERENCE:	Field Office Technical Guide National Engineering Manual National Engineering Handbook National Handbook of Conservation Practices Kansas Irrigation Guide Engineering Field Manual
METHOD OF INSTRUCTION:	Directed Conference
EQUIPMENT NEEDED:	Slide Projector Projector Screen Overhead Projector Pencils Sample Problems Hand Held Calculator
TOTAL TIME REQUIRED FOR LESSON:	2 hours

LESSON PLAN

Time, Method, Aids, References, Etc.	Detailed Outline of Instruction
Slide 1	BLANK
Slide 2	IRRIGATION WATER MANAGEMENT Irrigation plays a major roll in the agricultural economy of western Kansas. It provides a stabilizing effect to offset the limited rainfall received in this area.
Slide 3	FLOWING IRRIGATION WATER But irrigation requires adequate water supplies,
Slide 4	IRRIGATION FROM RIVER such as rivers and streams,
Slide 5	POND ponds,
Slide 6	IRRIGATION PUMPING PLANT and groundwater.
Slide 7	AERIAL VIEW OF CENTER PIVOT Groundwater is used on 95% of the irrigated land in Kansas.
Slide 8	OGALLALA AQUIFER MAP The Ogallala formation is the primary source of groundwater for irrigation in western Kansas. This aquifer underlies a major part of the western Kansas.
Slide 9	DROP IN LEVEL OF AQUIFER Groundwater levels in Kansas are declining. The Ogallala formation has declined an average of 1.5 to 2 feet per year for the past 20 years.
Slide 10	IRRIGATION WATER NEEDS OF FIVE CROPS Irrigated agriculture will also decline if present water use is not reduced. Some crops, such as corn and alfalfa have much higher water requirements than grain sorghum, wheat, and soybeans.
Slide 11	FURROW IRRIGATED WHEAT The future of irrigated agriculture in Kansas will require more efficient use of irrigation water.
Slide 12	FURROW IRRIGATION Highly efficient water use can only be achieved by good irrigation water management. What is irrigation water management?

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Slide 13	IRRIGATION WATER MANAGEMENT * CONTROLLED RATE * PLANNED AMOUNT * PROPER TIMING Irrigation water management is determining and controlling the rate, amount, and timing of irrigation water application in a planned and efficient manner. How can this be achieved?
Slide 14	IRRIGATION WATER MANAGEMENT GOAL: APPLY WATER UNIFORMLY IN SUFFICIENT QUANTITIES TO MEET CROP WATER NEEDS WITHOUT GENERATING RUNOFF, EXCESSIVE EVAPORATION OR DEEP PERCOLATION.
Slide 15	IRRIGATION WATER MANAGEMENT ACCOMPLISHED BY: DESIGNING AND OPERATING AN IRRIGATION SYSTEM THAT FITS THE EXISTING RESOURCES AND PLANNED MANAGEMENT SCHEME.
Slide 16	COMPONENTS OF A FIELD WATER BALANCE. INFLOW: RAINFALL IRRIGATION WATER SUPPLY RETURN FLOW OUTFLOW: EVAPORATION CONVEYANCE LOSS DEEP PERCOLATION RUNOFF EVAPOTRANSPIRATION STORAGE: SOIL WATER HOLDING CAPACITY An irrigated field can be considered an artificial ecosystem to promote maximum yield potential. Water is input into the water balance part of the ecosystem from rainfall, the irrigation water source and possibly through irrigation return flow. Water leaves the system through evaporation, conveyance losses, deep percolation, runoff and evapotranspiration. Evapotranspiration is the only desirable loss to the ecosystem.

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Slide 17	TESTING WATER QUALITY One of the first requirements for a successful irrigation system is that the water must be of suitable quality.
Slide 18	SALINE SOIL Poor quality water can have serious effects on soils and plant growth alike.
Slide 19	IRRIGATION WELL Groundwater used for irrigation is raised to the surface,
Slide 20	PUMPING PLANT using a pumping plant, consisting of a pump, gearhead, and power unit.
Slide 21	IMPELLERS The pump must be matched to the operating conditions of the well for maximum efficiency. It should deliver the desired volume of water at the required pressure with the highest possible efficiency. Pumps should be adjusted as needed to maintain optimum efficiency. Periodically it may be necessary to pull the pump and check the bowls and impellers for wear and needed repair.
Slide 22	LOW PRESSURE SPRAY NOZZLES Operating pressure decreased when converting from a high pressure to low pressure sprinkler. This may reduce the efficiency of the pump.
Slide 23	POWER UNIT Power units should be kept properly tuned for efficient energy use. Sometimes a simple adjustment of engine speed, carburation, or timing will increase the engine efficiency.
Slide 24	MONEY The end result of an efficient pumping plant is money in the irrigation farmer's pocket.
Slide 25	SIPHON TUBES Early irrigation systems used open earthen ditches with siphon tubes to irrigate the crops. Some irrigators still use this method. Valuable water is lost through seepage and evaporation with this type delivery system.

