
Chapter 15

Resource Planning and Evaluation Tools and Worksheets

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652.1500 General

Chapter 15 lists and describes resource planning and evaluation tools and worksheets commonly used by the Natural Resources Conservation Service (NRCS). These tools and worksheets can assist the irrigation planner in:

- Addressing irrigation related environmental concerns relating to soil, water, air, plants, and animals.
- Providing technical assistance to the farmer and irrigation decisionmaker in irrigation system—planning, design, cost analysis, evaluation, and management.
- Providing technical assistance for evaluating and planning river basin, watershed, and project activities.

652.1501 Water quality, water management, and irrigation evaluation tools

Computer software programs and models include:

NRCS (SCS) Scheduler—NRCS Scheduler is a computer assisted method to predict up to 10 days ahead when irrigation will be needed. Predictions are based on daily climatic data from a weather station and calculated plant water use. Periodic calibration to actual soil moisture is used to maintain accuracy. Developed by Michigan State University with support from NRCS.

FIRI—Farm Irrigation Rating Index is used to evaluate effects of existing irrigation systems and management, and to evaluate changes. Changes can be improvements or reversals in management techniques and system condition. Developed by NRCS West National Technical Center.

SIDESIGN—Subsurface Irrigation Design program involves an analysis of providing water table control for irrigation through buried conduits. Developed by Michigan State University with support from NRCS.

NLEAP—Nitrate Leaching and Economic Analysis Package. The model provides site specific estimates of nitrate leaching potential under agricultural crops and impacts on associated aquifers. Irrigations are included as precipitation events. This model is generally used as a planning tool. Developed by the Agricultural Research Service (ARS), Water Management Research Laboratory, Fort Collins, Colorado.

CREAMS—A field scale model for Chemical, Runoff, and Erosion from Agricultural Management Systems. This mathematical model evaluates nonpoint source pollution from field-size areas. Developed by ARS laboratories in Chickasha, OK, West Lafayette, IN, and Athens, Georgia.

GLEAMS—Groundwater Loading Effects of Agricultural Management Systems. GLEAMS uses CREAMS technology to evaluate surface chemical response, hydrology, and erosion. It provides a water budget of precipitation, crop evapotranspiration, runoff, deep percolation, soil moisture, and irrigation applications. Crop evapotranspiration is checked and adjusted for localized conditions. Developed by University of Georgia in cooperation with ARS, Southeast Watershed Laboratory, Tifton, Georgia.

WEPP—Water Erosion Prediction Program is proposed to provide an analysis of precipitation and irrigation related erosion and sediment deposition. When complete, WEPP will include furrow and border surface irrigation and periodic move, fixed, and continuous move sprinkle irrigation systems. The FUSED, RUSLE, and SPER programs are available for field use until WEPP is validated and available. Being developed by ARS, National Erosion Laboratory, (Purdue University), West Lafayette, Indiana; and (University of Nebraska), Lincoln, Nebraska.

SWRRB—This basin scale water quality model process considers surface runoff, return flow percolation, evapotranspiration, transmission losses, pond storage, sedimentation, and crop growth. Crop evapotranspiration must be checked and may need to be localized. Developed by ARS, Temple, Texas.

EPIC—Process considers climate factors, hydrology, soil temperature, erosion, sedimentation, nutrient cycling, tillage, management, crop growth, pesticide and nutrient movement with water and sediment, and field scale costs and returns. Crop evapotranspiration is checked and adjusted for local conditions. Developed by ARS, Temple, Texas.

DRAINMOD—An evaluation tool for analysis of water table control for subsurface drainage systems. Included is an estimated value for upward water movement (upflux) based upon specific soil series. Developed by North Carolina State University with support from NRCS.

Instream Water Temperature Model—The model provides a process to predict instream water temperature based on either historical or synthetic hydrological, meteorological parameters, streamside vegetation, and stream channel geometry.

652.1502 Irrigation system selection, design, costs, and evaluation tools

Many programs are available from commercial sources and Universities. Most need to be purchased, but some are available as *cooperative agency programs*. A few require site licenses to use multiple program copies at several locations at one time. Several irrigation programs are available from ARS, universities, and the U.S. Bureau of Reclamation. Some of the more common programs available include:

- REF-ET—Reference crop Evapotranspiration model, from Utah State University.
- SIRMOD—Surface Irrigation Model includes surge and conventional analysis for furrow irrigation, from Utah State University.
- CPNOZZLE—Center Pivot Nozzling and surface storage program, from University of Nebraska.
- SPACE—Sprinkler Profile And Coverage Evaluation program evaluates all sprinkler heads manufactured and currently available, from California Agricultural Technology Institute, California State University.
- SRFR—Surface irrigation simulation program uses zero inertia and kinematic wave relationships to model surface irrigation, from ARS, Phoenix, Arizona.
- AGWATER—Surface irrigation system (furrow, border) model using measured advance time and field specific information for management improvements (inflow, time of set, length of run), from California Polytechnic State University.
- PUMP—Centrifugal pump selection program, from Cornell Pump Company, Portland, Oregon.
- CATCH3D—Sprinkler pattern overlap evaluation and 3D plot program, from Utah State University.
- Water Management Utilities, Interactive Simulation of One-Dimensional Water Movement in Soils, IRRIGATE—An irrigation decision aid, potential evapotranspiration, citrus irrigation scheduling.
- CMLS—Chemical Movement in Layered Soils, from University of Florida.
- Flowmaster—Open channel flow and pressure pipeline design program, from Haestad Methods, Inc., Waterbury, Connecticut.
- KYPIPE2—Pipe network flow analysis program, from Haestad Methods, Inc., Waterbury, Connecticut.

652.1503 Irrigation system planning, design, and evaluation worksheets

Example evaluations and blank worksheets are included at the back of this chapter. They may be copied and used as needed. They include:

Irrigation Planning

- Irrigation Planning
- Irrigation System Inventory

Irrigation System Design

- Sprinkler Irrigation System Planning/Design

Irrigation System Evaluation

- Walk Through Sprinkler Irrigation System Analysis

- Sprinkler Irrigation Systems Evaluation

 - Periodic Move Sprinkler—Side Wheel-roll, Lateral Tow, Hand Move and Fixed (Solid) Set Systems
 - Continuous/Self Move Sprinkler—Pivot System

- Pumping Plant Evaluation

 - Electric Motor Powered
 - Natural Gas Engine Powered

- Micro Irrigation Systems Evaluation

- Surface Irrigation Systems Evaluation

 - Graded Borders
 - Basins, Level Border
 - Graded Furrows
 - Level furrows

Irrigation Water Management

- Irrigation Water Management Plan
- Soil Moisture—Feel and Appearance Method, Speedy Moisture Meter and Eley Volumeter
- Crop and Soil Data for Irrigation Water Management
- Checkbook Method of Irrigation Scheduling
- Pan Evaporation Method of Irrigation Scheduling

652.1504 Blank worksheets

Irrigation Planning Worksheet

OWNER/OPERATOR _____ FIELD OFFICE _____
 JOB DESCRIPTION _____
 LOCATION _____
 ASSISTED BY _____ DATE _____

Soil—Data for limiting soil

Soil series	Percent of area (%)	Cumulative AWC					Depth to restrictive layer ¹	Intake fam., grp. max. rate
		1 ft (in)	2 ft (in)	3 ft (in)	4 ft (in)	5 ft (in)		

¹ Actual observed depth in the field

Maximum time between irrigations for any method/system based on peak crop ET

Crop	Management root zone (ft)	Total AWC (in)	MAD percent (in)	Maximum net replacement		Peak daily crop ET (in/d)	Maximum irrigation frequency (days)
				(in/d)	(days)		

Minimum system flow requirement for irrigation system

System description	Depth of irrigation application			Peak daily crop ET (in/d)	Max. irrig. frequency (days)	Minimum system flow requirement total flow	
	Net (F _N) (in)	Efficiency (%)	Gross (F _G) (in)			(gpm)	(ft ³ /s)

Minimum dependable flow available to system _____ gpm, ft³/s, inches, etc.

Total irrigated area _____ acres. Total operating hours per day _____ .

Irrigation System Inventory Worksheet

OWNER/OPERATOR _____ FIELD OFFICE _____

JOB DESCRIPTION _____

LOCATION _____

ASSISTED BY _____ DATE _____

(Collect and fill out only portions of this form that apply and are needed)

Area irrigated _____ acres

Crops

Crops now grown			
Typical planting date			
Typical harvest date			
Typical yield (unit)	()	()	()
Age of planting			
Cultivation and other cultural practices			

Water

Water source(s)				
irrigation organization				
Water available (ft ³ /sec, gpm, miners inches, mg/da)				
Seasonal total water available (ac-ft, million gal)				
Water availability	continuous	demand	rotation	fixed schedule
Typical water availability times (schedule and ordering procedure)				
Method of determining when and how much to irrigate:				
Is flow measuring device maintained and used?				
Method of measuring water flow rate				
Water quality: Sediment			Debris, moss	
Electrical conductivity		mmhos/cm	SAR	
Comments				

Example Irrigation System Inventory Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Soils (principal soil in field)

Soil # 1

Map symbol		Soil series & surface texture		
Percentage of field (%)		Area (acres)		
Depth	Texture	AWC (in/in)	AWC (in)	Cum AWC (in)
Depth to water table or restrictive layer ¹				
Intake family/intake group/max application rate				
Comments				

Soil # 2

Map symbol		Soil series & surface texture		
Percentage of field (%)		Area (acres)		
Depth	Texture	AWC (in/in)	AWC (in)	Cum AWC (in)
Depth to water table or restrictive layer ¹				
Intake family/intake group/max application rate				
Comments				

Soil # 3

Map symbol		Soil series & surface texture		
Percentage of field (%)		Area (acres)		
Depth	Texture	AWC (in/in)	AWC (in)	Cum AWC (in)
Depth to water table or restrictive layer ¹				
Intake family/intake group/max application rate				
Comments				

¹ If restrictive for root development or water movement

Irrigation System Inventory Worksheet—*Continued*

NAME _____ DATE _____ PREPARED BY _____

Water supply and distribution system

Supply system to field (earth ditch, lined ditch, plastic pipeline, etc.):

Type
Size
Capacity (ft ³ /sec, gpm, miners inches, mgal/day)
Pressure/Elevation at head of field or turnout (lb/in ²) (ft)
System condition
Estimated conveyance efficiency of supply system (%)

In-field distribution system (earth or lined ditch, buried pipe, surface portable pipe, lay flat tubing):

Type
Size
Capacity
Total available static head (gravity) (ft)
System condition
Estimated efficiency of delivery system (%)
Comments

Water application system

Existing sprinkler system (attach design and/or system evaluation. if available):

Type system (center pivot, sidewheel-roll, hand move, traveler, big gun)
Manufacturer name and model
Tower spacing (pivot or linear) (ft) End gun (pivot)?
Wheel size (sidewheel-roll) diameter
Type of drive
Pressure at lateral entrance (first head) (lb/in ²)
Mainline diameter/length
Lateral diameter/length
Lateral spacing (S ₁) Sprinkler head spacing (S _m)
Sprinkler make/model
Nozzle size(s) by type
Design nozzle pressure (lb/in ²) Wetted diameter (ft)
(Attach sprinkler head data for pivot)
Maximum elevation difference: Along lateral
Between sets
Application efficiency low 1/4 (E _Q) (%) (Estimated or attach evaluation)
Wind - Prevailing direction and velocity
Comments

Irrigation System Inventory Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Existing surface system (attach system evaluation if available)

Type of system (graded border, level border, graded furrow, level furrow, contour levee, contour ditch, wild flooding)			
Leveled fields:	Field slope:	In direction of irrigation	ft/ft
Cross slope		ft/ft	
Smoothness:	<input type="checkbox"/> Rough	<input type="checkbox"/> Smooth	<input type="checkbox"/> Very smooth
			Laser equipment used <input type="checkbox"/> yes <input type="checkbox"/> no
Border or levee width		Furrow/corrugation/rill spacing	
ft		in	
Length of run:	Minimum	ft	Maximum
		ft	Average
ft			
Number of furrows or borders per set			
Border or levee dike heights			
Application efficiency, low 1/4 (E _q)		% (Estimated or attach evaluation)	
General maintenance of system			

Drainage, tail water reuse facility

Method for collection and disposal of field runoff (tailwater, precipitation)
Final destination of runoff water
Surface/subsurface drainage system
Environmental impacts of existing drainage system

Existing micro irrigation system (Attach design or system evaluation if available)