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Slide 26	ALFALFA VALVE AND GATED PIPE Water loss in irrigation systems can be reduced by using buried pipelines in combination with surface gated pipe.
Slide 27	LEAKING JOINT Leaking joints and gates should be repaired.
Slide 28	WET SPOT IN FIELD Underground pipelines can also be a source of water loss in older systems. This water loss is usually indicated by a wet spot along the pipeline.
Slide 29	CENTER PIVOT Distribution systems should be able to deliver adequate amounts of water to all parts of the field. This is true for a sprinkler system,
Slide 30	BORDER IRRIGATION a border system,
Slide 31	FURROW IRRIGATION a furrow system,
Slide 32	DRIP IRRIGATION or a drip system.
Slide 33	LAND LEVELING Land leveling to a uniform slope is necessary for uniform distribution of irrigation water.
Slide 34	TAILWATER RECOVERY PIT Recovery systems can greatly improve gravity irrigation system efficiency. They provide for reuse of excess tailwater.
Slide 35	IRRIGATION RUNOFF Poor water distribution and runoff in sprinkler systems can result from wear in the nozzles, or improper nozzle size. Nozzles should be inspected annually for wear.
Slide 36	TAILWATER It takes more that an efficient pumping plant and distribution system to achieve good irrigation water management.

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Slide 37	FLOW METER An accurate flow measurement of the well or water source is necessary to operate an irrigation system efficiently. It enables the irrigator to determine the proper amount of water to apply to the crop and the total number of acres that can be irrigated.
Slide 38	IRRIGATED SUGAR BEETS The irrigator must also know about crops and soils, so that he can apply the correct amount of water at the proper time.
Slide 39	WATER NEED PER IRRIGATION DEPENDS ON * SOIL WATER HOLDING CAPACITY * ROOT DEPTH * CROP WATER NEEDS The amount of water required per irrigation depends on the water holding capacity of the soil, depth of the root zone, and amount of water required by the crop.
Slide 40	SOILS The soil serves as a storehouse for plant nutrients, habitat for bacteria, an anchorage for plants, and a water reservoir for plant use.
Slide 41	WATER HOLDING CAPACITY VS. TEXTURE Soil texture determines the soil's ability to hold water for plant use.
Slide 42	WATER HOLDING CAPACITY VS. STRUCTURE Soil structure influences the rate that water enters and moves through the soil.
Slide 43	HANDFUL OF SOIL Both texture and structure influence soil tilth and fertility. Irrigation water use efficiency will increase on fertile soils.
Slide 44	SOIL INTAKE RATE Knowing your soil characteristics is one of the major factors in determining how fast, how much, and how often irrigation water needs to be applied to the crop.
Slide 45	GATED PIPE Soil characteristics greatly influence the method chosen to apply the water.

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Slide 46	FURROW IRRIGATED WHEAT The application method must match the soil conditions to obtain efficient water use.
Slide 47	SOIL SURVEY INFORMATION Information can be compiled from the published soil survey and the Kansas Irrigation Guide to determine the intake family and the soil water holding capacity for the field.
Slide 48	AVERAGE WATER EXTRACTION PATTERN DIAGRAM Assuming that all crop growth requirements are satisfied including nutrients, sunlight and water, most crops will take 40% of their soil water from the upper 1/4 of the root zone. 30% will be received from the next 1/4 of the root zone. 20% from the next 1/4 and 10% from the lower 1/4 of the plants root zone.
Slide 49	AVAILABLE WATER HOLDING CAPACITY Irrigation on most crops should begin when the available water in the root zone has been depleted to appropriately 50% of field capacity.
Slide 50	METHODS OF MEASURING SOIL MOISTURE Producers can use several methods to determine the available water in the root zone.
Slide 51	SOIL PROBE A steel rod with a ball bearing welded on the end can be pushed into silty soils until it encounters dry soil.
Slide 52	AUGER Soil can be removed with an auger and the soil moisture can be checked by feel and appearance. Although measuring soil water by appearance and feel is not precise, with experience and judgement the irrigator should be able to estimate the level with a reasonable degree of accuracy.
Slide 53	TENSIOMETERS A tensiometer is a sealed, water filled tube with a vacuum gauge on the upper end and a porous ceramic tip on the lower end. As the soil around the tensiometer dries out, water is drawn from the tube through the ceramic tip creating a vacuum which can be read on the vacuum gauge.