Type of system:	Drip emitters	Mini spray/sprinklers	Line source
Spacing between discharge devices along distribution laterals		(ft, in)	
Laterals - diameter, length			
Main lines and submains - diameter, length, etc.			
Spacing between distribution laterals		(ft, in)	
Average application device discharge pressure (lbs/in ²)			
Are pressure compensating devices required?		<input type="checkbox"/> yes	<input type="checkbox"/> no
Are pressure compensating devices used?		<input type="checkbox"/> yes	<input type="checkbox"/> no
Average application device discharge (gph, gpm)			
Area irrigated by one irrigation set		(acres)	
Typical irrigation set time		(hr, min)	
Maximum elevation difference with one irrigation set		(ft)	
Type and number of filters used			
Irrigation is initiated by: <input type="checkbox"/> manual control <input type="checkbox"/> programmed timer <input type="checkbox"/> clock timer <input type="checkbox"/> soil moisture sensing device			
Comments:			

Irrigation System Inventory Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Existing subsurface irrigation system

Water table control type and number of system or segments	
Water table control devices	<input type="checkbox"/> flashboard <input type="checkbox"/> float
Buried laterals	<input type="checkbox"/> diameter <input type="checkbox"/> spacing <input type="checkbox"/> depths
Water table elevation(s): Existing	Planned

Month	Elevation	Depth below surface

**Pumping plant
 Pump**

(Attach pump characteristic curves and/or pump system analysis if available)			
Pump elevation above mean sea level (approx) (ft)			
Pump type: <input type="checkbox"/> centrifugal <input type="checkbox"/> turbine <input type="checkbox"/> submersible <input type="checkbox"/> Propeller <input type="checkbox"/> axial flow			
Make		Model	
Electric motor RPM		Engine operating RPM	
Pump design discharge		gpm @ _____ ft or lb/in ²	
Impeller size	Impeller diameter	Number of impellers	
Pressure at outlet of pump or inlet to pipeline		lb/in ²	date
Discharge	gpm	How measured	date
Valves, fittings			

Power unit

Rated HP	at RPM
----------	--------

Gear or belt drive mechanism

Type (direct, gear, belt)	
RPM at driver	RPM at pump
Energy (A pump evaluation is required to get this data)	
Energy input (from evaluation) (KW) (gal/hr) (mcf)	
Pumping plant efficiency (from evaluation) (%)	
Energy cost per acre foot (from evaluation)	
General condition of equipment, problems	

Irrigation System Inventory Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Irrigation management

Irrigation scheduling method(s)
Typical number of irrigations per season
Typical time between irrigations
Set times or time per revolution
Method of determining soil moisture
Typical water application per (set, revolution, pass)
Source, availability and skill of irrigation labor

Comments about management of the existing system and reasons for improvement. What are the objectives of the irrigation decisionmaker?

What management level is planned?

Other observations and comments

Sprinkler Irrigation System Planning/Design Worksheet

NAME _____ DATE _____ PREPARED BY _____

DISTRICT _____ COUNTY _____ ENGR JOB CLASS _____

Inventory

Water source _____ Amount available _____ ft³/sec _____ gpm _____ acre-ft Seasonal variation _____

Power source: Electric _____ volts, _____ phase; Internal combustion engine _____ fuel type; Other _____

Soils Data

Design Soil Series	Available water capacity, AWC (in/ft depth)					Depth to ¹		Sprinkler intake rate (in/hr)
	0-1	1-2	2-3	3-4	4-5	Inhibiting layer (ft)	Water table (ft)	

¹ Actual observed depth in the field.

Crop Evapotranspiration (Monthly)

Crops	Acres	Month		Month		Month	
		Depth (in)	Volume (ac-in)	Depth (in)	Volume (ac-in)	Depth (in)	Volume (ac-in)
Totals (1)		(2)		(3)		(4)	

Crop Weighted Evapotranspiration (Monthly) (Note: Maximum Monthly Total ET is greatest of nos. 2, 3, or 4 above)

ET, depth = $\frac{\text{Maximum Total Monthly ET, ac-in/mo}}{\text{Total Acres, A (1)}}$ = _____ = _____ in /mo

Irrigation Requirements

Crops	Root zone depth ² (ft)	Total AWC (in)	Management allowed depletion (%)	Max Net replacement (in)	Peak daily ET (in)	Max freq @ peak E T @ max net (days)

² Use weighted peak monthly ET and net irrigation to determine weighted peak daily E T.

Sprinkler Irrigation System Planning/Design Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Design Data — (Based on weighted crop ET, _____ % irrigation efficiency)

	Application		Weighted ² peak daily crop ET (in)	Frequency, F (days)	System requirements	
	Net, D (in)	Gross F _g (in)			Total gpm, Q	gpm/ac

² Use weighted peak monthly ET and net irrigation to determine weighted peak daily E T.

Q = system requirements—gpm
 H = Total operating hours/day
 (suggest using 23 hours for one move per day)
 (suggest using 22 hours for two moves per day)

$$Q = \frac{453 A D}{F H \text{ Eff}/100} = \text{_____ gpm} = \text{_____ gpm}$$

Sprinkler head spacing, (S_L) _____ ft, Lateral spacing on mainline (S_M) _____ ft, Minimum Required wetted diameter = _____ ft

Sprinkler head: make _____; model _____; nozzle size _____; lb/in² _____ gpm _____; wetted dia _____ ft

Application rate _____ in/hr, Application time _____ hr/set. Net application = (_____ in/hr) (_____ eff) (_____ hr/set) = _____ in

Maximum irrigation cycle = Net application _____ in/peak ET in/d = _____ days

Minimum number of laterals = _____ number of lateral sites _____
 (irrigation frequency, _____ days) (moves/day, _____)

Designed laterals: Number _____, Diameter _____ in, Type _____, Moves/day _____

Total number of sprinkler heads = (number of laterals) (number of heads/lateral) = _____

System capacity = (Total number of sprinkler heads _____) (gpm/head _____) = _____ gpm

Lateral design

Allowable pressure difference along lateral = 0.2 (sprinkler head operating pressure in lb/in²) = _____ lb/in²

Actual head loss (worst condition) _____ lb/in²

Pressure required at mainline: P = (sprinkler head lb/in² _____) + (0.75) (Lateral friction lb/in² _____) +/- (ft elev) / (2) (2.31) = _____ lb/in²

(plus for uphill flow in lateral, minus for downhill flow). Use sprinkler head lb/in² only if elevation difference along lateral is = or > 0.75 (lateral friction loss lb/in²)

(2.31). Under this condition, flow regulation may be required at some sprinkler heads to maintain proper sprinkler head operating near the mainline.

Sprinkler Irrigation System Planning/Design Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Mainline Design

Mainline material _____ (IPS, PIP, SDR, CLASS) lb/in² rating _____, other description, _____

Friction factor used _____. Formula (check one) Hazen-Williams Manning's Darcy-Weibach Other (name) _____

Station		Diameter pipe (in)	Flow (gpm)	Velocity (fps)	Distance (ft)	Friction loss (ft/100 ft)	Friction loss this section (ft)	Accumulated friction loss (ft)	Remarks
From	To								

NOTE: desirable velocities—5 ft/sec or less in mainlines, 7 ft/sec or less in sprinkler laterals.

Determination of Total Dynamic Head (TDH)

Pressure required at main _____ lb/in² _____ ft

Friction loss in main _____ lb/in² _____ ft

Elevation raise/fall in main _____ lb/in² _____ ft (2.31 feet = 1 psi pressure)

Lift (water surface to pump) _____ lb/in² _____ ft

Column friction loss _____ lb/in² _____ ft

Miscellaneous loss _____ lb/in² _____ ft

Total (TDH) _____ lb/in² _____ ft (NOTE; TDH must be in feet for horsepower equation)

Approximate brake horsepower = $\frac{\text{TDH (ft)} \times \text{Q (gpm)}}{3960 \times \text{Eff} / 100}$ = _____ ft X _____ gpm = _____ HP

$\frac{\text{TDH (ft)} \times \text{Q (gpm)}}{3960 \times \text{Eff} / 100}$

Mean sea level elevation of pump _____ ft (NOTE: check required versus available NPSL for centrifugal pumps)

Pump curve data attached yes no , If not, pumping plant efficiency assumed = _____% (recommended using 65-75%)

Bill of materials attached yes no

Sprinkler Irrigation System Planning/Design Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Other Design Considerations

Item	Evaluation performed	NOT needed	Location	Size
Measuring device				
Expansion couplers				
Reducers				
Enlargers (expanders)				
Manifolds				
Bends & elbows				
Tees				
Valved outlets				
Surge facilities (valves, chambers)				
Control valves				
Check non-return flow valves				
Pressure relief valves				
Air-vacuum valves				
Drain facilities				
Thrust blocks				
Anchors				
Pipe supports				
Other				

Remarks

Special drawing(s) attached _____

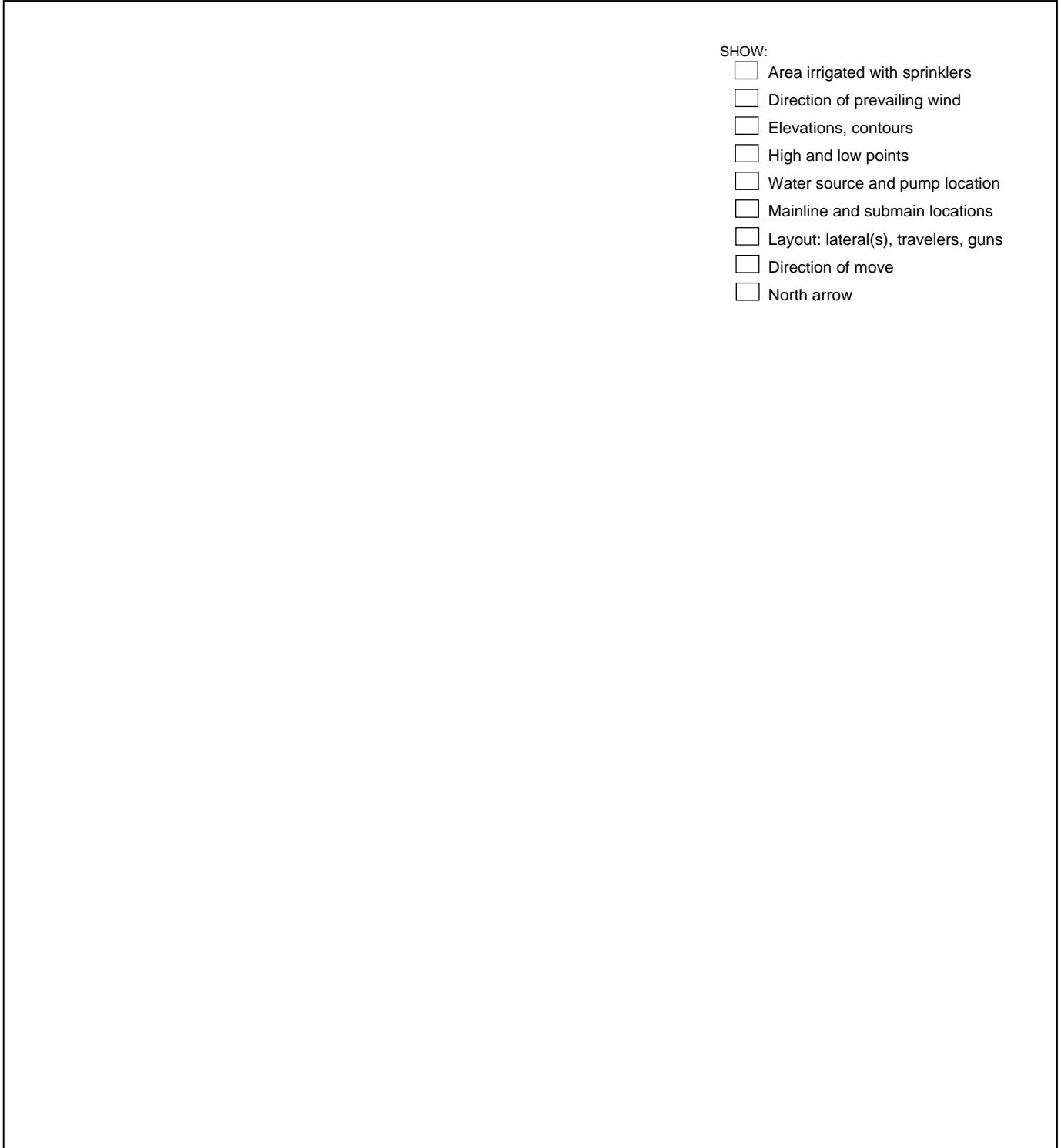
Irrigation system design by _____ Date _____

Reviewed and approved by _____ Date _____

Sprinkler Irrigation System Planning/Design Worksheet—Continued

NAME _____ DATE _____ PREPARED BY _____

Irrigation System Location and Layout Map



SHOW:

- Area irrigated with sprinklers
- Direction of prevailing wind
- Elevations, contours
- High and low points
- Water source and pump location
- Mainline and submain locations
- Layout: lateral(s), travelers, guns
- Direction of move
- North arrow

Scale	Community	Section	Township	Range
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Irrigation Water Management Plan—Sprinkler Irrigation System

NAME _____ DATE _____ PREPARED BY _____
 DISTRICT _____ COUNTY _____ ENGR JOB CLASS _____

Crop information

Field number(s)				
Crop irrigated				
Acres Irrigated (acres)				
Normal rooting depth (feet, inches)				
Management allowable depletion (MAD) (percent, inches)				
Peak daily crop requirements (ac-in/day)				
Average annual net irrigation requirements (ac-in/ year)				

Soil Information

Soils series and surface texture		
Capability class		
Allowable soil loss (T=tons per-acre per year)		
Wind Erodibility Group (WEG)		
Actual on-site (observed and measured) average root zone depth		
Total available water capacity (AWC) of soil plant root zone		
Soil intake (Maximum application rate for sprinkler system)		
Available water capacity (AWC) for crop rooting depth:	Depth (inches)	AWC
		(inch/inch) (total inches)

Irrigation system management information

Irrigation system
Source of water
Delivery schedule
Estimated overall irrigation efficiency
Management allowable depletion for pasture
Irrigation set time to apply full irrigation and replace full MAD
Gross application
Net application
Actual gross sprinkler application rate
Irrigation system flow capacity requirement for full time irrigation, Q (gpm)

Irrigation Water Management Plan— Sprinkler Irrigation System—*Continued*

NAME _____ DATE _____ PREPARED BY _____

Irrigation scheduling Information

Month	Monthly net ¹ irrigation requirement (inches)	Crop evapo- transpiration use rate (in/day)	Irrigation frequency needed (days)	Average ² number of Irrigations needed
April				
May				
June				
July				
August				
September				
October				
Total				

¹ Net irrigation requirement (NIR) represents crop evapotranspiration less effective rainfall.

² Assuming a full soil profile at start of season. Check soil moisture before irrigating. Account for rainfall that can replace soil moisture depletion. If soil moisture depletion is less than 50% wait for a few days and check it again.

Warmer than “average” months will typically require additional irrigation water; cooler than “average months will typically require less irrigation water; months with more than “average” effective rainfall will typically require less irrigation water.

Only operate the system when needed to furnish water for crop needs. The preceding irrigation schedule can be used as a guide to determine when to irrigate. It is a guide only for average month and year conditions. Optimizing use of rainfall to reduce unnecessary irrigations during the growing season is a good management practice. In semi-humid and humid areas, it is recommended to not replace 100 percent of the soil moisture depletion each irrigation. Leave room in the plant root zone for containing water infiltration from rainfall events. This will vary with location, frequency, and amount of rainfall occurring during the growing season. It should be approximately 0.5 to 1.0 inches.

Maintaining to a higher soil moisture level (MAD) typically does not require more irrigation water for the season, just more frequent smaller irrigations. This is especially true with crops such as root vegetables, potatoes, onions, garlic, mint, and sweet corn.

The attached chart for evaluating soil moisture by the feel and appearance method can be used to help determine when to irrigate. Other common methods to monitor crop water use and soil moisture include: plant signs (crop critical moisture stress periods), atmometer, evaporation pan (applying appropriate factors), tensiometers, electrical resistance blocks (moisture blocks), and crop water stress index (CWSI gm).

NRCS (SCS) - SCHEDULER computer software is available to provide calculations of daily crop evapotranspiration when used with local daily weather station values. On-site rainfall data is necessary to determine effective rainfall, whereas local weather station rainfall data is not sufficiently accurate due to spatial variability. Current rainfall and soil moisture data can be input manually or electronically to assist in predicting when irrigation is needed.

Irrigation Water Management Plan—Sprinkler Irrigation System—Continued

NAME _____ DATE _____ PREPARED BY _____

A properly operated, maintained, and managed sprinkle irrigation system is an asset to your farm. Your system was designed and installed to apply irrigation water to meet the needs of the crop without causing erosion, runoff, and losses to deep percolation. The estimated life span of your system is 15 years. The life of the system can be assured and usually increased by developing and carrying out a good operation and maintenance program.

Pollution hazards to ground and surface water can be minimized when good irrigation water management practices are followed. Losses of irrigation water to deep percolation and runoff should be minimized. Deep percolation and runoff from irrigation can carry nutrients and pesticides into ground and surface water. Avoiding spills from agricultural chemicals, fuels, and lubricants will also minimize potential pollution hazards to ground and surface water.

Leaching for salinity control may be required if electrical conductivity of the irrigation water or soil water exceeds plant tolerance for your yield and quality objectives. If this condition exists on your field(s), a salinity management plan should be developed.

The following are system design information and recommendations to help you develop an operation and maintenance plan (see irrigation system map for layout):

- average operating pressure = _____ lb/in² (use a pressure gage to check operating pressure)
- nozzle size = _____ inch (use shank end of high speed drill bit to check nozzle wear)
- average sprinkler head discharge _____ gpm
- sprinkler head rotation speed should be 1 - 2 revolutions per minute
- sprinkler head spacing on lateral = _____ ft; outlet valve spacing on main line _____ ft
- lateral, number(s) _____, _____ ft, _____ inch diameter _____
- main line = _____ ft _____ inch diameter, type _____, class _____
- pump = _____, _____ gpm @ _____ ft Total Dynamic Head (TDH)

Make sure that all measuring devices, valves, sprinkler heads, surface pipeline, and other mechanical parts of the system are checked periodically and worn or damaged parts are replaced as needed. Always replace a worn or improperly functioning nozzle with design size and type. Sprinkler heads operate efficiently and provide uniform application when they are plumb, in good operating condition, and operate at planned pressure. Maintain all pumps, piping, valves, electrical and mechanical equipment in accordance with manufacturer recommendations. Check and clean screens and filters as necessary to prevent unnecessary hydraulic friction loss and to maintain water flow necessary for efficient pump operation.

Protect pumping plant and all associated electrical and mechanical controls from damage by livestock, rodents, insects, heat, water, lightning, sudden power failure, and sudden water source loss. Provide and maintain good surface drainage to prevent water pounding around pump and electrical equipment. Assure all electrical/gas fittings are secure and safe. Always replace worn or excessively weathered electric cables and wires and gas tubing and fittings when first noticed. Check periodically for undesirable stray currents and leaks. Display appropriate bilingual operating instructions and warning signs as necessary. During non-seasonal use, drain pipelines and valves, secure and protect all movable equipment (i.e. wheel lines).

If you need help developing your operation and maintenance plan, contact your local USDA Natural Resources Conservation Service office for assistance.

Soil Water Holding Worksheet

Field _____ Location in field _____
 Year _____ By _____
 Crop _____
 Planting data _____ Emergence data _____
 Soil name if available _____

Factor	Season	
	1st 30 days	Remainder of season
Root zone depth or max soil depth - ft		
Available water capacity AWC - in		
Management allowed deficit MAD - %		
Management allowed deficit MAD - in		

(Note: Irrigate prior to the time that SWD is equal to or greater than MAD - in)

Estimated irrigation system application efficiency _____ percent

Data obtained during first field check					Data obtained each check		
(1) Depth range (in)	(2) Soil layer thickness (in)	(3) Soil texture	(4) Available water capacity (AWC) (in/in)	(5) AWC in soil layer (in)	(6) Field check number	(7) Soil water deficit (SWD) (%)	(8) Soil water deficit (SWD) (in)
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		

Total AWC for root zone depth of _____ ft=

Total AWC for root zone depth of _____ ft=

$AWC(5) = \text{layer thickness}(2) \times AWC(4)$

$SWD(8) = \frac{AWC(5) \times SWD(7)}{100}$

SWD summary		
Check number	Check date	SWD totals
1		
2		
3		
4		
5		
6		
7		
8		

Worksheet
Soil-Water Content
(Gravimetric Method)

Land user _____ Date _____ Field office _____

Taken by _____ Field name/number _____

Soil name (if available) _____ Crop _____ Maximum effective root depth _____ ft

Depth range inches	Soil layer thickness inches d	Soil texture	Sample			Tare weight g Tw	Net dry weight g Dw	Volume of sample cc Vol	Moisture percentage % Pd	Bulk density g/cc Dbd	Soil-water content in/in SWC	Layer water content inches TSWC
			Wet weight g WW	Dry weight g DW	Water loss g Ww							

Dry weight (Dw) of soil = DW - TW = _____ g Weight of water lost (Ww) = WW - DW = _____ g Bulk density (Dbd) = $\frac{Dw(g)}{Vol (cc)}$ = _____ g/cc

Percent water content, dry weight Pd = $\frac{Ww}{Dw} \times 100$ = _____ % Soil-water content (SWC) = $\frac{Dbd \times Pd}{100 \times 1}$ = _____ in/in

Total soil-water content in the layer (TSWC) = SWC x d = _____ inches

**Determination of Soil Moisture and Bulk Density (dry)
 Using Eley Volumeter and Carbide Moisture Tester**

Farm _____ Location _____ SWCD _____
 Crop _____ Soil type _____ Date _____ Tested by _____

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	
Texture	Thickness of layer	Volumeter							Bulk density (g/cc)	Soil-water content (in)	Soil-water content at field capacity	Soil-water deficit (in)	
		Reading before (cc)	Reading after (cc)	Volume (cc)	% Wet wt.	% Dry wt.	% Wilting point	% Soil-water					
	d			V	W _p	P _d	P _w	SWC _p	Db _d	SWC	AWC	SWD	
Wet weight of all samples in grams unless otherwise shown.										Totals			

$$Db_d = \frac{26}{\frac{V(1 + P_d)}{100}}$$

$$SWC = \frac{Db_d \times SWC_p \times d}{100 \times 1}$$

$$SWC_p = P_d - P_w$$

**Surface Irrigation System
 Detailed Evaluation Graded Border Worksheet**

Land user _____ Field office _____

Field name/number _____

Observer _____ Date _____ Checked by _____ Date _____

Field Data Inventory:

Field area _____ acres

Border number _____ as counted from the _____ side of field

Crop _____ Root zone depth _____ ft MAD _____ %

Stage of crop _____

Soil-water data for controlling soil:

Station _____ Moisture determination method _____

Soil series name _____

Depth	Texture	AWC (in)*	SWD (%)*	SWD (in)*
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
Total		_____	_____	_____

MAD, in = $\frac{\text{MAD, \%} \times \text{total AWC, in}}{100}$ = _____ = _____ in

Comments about soils: _____

Typical irrigation duration _____ hr, irrigation frequency _____ days

Typical number of irrigation's per year _____

Annual net irrigation requirement, NIR (from irrigation guide) _____ in

Type of delivery system (gated pipe, turnouts, siphon tubes) _____

Delivery system size data (pipe size & gate spacing, tube size & length, turnout size) _____

Border spacing _____, Strip width _____, Wetted width _____, Length _____

Field Observations:

Evenness of water spread across border _____

Crop uniformity _____

Other observations _____

NOTE: MAD = Management allowed deficit AWC = Available water capacity SWD = Soil water deficit

**Surface Irrigation System
 Detailed Evaluation Graded Border Worksheet**

Data: Inflow _____ Outflow _____

Type of measuring device _____

Clock ^{1/} time	Elapsed time (min)	Δ T (min)	Gage H (ft)	Flow rate (gpm)	Average flow rate (gpm)	Volume ^{2/} (ac-in)	Cum. volume (ac-in)
Turn on							
Turn off							

Total volume (ac-in) _____

Average flow rate =

Total irrigation volume (ac-in) x 60.5 = _____ = _____ ft³/s Inflow time (min)

Unit flow:

$q_u = \frac{\text{Average flow rate}}{\text{Border strip spacing}} = \text{_____} = \text{_____} \text{ ft}^3/\text{s}/\text{ft}$

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. should be recorded as 1330 hours.