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Slide 54	GYPSUM BLOCKS Electrical resistance blocks or gypsum blocks are made with gypsum around a pair of stainless steel wire grids. The flow of electricity between the wire grids varies with the water content and a reading on the resistance meter will give a measure of the soil water content.
Slide 55	SCS POLICY FOR IRRIGATION TECHNICAL ASSISTANCE: NATIONAL ENGINEERING MANUAL, PART 523 KANSAS IRRIGATION GUIDE, PART 1. GENERAL MANUAL 180-CPA, PART 409 Information about policy is found in the National Engineering Manual. Technical information for the state is presented in the Kansas Irrigation Guide. Policy regarding planning procedures is found in the General Manual.
Slide 56	KANSAS WATER LAW KANSAS IS A COMMON LAW STATE, WHICH MEANS: THE FIRST OR EARLIER USER OF WATER FOR A BENEFICIAL PURPOSE HAS THE BEST RIGHT. ALL WATER RIGHTS ARE SPECIFIC AS TO TIME, PLACE, AND AMOUNT.
Slide 57	SPRINKLER SYSTEM DESIGN & MANAGEMENT Center pivot sprinkler systems have become the dominant system in western Kansas. While 1/2 of the system are still surface irrigation systems, most technical assistance requests in the field office are now related to center pivot sprinklers.
Slide 58	SPRINKLER SYSTEM DESIGN & MANAGEMENT SYSTEM FLOW RATE * ENVIRONMENTAL FACTORS * ESTIMATED DOWN TIME * SOIL WATER HOLDING CAPACITY * AREA IRRIGATED The first consideration for sprinkler design should be the system flow rate. The system flow rate is often chosen for the producer by the environment and the water right. The area irrigated is then maximized based on the system flow rate. Corn in Colby, Kansas requires 4.0 gpm/acre to produce maximum yields based on 80% chance rainfall.

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Slide 59	SPRINKLER SYSTEM DESIGN & MANAGEMENT NOZZLE APPLICATION RATE DESIGN * SYSTEM LENGTH * SYSTEM FLOW RATE * WETTED RADIUS PRODUCED NOZZLE HEIGHT NOZZLE TYPE The nozzle application rate can be adjusted by changing the system length, system flow rate or the wetted radius produced by the sprinkler nozzle.
Slide 60	POTENTIAL RUNOFF FOR MOVING SPRINKLER The nozzle application rate can be compared with the soils infiltration rate by plotting them with respect to time. When water is applied to soil, the infiltration rate decreases rapidly and then becomes rather constant. The application rate curve is parabolic. The application rate begins at zero and peaks when the nozzle is directly above the location being measured. It then returns to zero as the nozzle moves away. The area under the application rate curve represents the volume of water applied. The area below the infiltration rate curve represents the volume of water infiltrated into the soil. The difference between these two areas represents the volume of water that must be temporarily stored on the soil surface or results in runoff.
Slide 61	SPRINKLER SYSTEM DESIGN & MANAGEMENT SURFACE STORAGE * SURFACE PITTING * INCREASED SURFACE RESIDUE * CONTOUR FARMING To prevent runoff from a sprinkler system with high application rates, we must provide temporary surface storage. This can be done by creating small storage reservoirs with dammer dikers, increased surface residue and contour farming.
Slide 62	DAMMER DIKER A dammer diker is a machine with rotating paddles that drags soil within the furrow for a short distance.
Slide 63	SURFACE PITS A trip mechanism releases the paddle and leaves a small depression up slope from a small furrow dike.