2/ Flow rate to volume factors:
 Find volume using ft³/s: Volume (ac-in) = .01653 x time (min) x flow (ft³/s)

Find volume using gpm: Volume (ac-in) = .00003683 x time (min) x flow (gpm)

**Surface Irrigation System Detailed Evaluation
 Graded Border Worksheet**

Average depth infiltrated low 1/4 (LQ):

Low 1/4 strip length = $\frac{\text{Actual strip length}}{4}$ = _____ = _____ ft

LQ = $\frac{(\text{Depth infiltrated at begin of L1/4 strip}) + (\text{Depth infiltrated at the end of L1/4 strip})}{2}$

= _____ = _____ in

Areas under depth curve:

- 1. Whole curve _____ sq in
- 2. Runoff _____ sq in
- 3. Deep percolation _____ sq in
- 4. Low quarter infiltration _____ sq in

Actual border strip area:

= $\frac{(\text{Actual border length, ft}) \times (\text{Wetted width, ft})}{43,560}$ = _____ = _____ acres

Distribution uniformity low 1/4 (DU):

DU = $\frac{\text{Low quarter infiltration area} \times 100}{(\text{Whole curve area} - \text{runoff area})}$ = _____ %

Runoff (RO):

RO, % = $\frac{\text{Runoff area} \times 100}{\text{Whole curve area}}$ = _____ %

RO = $\frac{\text{Total irrigation volume, ac-in} \times \text{RO, \%}}{\text{Actual strip area, ac} \times 100}$ = _____ in

Deep percolation, DP:

DP = Deep percolation area x 100 = _____ = _____ %

DP = $\frac{\text{Total irrigation volume, ac-in} \times \text{DP, \%}}{\text{Actual strip area, ac} \times 100}$ = _____ in

**Surface Irrigation System
 Detailed Evaluation Graded Border Worksheet**

Evaluation computations, cont:

Gross application, F_g :

$$F_g = \frac{\text{Total irrigation volume, ac-in}}{\text{Actual strip area, ac}} = \underline{\hspace{4cm}} = \underline{\hspace{2cm}} \text{ in}$$

Application efficiency, E_a :

(Average depth stored in root zone = Soil water deficit (SWD) if entire root zone depth will be filled to field capacity by this irrigation, otherwise use F_g , in - RO, in)

$$E_a = \frac{\text{Average depth stored in root zone} \times 100}{\text{Gross application, in}} = \underline{\hspace{4cm}} = \underline{\hspace{2cm}} \%$$

Application efficiency low 1/4, E_q :

$$E_q = \frac{DU \times E_a, \%}{100} = \underline{\hspace{4cm}} = \underline{\hspace{2cm}} \%$$

Average net application, F_n

$$F_n = \frac{\text{Total irrigated volume, ac-in} \times E_a, \%}{\text{Actual strip area, ac} \times 100} = \underline{\hspace{4cm}} = \underline{\hspace{2cm}} \%$$

Time factors:

Required opportunity time to infiltrate soil water deficit of _____ in

$$T_o = \underline{\hspace{2cm}} \text{ min (} \underline{\hspace{2cm}} \text{ hr - } \underline{\hspace{2cm}} \text{ min)}$$

Estimated required irrigation inflow time from adv.-recession curves;

$$T_{in} = \underline{\hspace{2cm}} \text{ min (} \underline{\hspace{2cm}} \text{ hr - } \underline{\hspace{2cm}} \text{ min)}$$

At inflow rate of:

$$Q = \underline{\hspace{2cm}} \text{ ft}^3/\text{s per border strip}$$

**Surface Irrigation System Detailed Evaluation
 Graded Border Worksheet**

Present management:

Estimated present average net application per irrigation _____ inches

Present gross applied per year = $\frac{\text{Net applied per irrigation} \times \text{number of irrigations} \times 100}{\text{Application efficiency (E}_a\text{)}^{1/}}$

= _____ = _____ in

^{1/} Use the best estimate of what the application efficiency of a typical irrigation during the season may be. The application efficiency from irrigation to irrigation can vary depending on the SWD, set times, etc. If the irrigator measures flow during the season, use that information.

Potential management:

Annual net irrigation requirement _____ inches, for _____ (crop)

Potential application efficiency (E_{pa}) _____ percent (from irrigation guide, NEH or other source)

Potential annual gross applied = $\frac{\text{Annual net irrigation requirement} \times 100}{\text{Potential application efficiency (E}_{pa}\text{)}}$

= _____ = _____ in

Total annual water conserved

= $\frac{(\text{Present gross applied} - \text{potential gross applied}) \times \text{area irrigation (ac)}}{12}$

= _____ = _____ acre feet

Annual cost savings:

Pumping plant efficiency _____ Kind of fuel _____

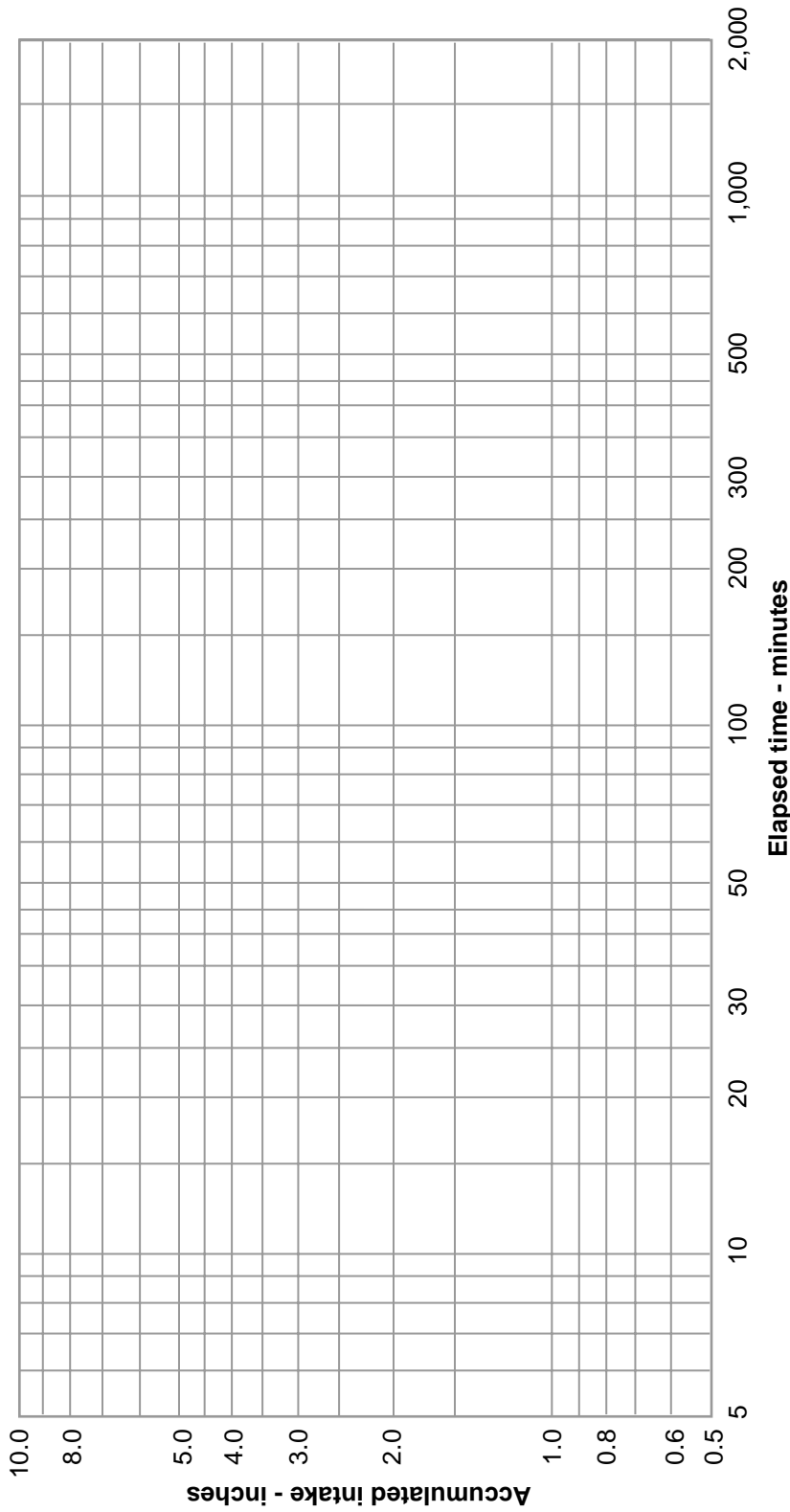
Cost per unit of fuel _____ Fuel cost per acre foot \$ _____

Cost savings = Fuel cost per acre foot x acre feet conserved per year

= _____ = \$ _____

Cylinder Infiltrometer Curves

Land user _____
Date _____
Field office _____



U.S. Department of Agriculture
National Resources Conservation Service

Cylinder Infiltrometer Test Data

-322
 02-96

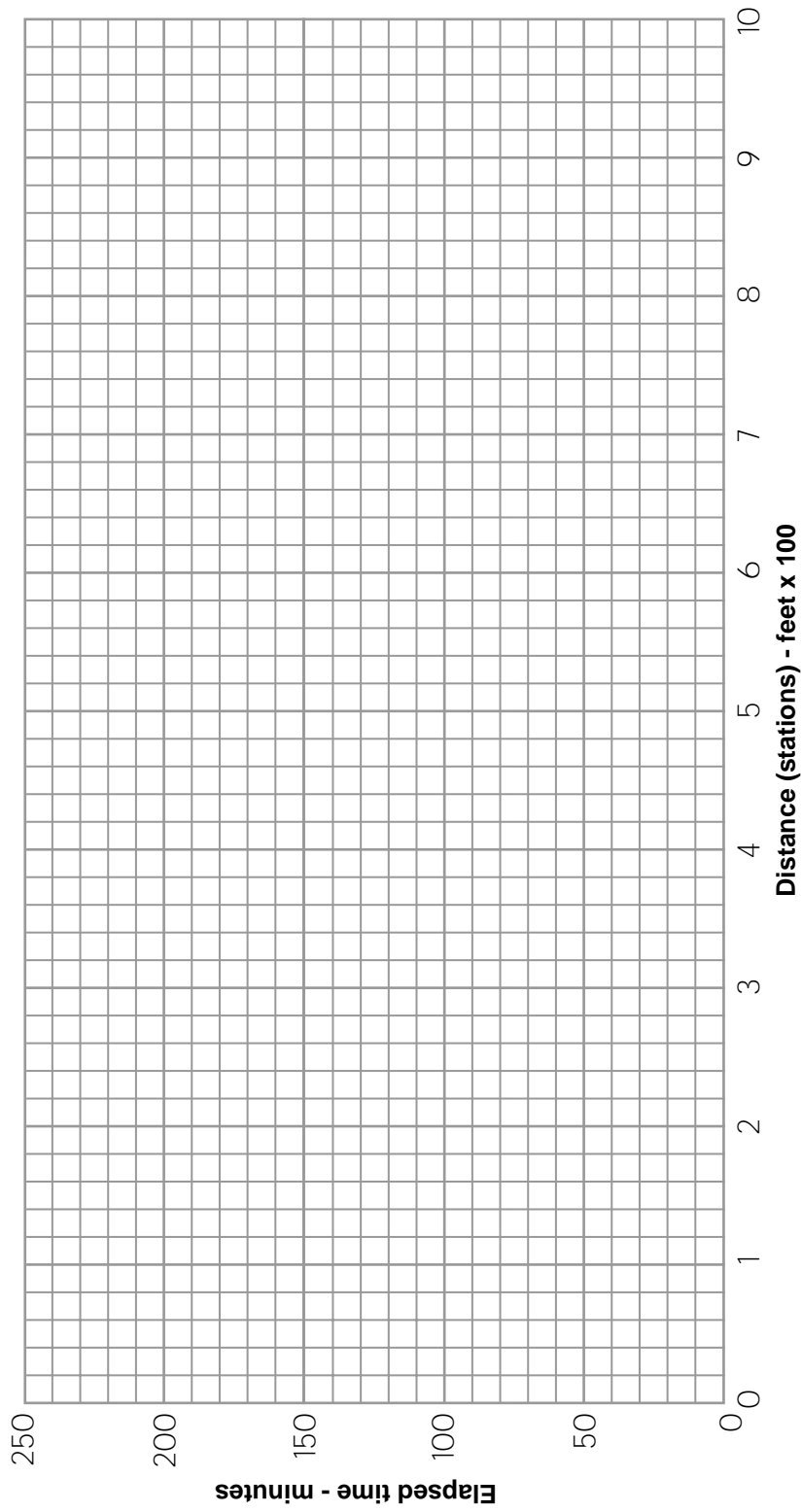
FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:	
CROP	STAGE OF GROWTH			

GENERAL COMMENTS

Elapsed time	Cylinder No. 1			Cylinder No. 2			Cylinder No. 3			Cylinder No. 4			Cylinder No. 5			Average accum. intake
	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	
	Min.	Inches		Inches		Inches		Inches		Inches		Inches				

Land user _____
Date _____
Field office _____

Advance and recession curves

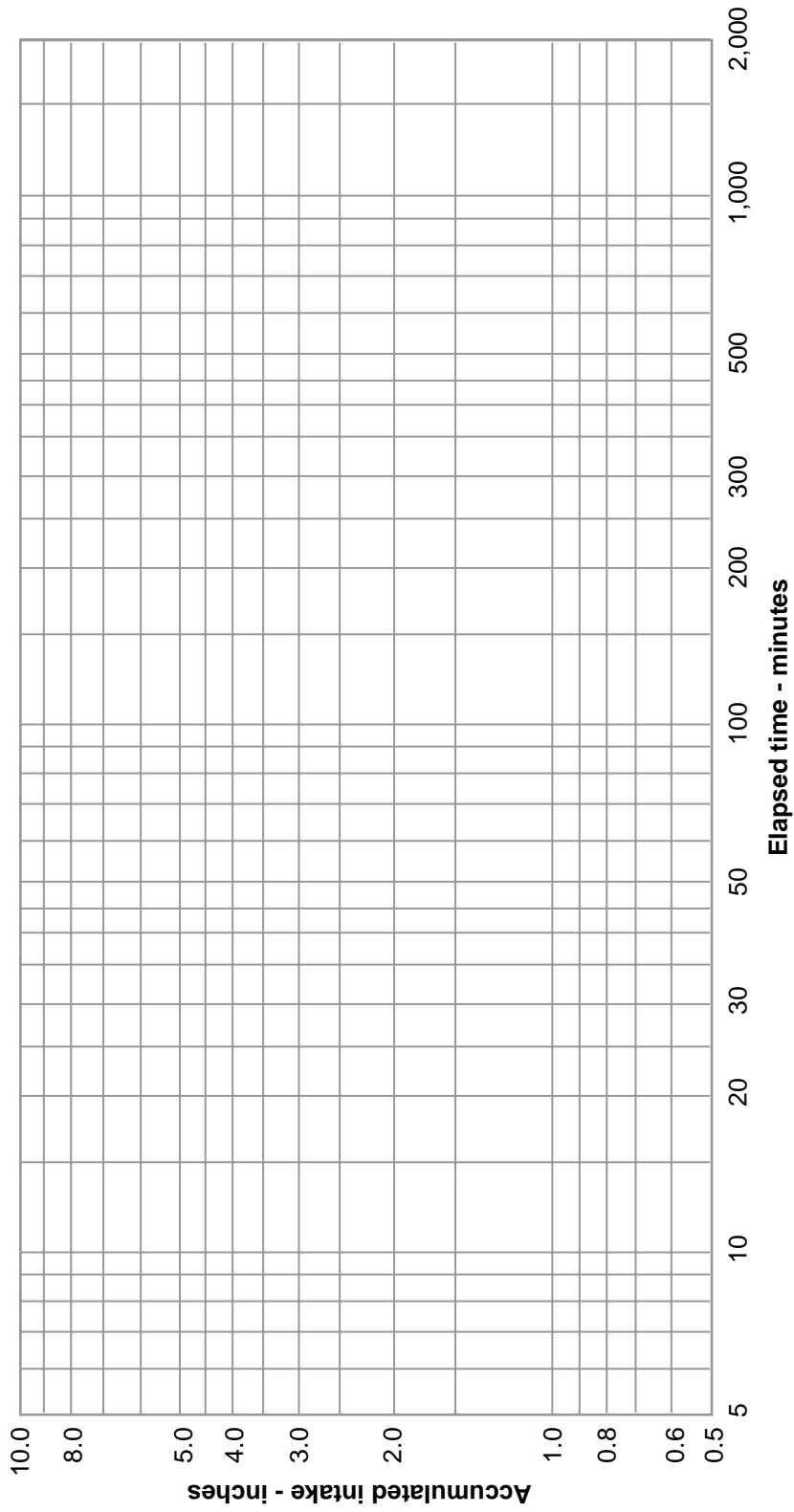


Cylinder infiltrometer Curves

Land user _____

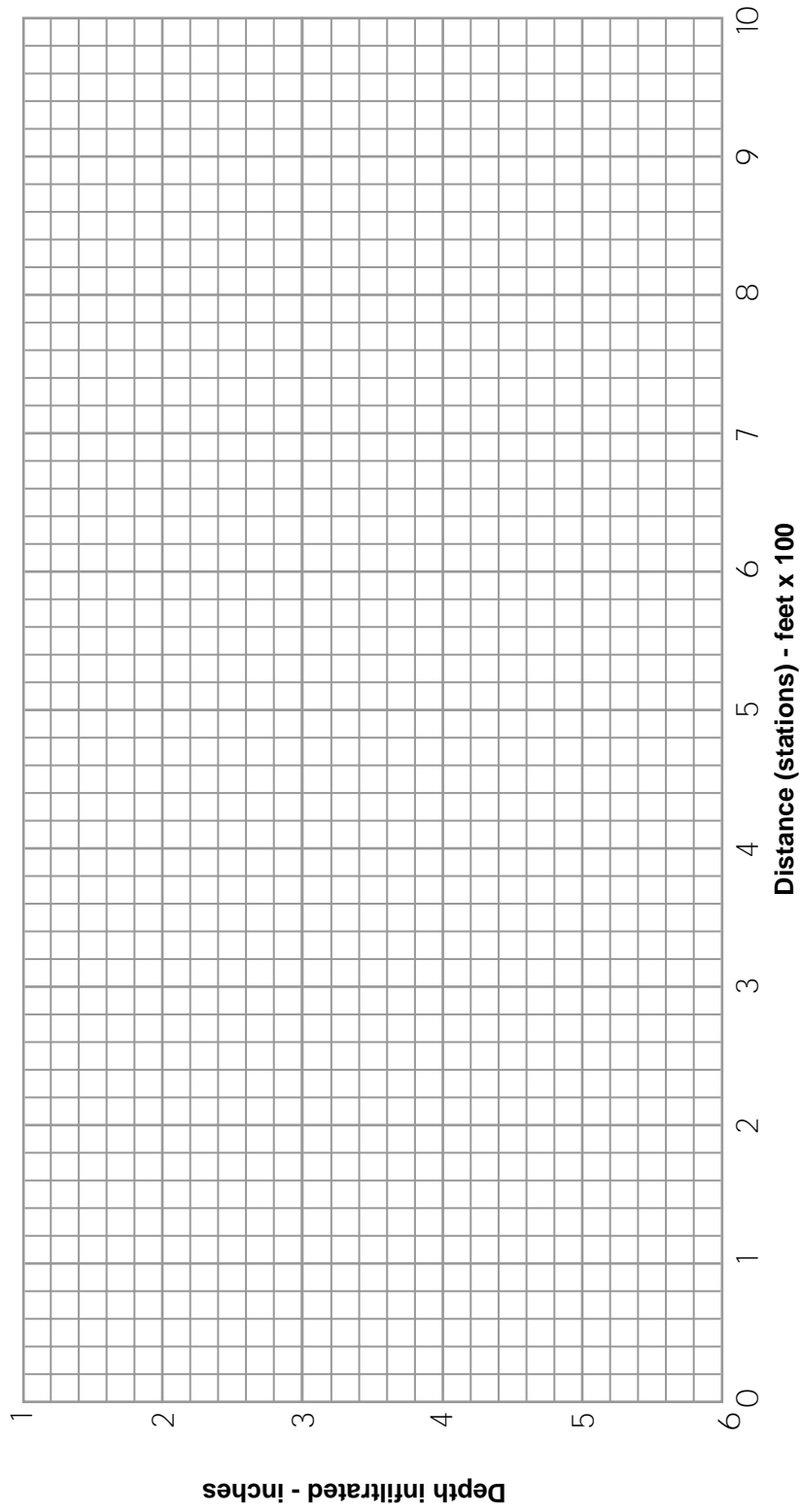
Date _____

Field office _____



Land user _____
Date _____
Field office _____

Depth infiltrated curve



**Surface Irrigation System
 Detailed Evaluation Graded Border Worksheet**

Land user _____ Field office _____

Field name/number _____

Observer _____ Date _____ Checked by _____ Date _____

Field Data Inventory:

Field area _____ acres

Border number _____ as counted from the _____ side of field

Crop _____ Root zone depth _____ ft MAD _____ %

Stage of crop _____

Soil-water data for controlling soil:

Station _____ Moisture determination method _____

Soil series name _____

Depth	Texture	AWC (in)*	SWD (%)*	SWD (in)*
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
Total		_____	_____	_____

MAD, in = $\frac{\text{MAD, \%} \times \text{total AWC, in}}{100}$ = _____ in

Comments about soils: _____

Typical irrigation duration _____ hr, irrigation frequency _____ days

Typical number of irrigation's per year _____

Annual net irrigation requirement, NIR (from irrigation guide) _____ in

Type of delivery system (gated pipe, turnouts, siphon tubes) _____

Delivery system size data (pipe size & gate spacing, tube size & length, turnout size) _____

Border spacing _____, Strip width _____, Wetted width _____, Length _____

Field Observations:

Evenness of water spread across border _____

Crop uniformity _____

Other observations _____

NOTE: MAD = Management allowed deficit AWC = Available water capacity SWD = Soil water deficit

**Surface Irrigation System
 Detailed Evaluation Level Border and Basins Worksheet**

1. Basin area (A):

$$A = \frac{\text{Length} \times \text{Width}}{43,560} = \frac{\quad \times \quad}{46,560} = \quad \text{acres}$$

2. Gross application, F_g , in inches:

$$F_g = \frac{\text{Total irrigation volume, in ac-in}}{A, \text{ ac}} = \quad = \quad \text{in}$$

3. Amount infiltrated during water inflow, V_i :

$$V_i = \text{Gross application} - \text{Depth infiltrated after turnoff} = \quad = \quad \text{in}$$

4. Deep percolation, DP, in inches:

$$DP = \text{Gross application} - \text{Soil water deficit, SWD} = \quad = \quad \text{in}$$

$$DP, \text{ in \%} = \frac{\text{Soil water depletion, DP in inches} \times 100}{\text{Gross application, } F_g} = \quad = \quad \%$$

5. Application efficiency, E_a :

Average depth of water stored in root zone = Soil water deficit, SWD, if the entire root zone average depth will be filled to field capacity by this irrigation.

$$E_a = \frac{\text{Average depth stored in root zone, } F_n \times 100}{\text{Gross application, } F_g} = \quad = \quad \%$$

6. Distribution uniformity, DU:

$$\begin{aligned} \text{Depth infiltrated low } 1/4 &= \frac{(\text{max intake} - \text{min intake}) + \text{min intake}}{8} \\ &= \frac{\quad + \quad}{8} = \quad \end{aligned}$$

$$DU = \frac{\text{Depth infiltrated low } 1/4}{\text{Gross application, } F_g} = \quad = \quad$$

7. Application efficiency, low 1/4, E_q :

$$E_q = \frac{DU \times E_a}{100} = \quad = \quad \%$$

**Surface Irrigation System
 Detailed Evaluation Level Border and Basins Worksheet**

1. Present management

Estimated present average net application per irrigation = _____ inches

Present annual gross applied = $\frac{(\text{net applied per irrigation}) \times (\text{number of irrigations}) \times 100}{\text{Application efficiency, low } 1/4, E_q}$

= _____ x 100 = _____ inches

2. Potential management

Recommended overall irrigation efficiency, E_{des} _____

Potential annual gross applied = $\frac{\text{Annual net irrigation requirements} \times 100}{E_{des}}$

= _____ = _____ inches

3. Total annual water conserved:

= $\frac{(\text{resent gross applied, in} - \text{potential gross applied, in}) \times \text{area irrigated, acres}}{12}$

+ _____ = _____ ac-ft

4. Annual potential cost savings

From pumping plant evaluation:

Pumping plant efficiency _____ Kind of fuel _____

Cost per unit of fuel _____ Fuel cost per acre-foot \$ _____

Cost savings = (fuel cost per acre foot) x (water conserved per year, in ac-ft)

= _____ x _____ = \$ _____

Water purchase cost per acre-foot, per irrigation season _____

Water purchase cost savings = (Cost per acre-foot) x (water saved per year, in acre-feet)

= _____ = \$ _____

Potential cost savings = pumping cost + water purchase cost = _____ = \$ _____

**Surface System
 Detailed Evaluation Level Border and Basins Worksheet**

Advance - Recession Data

Station (ft)	Elevation (ft)	Advance time ^{1/} (hr: min)	Recession time ^{1/} (hr: min)	Opportunity time To (min)	Intake ^{2/} (in)	Minimum maximum intake (in)
Total						

Water surface elevation at water turnoff _____ ft ^{3/}

Average field elevation = $\frac{\text{elevation total}}{\text{no. of elevations}}$ = _____ = _____ ft

Depth infiltrated after water turnoff
 = (water surface at turnoff - average field elev) x 12
 = (_____ - _____ x 12 = _____ in

Average opportunity time = $\frac{\text{total opportunity time}}{\text{no. of sample locations}}$ = _____ = _____ min