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Slide 64	SPRINKLER SYSTEM DESIGN & MANAGEMENT INFILTRATION * DEEP RIPPING * IMPROVED SOIL TILTH * SMALLER DROPLET SIZE The soils infiltration characteristics can be modified slightly by deep ripping, improved soil tilth and eliminating large water droplets which tend to seal the soil surface.
Slide 65	SPRINKLER SYSTEM DESIGN & MANAGEMENT CAUTION! SELECTING A SPRINKLER PACKAGE WITH A PEAK WATER APPLICATION RATE MUCH HIGHER THAN THE SOIL'S INFILTRATION RATE CAN CAUSE EXCESSIVE RUNOFF.
Slide 66	RUNOFF FROM A SPRINKLER SYSTEM It is important to remember the if water is applied at a rate faster than the soils infiltration rate, it must be temporarily stored on the soil surface or lost to runoff.
Slide 67	SPRINKLER SYSTEM DESIGN AND MANAGEMENT Center Pivot Pressure Ranges **High Pressure Impact** **50-70 psi**
Slide 68	HIGH PRESSURE IMPACT SPRINKLER
Slide 69	SPRINKLER SYSTEM DESIGN AND MANAGEMENT Center Pivot Pressure Ranges High Pressure Impact 50-70 psi **Medium Pressure Impact** **40-55 psi**
Slide 70	MEDIUM PRESSURE IMPACT SPRINKLER

Time, Method, Aids, References, Etc.	Detailed Outline of Instruction
Slide 71	SPRINKLER SYSTEM DESIGN AND MANAGEMENT Center Pivot Pressure Ranges High Pressure Impact 50-70 psi Medium Pressure Impact 40-55 psi **Low Pressure Impact** **30-45 psi**
Slide 72	LOW PRESSURE IMPACT SPRINKLER
Slide 73	SPRINKLER SYSTEM DESIGN AND MANAGEMENT Center Pivot Pressure Ranges High Pressure Impact 50-70 psi Medium Pressure Impact 40-55 psi Low Pressure Impact 30-45 psi **Ultra-low Pressure Spray** **10-30 psi**
Slide 74	ULTRA-LOW PRESSURE SPRAY NOZZLE
Slide 75	SPRINKLER SYSTEM DESIGN & MANAGEMENT OPERATING PRESSURE: * PUMP CURVE * FRICTION LOSS * TOPOGRAPHY * PRESSURE REGULATORS Energy is required to produce pressure. Irrigators are learning that they can save significant energy costs if they reduce the system pressure. The pump curve, friction loss and topography should be carefully considered when the pressure is reduced. Pressure regulators may be required at each nozzle to provide the desired nozzle performance.

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Slide 76	SPRINKLER SYSTEM DESIGN & MANAGEMENT RULE OF THUMB FOR OPERATING PRESSURE THE PRESSURE OF THE SYSTEM, IN PSI, AT THE LOWEST POINT IN THE FIELD, SHOULD BE AT LEAST TWO TIMES THE GREATEST ELEVATION DIFFERENCE IN FEET.
Slide 77	CHANGE IN ELEVATION ALONG SPRINKLER SYSTEM
Slide 78	BLANK
Handout	Center pivot sprinkler design problem
Transparency 1	Center pivot sprinkler design problem
Transparency 2	Completed center pivot sprinkler design problem
Slide 79	SPRINKLER SYSTEM DESIGN & MANAGEMENT CROPS * MAXIMUM YIELD * ALTERNATIVE CROPS * IMPROVED YIELD & MAXIMUM PROFIT
Slide 80	YIELD VS. WATER APPLIED The yield for most crops increases linearly as additional water is applied. As maximum yields are approached, it takes a larger amount of water to produce greater yields. Maximum yields may not produce maximum profit.
Handout	Crop water needs problem
Transparency 3	Crop water needs problem
Transparency 4	Completed crop water needs problem
Transparency 5	OBJECTIVES: AT THE END OF THIS SESSION THE PARTICIPANTS WILL BE ABLE TO: (1) LIST THE SOURCES OF INFORMATION AVAILABLE FOR ASSISTANCE IN PLANNING AND DESIGNING IRRIGATION SYSTEMS. (2) PROVIDE SIMPLE IRRIGATION WATER MANAGEMENT INFORMATION TO PRODUCERS. (3) LIST THE TYPES OF IRRIGATION SYSTEMS USED IN KANSAS.