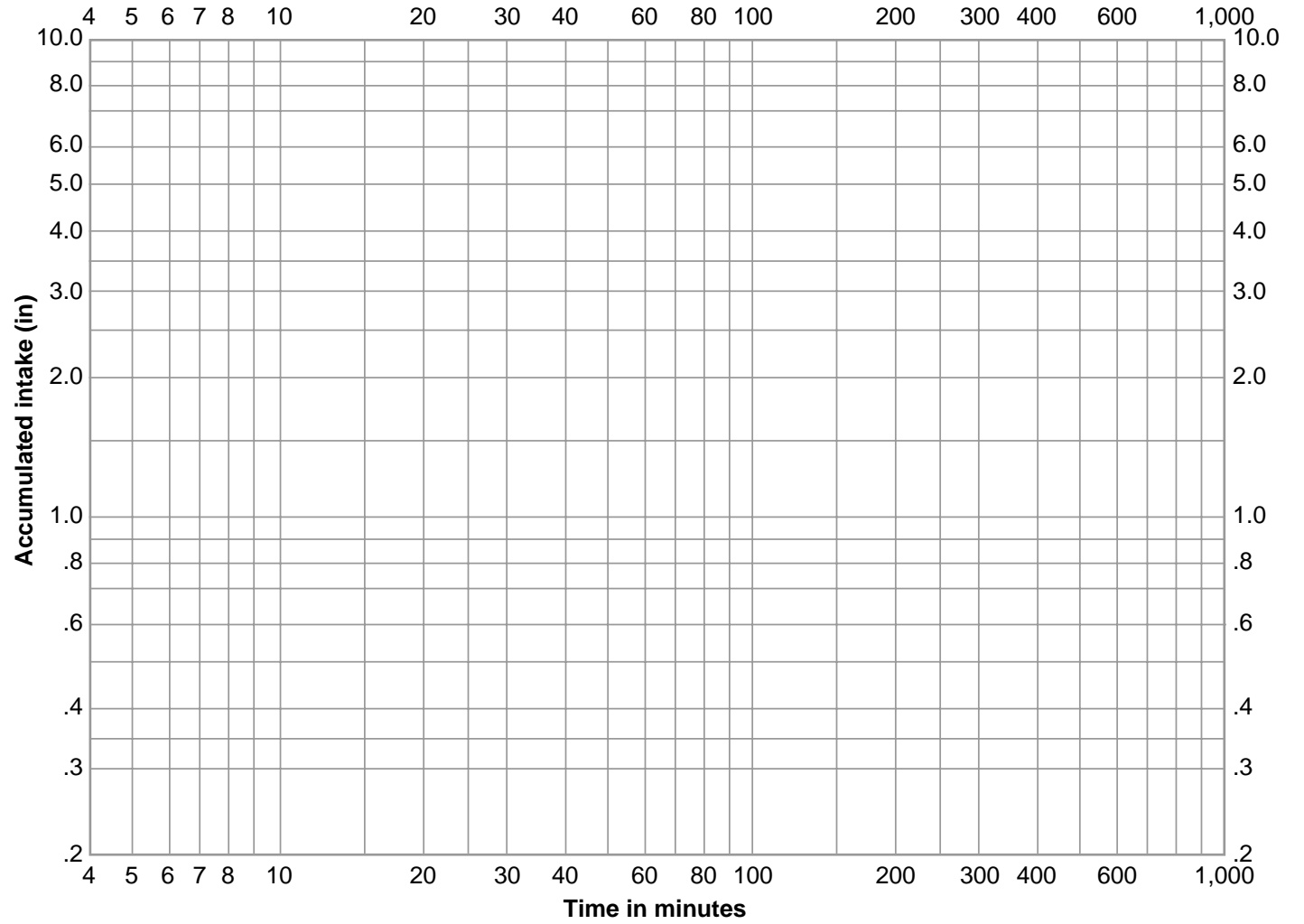
1/ Use 24-hour clock time. As a minimum, record times at upper end, mid point.
 2/ Obtain intake from plotted intake curve.
 3/ Water surface elevation should be read to nearest 0.01 ft.

Land user _____

Date _____

Field office _____

Soil Water Intake Curves



**Surface Irrigation System
 Detailed Evaluation Graded Furrow Worksheet 1**

Land user _____ Field office _____
 Field name/number _____
 Observer _____ Date _____ Checked by _____ Date _____

Field Data Inventory:

Show location on evaluation furrows on sketch or photo of field.

Crop _____ Actual root zone depth _____ MAD [†]/ _____ % MAD _____ in
 Stage of crop _____ Planting date (or age of planting) _____
 Field acres _____

Soil-water data:

(Show location of sample on soil map or sketch of field)

Soil moisture determination method _____
 Soil mapping unit _____ Surface texture _____

Depth	Texture	AWC (in) ^{1/}	SWD (%) ^{1/}	SWD (in) ^{1/}
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
Total				_____

Comments about soils: _____

Typical irrigation duration _____ hours, Irrigation frequency _____ days
 Typical number of irrigations per year _____
 Crop rotation _____

Field uniformity condition (smoothed, leveled, laser leveled, etc., and when) _____

1/ MAD = Management allowable depletion AWC = Available water capacity SWD = Soil water deficit

**Surface Irrigation System
 Detailed Evaluation Graded Furrow Worksheet 2**

Cultivation no.	Date	Crop stage	Irrigate?
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____

Delivery system size (pipe diameters, gate spacing, siphon tube size, etc.) _____

Field observations

Evenness of advance across field _____

Crop uniformity _____

Soil condition _____

Soil compaction (surface, layers, etc.) _____

Furrow condition _____

Erosion and/or sedimentation: in furrows _____
 head or end of field _____

Other observations (OM, cloddiness, residue, plant row spacing, problems noted, etc.) _____

Furrow spacing _____ inches

Furrow length _____ feet

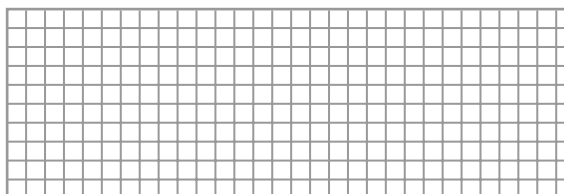
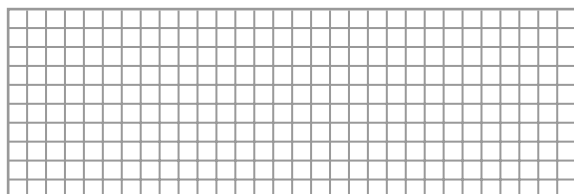
Irrigations since last cultivation _____

Furrow profile (rod readings or elevations at each 100 foot. station):

Furrow cross section:

Station: _____

Station: _____

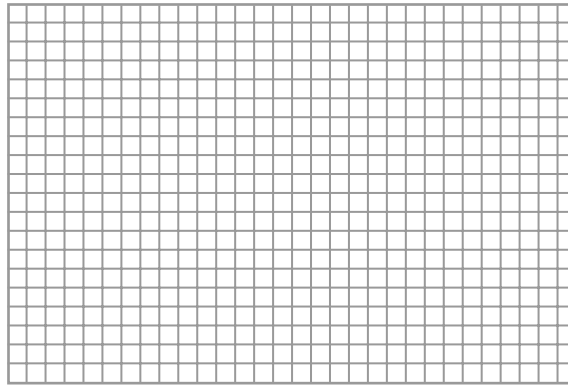


**Example - Surface Irrigation System Detailed Evaluation
 Graded Furrow Worksheet 3**

Furrow data summary:

Evaluation length _____ Slope _____ Average _____

Section through plant root zone:



Evaluation computations

Furrow area, $A = \frac{(\text{furrow evaluation length, } L, \text{ ft}) \times (\text{furrow spacing, } W, \text{ ft})}{43,560 \text{ ft}^2/\text{acre}}$

$A = \frac{\text{_____}}{43,560} = \text{_____ acre}$

Present gross depth applied, $F_g = \frac{\text{Total inflow volume, gal.} \times .0000368}{\text{Furrow area, } A, \text{ in acres}}$ (Total inflow from worksheet 7)

$F_g = \text{_____} = \text{_____ inches}$

Minimum opportunity time, $T_{ox} = \text{_____ min}$ at station _____ (from field worksheet 10)

Minimum depth infiltrated, $F_{min} = \text{_____ inches}$ (from worksheet 10)

Average depth infiltrated, $F_{(0-1)} = \text{_____}$ (from calculations on worksheet 10)

Distribution uniformity, $DU = \frac{\text{Minimum depth infiltrated, inches}}{\text{Average depth infiltrated, inches}} \times 100 = \frac{F_{min} \times 100}{F_{ave}}$

$= \text{_____} = \text{_____ \%}$

Example - Surface Irrigation System Detailed Evaluation Graded Furrow Worksheet 4

$$\text{Runoff, RO\%} = \frac{\text{Total outflow volume, gal} \times 100}{\text{Total inflow volume, gal}} = \text{_____} = \text{_____ \% (Total outflow, worksheet 8)} \\ \text{(Total inflow, worksheet 7)}$$

$$\text{RO, in} = \frac{\text{Total outflow volume, gal} \times .0000368}{\text{Evaluation furrow area, A, in acres}} = \text{_____} \times 0.0000368 = \text{_____ in (Furrow area, worksheet 3)}$$

Deep percolation, DP, in = Average depth infiltrated - Soil moisture deficit, SMD (Ave. depth worksheet 10 and SMD worksheet 1)

$$\text{DP} = \text{_____} = \text{_____ in}$$

$$\text{Deep percolation, DP, \%} = \frac{\text{Deep percolation, DP, in} \times 100}{\text{Gross depth applied, } F_g, \text{ inches}} = \text{_____} = \text{_____ \%}$$

Application efficiency, E_a

$$E_a = \frac{\text{Ave depth stored in root zone}^* \times 100}{\text{Gross application, } F_g, \text{ inches}} = \text{_____} = \text{_____ \%}$$

*Average depth of water stored in root zone = SWD if entire root zone depth is filled to field capacity by this irrigation. If irrigation efficiency is to be used in place of application efficiency, use average depth of water beneficially used (i.e., all infiltrated depths less than or equal to SWD) plus any other beneficial uses.

Example - Surface Irrigation System Detailed Evaluation Graded Furrow Worksheet 5

Potential water and cost savings

Present management

Estimated present gross net application, F_g per irrigation = _____ inches (F_g from worksheet 3)

Present gross applied per year = Gross applied per irrigation, F_g x number of irrigations

= _____ = _____ inches

Potential management

Annual net irrigation requirement _____ inches, for _____ (crop)

Potential application efficiency, E_{pa} = _____%

Potential annual gross applied = $\frac{\text{Annual net irrigation req.} \times 100}{\text{Potential application efficiency, } E_{pa}}$

= _____ = _____ inches

Total annual water conserved = $\frac{(\text{present gross applied} - \text{potential gross applied}) \times \text{area irrigated, ac}}{12}$

= _____ = _____ acre feet

**Surface Irrigation System
 Detailed Evaluation Furrow Worksheet 7-8**

Data: Furrow number _____ Inflow _____ Outflow _____

Type of measuring device _____

Clock ^{1/} time	Elapsed time (min)	Δ T (min)	Gage H (ft)	Flow rate (gpm)	Average flow rate (gpm)	Volume ^{2/} (gal)	Cum. volume (gal)
Turn on							
Total volume							

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. is recorded as 1330 hours.
 2/ Volume = Δ T x average flow rate

Average flow rate = $\frac{\text{Total irrigation volume, gallon}}{\text{Elapsed time, minute}}$ = _____ = _____ gpm

**Surface Irrigation System Detailed Evaluation
 Furrow Worksheet 10**

Furrow advance/recession data

Station (ft)	Advance time			Recession time			Total elapsed time ^{3/}	Opportunity time (T _o) ^{2/} (min)	Intake in wetted perimeter (in) ^{4/}	Intake in furrow width (in)
	Clock time ^{1/}	Δ T (min)	Elapsed time T _t (min)	Clock time ^{1/}	Δ T (min)	Elapsed time T _r (min)				
	Turn on			Turn off	Lag			Inflow T		
Totals										

1/ Use a 24-hour clock reading; i.e., 1:30 p.m. is 1330 hours.
 3/ Time since water was turned on.

2/ $T_o = T_i - T_t + T_r$
 4/ Interpolated from graph, furrows volume curve

Average opportunity time = $\frac{\text{total opportunity time}}{\text{number of stations}}$ = _____ = _____ minutes

Average depth infiltrated in wetted perimeter, F_{wp}:
 F_{wp} = $\frac{\text{total intake in wetted perimeter}}{\text{number of stations}}$ = _____ inches

Average depth infiltrated in tested length of furrow, F₀₋₁:
 F₀₋₁ = $\frac{F_{wp} \times P}{W}$ = _____ inches

**Surface Irrigation System Detailed Evaluation
Furrow Worksheet 11**

A large grid of graph paper, consisting of 30 columns and 40 rows of small squares. The grid is intended for recording data during a surface irrigation system evaluation.

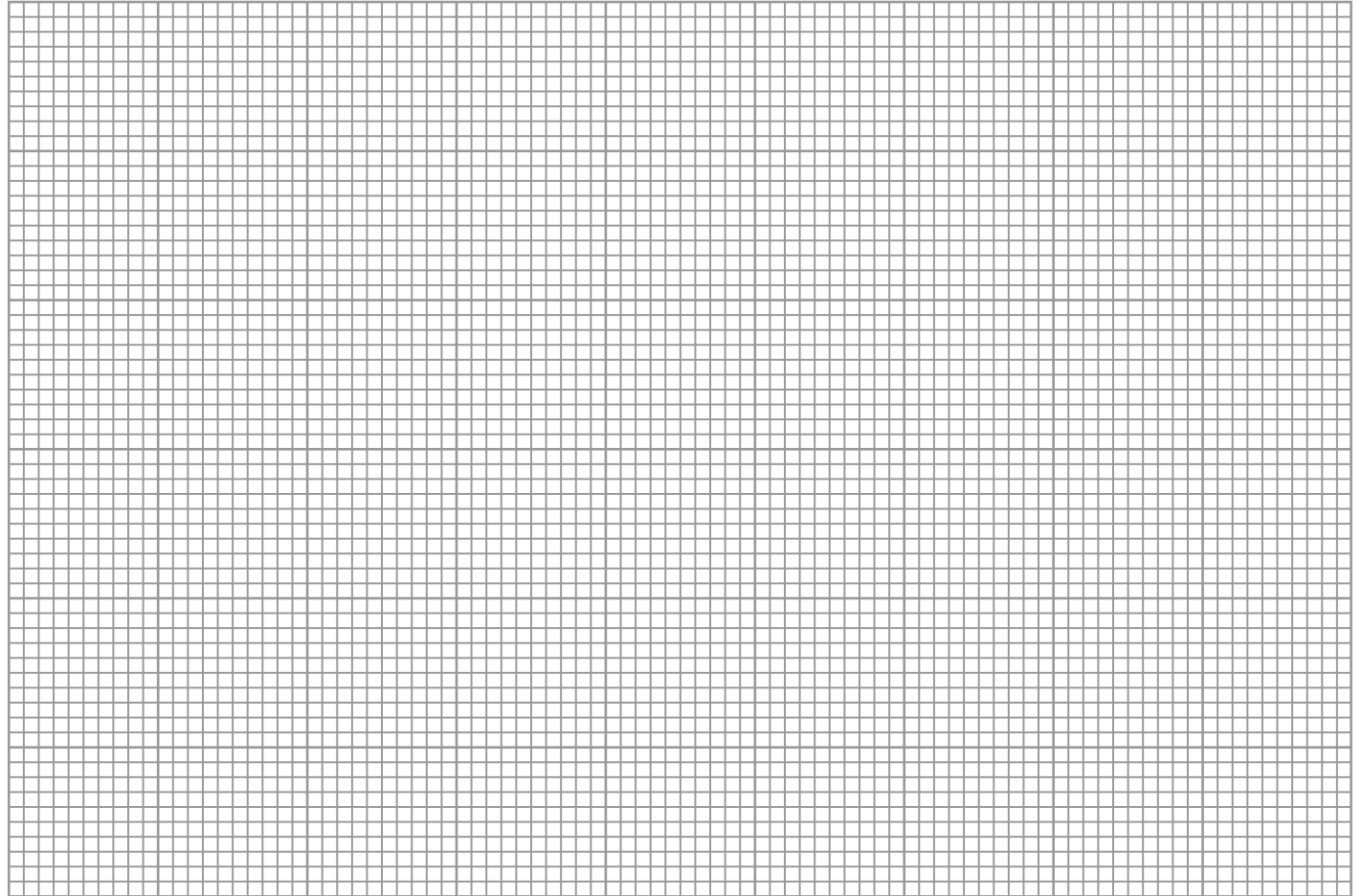
Land user _____

Date _____

Field office _____

Advance and recession curves

Time - minutes



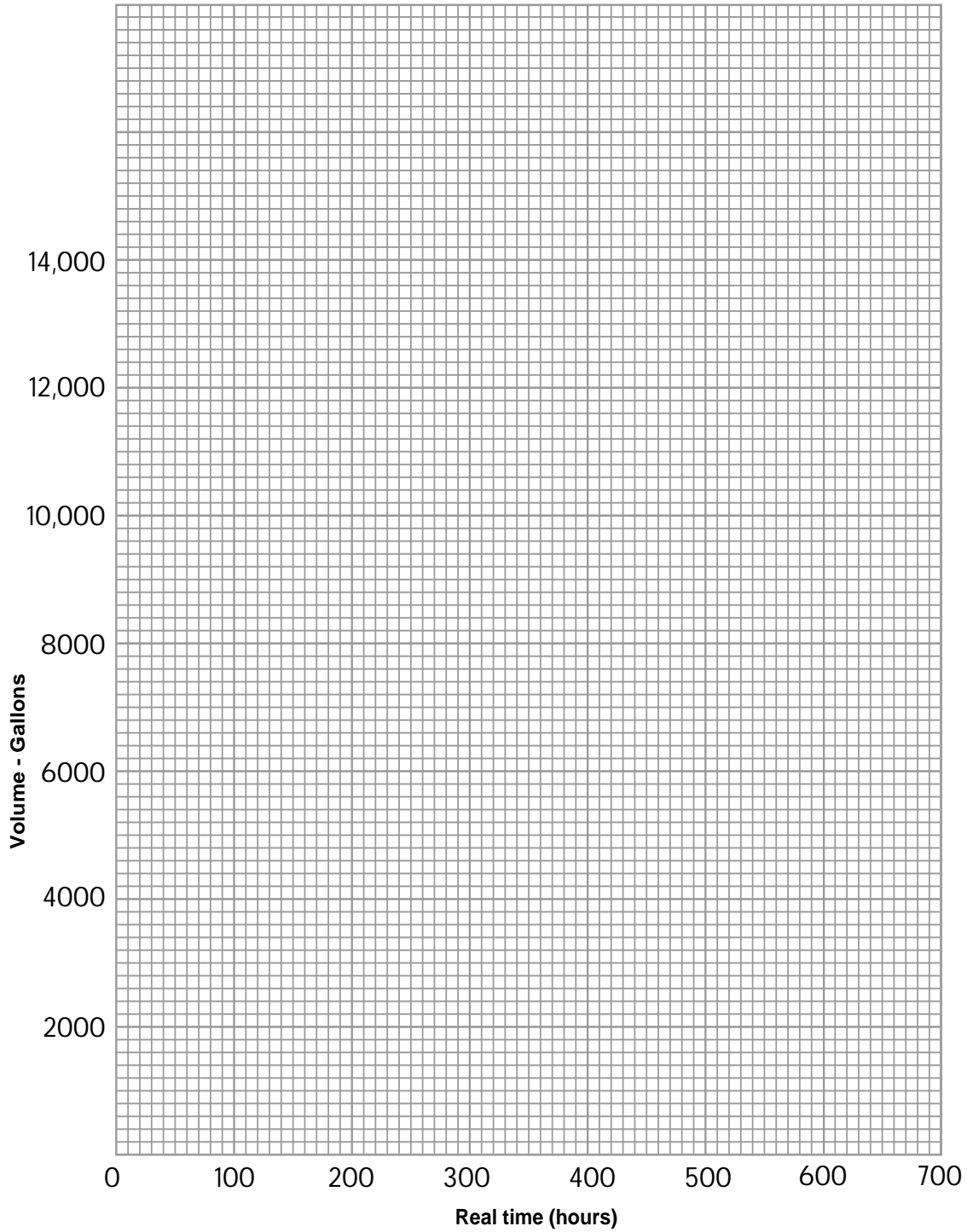
Distance (stations) - feet x 100

Land user _____

Date _____

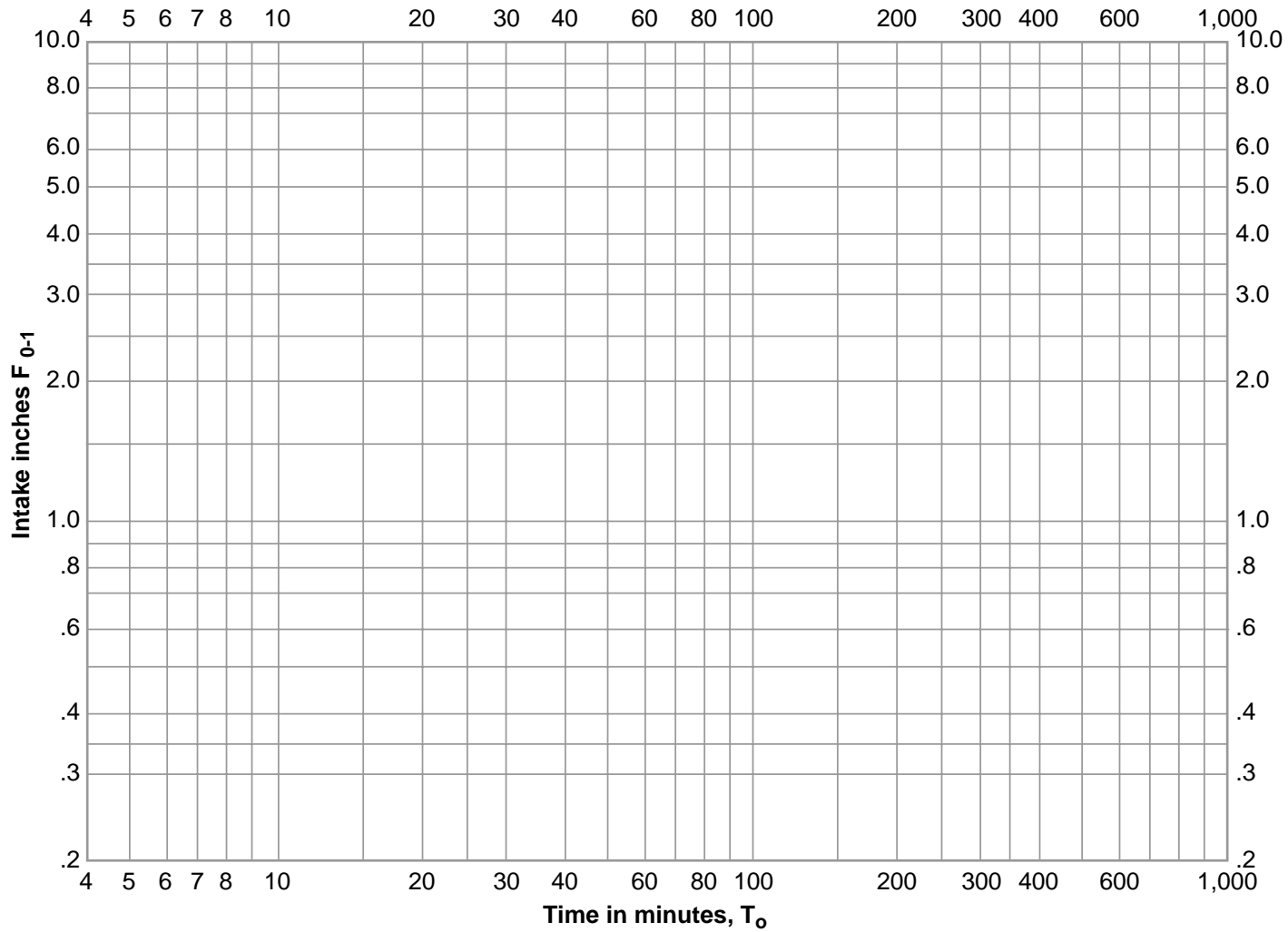
Field office _____

Flow volume curves



Soil water intake curves

Land user _____
Date _____
Field office _____



**Surface Irrigation System
 Detailed Evaluation Contour Ditch Irrigation System Worksheet**

Land user _____ Field office _____
 Field name/number _____
 Observer _____ Date _____ Checked by _____ Date _____

Field Data Inventory:

Field size _____ acres
 Crop _____ Root zone depth _____ ft MAD ^{1/} _____ % MAD ^{1/} _____ in
 Stage of crop _____

Soil-water data:

(Show location of sample on grid map of irrigated area.)

Soil moisture determination method _____

Soil series name _____

Depth	Texture	AWC ^{2/} (in)	SWD ^{3/} (%)	SWD ^{3/} (in)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
		Total	_____	_____

Comments about soils: _____

Typical irrigation duration _____ hr, irrigation frequency _____ days
 Typical number of irrigations per year _____

Type of delivery system, (earth ditch, concrete ditch, pipeline) _____

Method used to turn water out (shoveled opening, wood box turnout, siphon tubes, portable dams, concrete checks with check boards, etc.) _____

1/ MAD = Management allowable depletion
 2/ AWC = Available water capacity
 3/ SWD = Soil water deficit

**Contour Ditch Irrigation System
Detailed Evaluation Worksheet**

Field observations

Crop uniformity _____

Wet and/or dry area problems _____

Erosion problems _____

Other observations _____

Evaluation computations

Irrigated test area (from grid map) = (_____ in²) x (_____ in²/ac) = _____ ac

Actual total depth infiltrated, inches:

Depth, inches = $\frac{(\text{Irrigated volume, ac-in}) - (\text{Runoff volume, ac-in})}{(\text{Irrigated area, acres})}$

Depth, inches = _____ = _____ in

Gross application, F_g, inches:

F_g = $\frac{(\text{Total inflow volume, ac-in})}{(\text{Irrigated area, acres})}$ = _____ = _____ in

Distribution uniformity low 1/4 (DU):

DU = $\frac{(\text{Average depth infiltrated (adjusted) low 1/4, inches})}{(\text{Average depth infiltrated (adjusted), inches})}$

DU = _____ = _____

Runoff, RO, inches:

RO, inches = $\frac{(\text{Runoff volume, ac-in})}{(\text{Irrigated area, ac})}$ = _____ = _____ in

RO, % = $\frac{(\text{Runoff depth, inches}) \times 100}{(\text{Gross application, F}_g, \text{ inches})}$ = _____ = _____ %

**Contour Ditch Irrigation System
Detailed Evaluation Worksheet**

Deep percolation, DP, inches:

DP, inches = (Gross applic. F_g , inches) - (Runoff depth, RO, inches) - (Soil water deficit, SWD, inches)

DP, inches = _____ = _____ inches

DP, % = $\frac{\text{(Deep percolation, DP, inches)}}{\text{(Gross application, } F_g, \text{ inches)}} \times 100 = \text{_____} = \text{_____}\%$

Application efficiency (E_a):

(Average depth replaced in root zone = Soil water deficit, SWD, inches)

$E_a\%$ = $\frac{\text{(Average depth replaced in root zone, inches)}}{\text{(Gross application, } F_g, \text{ inches)}} \times 100 = \text{_____} = \text{_____}\%$

Potential water and cost savings

Present management:

Estimated present average net application per irrigation = _____ inches

Present gross applied per year = $\frac{\text{(Net applied per irrigation, inches)} \times \text{(no. of irrigations)}}{\text{(Application efficiency, } E_a, \text{ percent)}} \times 100$

Present gross applied per year = _____ = _____ inches

Potential management

Annual net irrigation requirement: _____ inches, for _____ (crop)

Potential application efficiency, E_{pa} : _____ % (from irrigation guide or other source)

Potential annual gross applied = $\frac{\text{(annual net irrigation requirement, inches)} \times 100}{\text{(Potential application efficiency, } E_{pa}, \text{ percent)}}$

Potential annual gross applied = _____ = _____ inches

Total annual water conserved:

= $\frac{\text{(Present gross applied, inches)} - \text{(Potential gross applied, inches)}}{12} \times \text{Area irrigated, ac}$

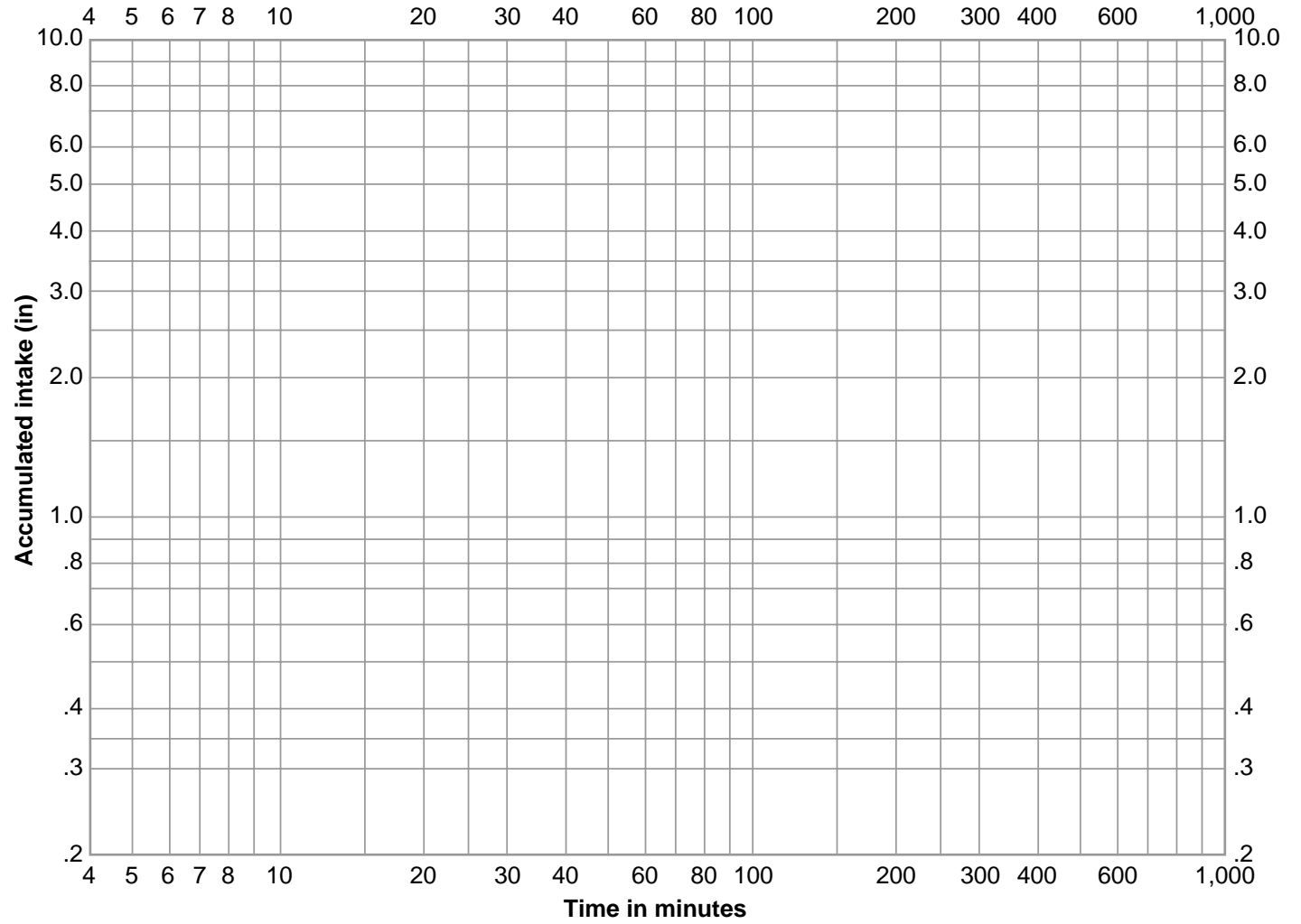
= $\left(\frac{\text{_____}}{12} \right) \times \left(\text{_____} \right) = \text{_____}$ acre-feet

Land user _____

Date _____

Field office _____

Soil Water Intake Curves



Cylinder Infiltration Test Data

FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:	
CROP	STAGE OF GROWTH			

GENERAL COMMENTS

Elapsed time	Cylinder No. 1			Cylinder No. 2			Cylinder No. 3			Cylinder No. 4			Cylinder No. 5			Average accum. intake
	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	Time of reading	Hook gage reading	Accum. intake	
	Min.	Inches		Inches		Inches		Inches		Inches		Inches				

Sprinkler Irrigation System Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Land user _____ Prepared by _____
 District _____ County _____ Engineer job class _____

Irrigation system hardware inventory:

Type of system (check one) : Side- roll _____ Handmove _____ Lateral tow _____ Fixed set _____
 Sprinkler head: make _____, model _____, nozzle size(s) _____ by _____ inches
 Spacing of sprinkler heads on lateral, S_1 _____ feet
 Lateral spacing along mainline, S_m _____ feet, total number of laterals _____
 Lateral lengths: max _____ feet, minimum _____ feet, average _____ feet
 Lateral diameter: _____ feet of _____ inches, _____ feet of _____ inches
 Manufacturer rated sprinkler discharge, _____ gpm at _____ psi giving _____ feet wetted diameter
 Total number sprinkler heads per lateral _____, lateral diameter _____ inches
 Elevation difference between first and last sprinkler on lateral (=/-) _____ feet
 Sprinkler riser height _____ feet, mainline material _____
 Spray type: _____ fine (>30psi), _____ coarse (<30psi)

Field observations:

Crop uniformity _____
 Water runoff _____
 Erosion _____
 System leaks _____
 Fouled nozzles _____
 Other observations _____

Field data inventory & Computations:

Crop _____, root zone depth _____ feet, MAD 1/ _____ %, MAD 1/ _____ inches
 Soil-water data (typical):
 (Show locations of sample on soil map or sketch of field)
 Moisture determination _____
 Soil series and surface texture _____

Depth	Texture	AWC ^{1/} (in)	SWD ^{1/} (%)	SWD ^{1/} (in)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
Totals		_____	_____	_____

1/ MAD = Management allowable depletion, AWC = Available water capacity, SWD = Soil water deficit

Sprinkler Irrigation System Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Comments about soils (including restrictions to root development and water movement): _____

Present irrigation practices:

Typical irrigation duration _____ hr, irrigation frequency _____ days

Typical number irrigations per year _____

Distance moved per set _____ ft, Alternate sets? _____

Measured nozzle diameters (using shank of high speed drill bit)

Sprinkler no. _____

Diameter _____

Size check _____

(state whether t = tight, m = medium, l = loose)

Actual sprinkler pressure and discharge data:

Sprinkler number on test lateral

1st

end

Initial pressure (psi) _____

Final pressure (psi) _____

Catch volume (gal) _____

Catch time (sec) _____

Discharge (gpm) _____

Test:

Start _____ stop _____ duration _____ = _____ hours

Atmospheric data:

Wind: Direction: Initial _____ during _____ final _____

Speed (mph): initial _____ during _____ final _____

Temperature: initial _____ final _____ Humidity: _____ low _____ med _____ high

Evaporation container: initial _____ final _____ loss _____ inch

Sprinkler Irrigation System Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Lateral flow data:

Flow meter reading _____ gpm

Average discharge of lateral based on sprinkler head discharge

$$= [1\text{st gpm} - .75 \text{ times } (1\text{st gpm} - \text{last gpm})] \text{ times } (\text{number of heads})$$

$$= \text{_____} = \text{_____ gpm (ave flow per head)}$$

$$= \text{_____ heads} \times \text{_____ gpm/head} = \text{_____ gpm}$$

Calculations:

$$\text{Gross application per test} = \frac{(\text{flow, gpm}) \times (\text{time, hr}) \times 96.3}{(\text{lateral length}) \times (\text{lateral spacing})}$$

$$= \frac{(\text{_____ gpm}) \times (\text{_____ hours}) \times 96.3}{(\text{_____ feet}) \times (\text{_____ feet})} = \text{_____ inches}$$

$$\text{Gross application per irrigation} = \frac{(\text{gross application per test, in}) \times (\text{set time, hour})}{(\text{time, hour})}$$

$$= \frac{(\text{_____ inches}) \times (\text{_____ hour})}{(5.95 \text{ hour})} = \text{_____ inches}$$

Catch container type _____

_____ cc (mL) or in, measuring container = _____ inches in container

Total number of containers _____

$$\text{Composite number of containers} = \frac{\text{Total number of containers}}{2} = \text{_____} = \text{_____}$$

Total catch, all containers = _____ cc (mL) = _____ inches
 cc/in

$$\text{Average total catch} = \frac{\text{Total catch}}{\text{composite no. containers}} = \text{_____} = \text{_____ inches}$$

$$\text{Number of composite containers in low } 1/4 = \frac{\text{composite no. containers}}{4} = \text{_____} = \text{_____}$$

Total catch in low 1/4 composite containers = _____ cc(mL) = _____ inches
 cc/in

Sprinkler Irrigation System Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Average catch of low 1/4 composite containers = $\frac{\text{total catch in low 1/4}}{\text{no. composite low 1/4 containers}}$

= _____ = _____ inches

Average catch rate = $\frac{\text{Average total catch, inches}}{\text{Test time, hour}}$ = _____ = _____ inch/hour

NOTE: Average catch rate is application rate at plant canopy height.

Distribution uniformity low 1/4 (DU):

DU = $\frac{\text{Average catch low 1/4 composite containers}}{\text{Average total catch}}$ x 100 = _____ inches x 100 = _____ %

Approximate Christiansen Uniformity (CU):

CU = 100 - [0.63 x (100 - DU)] = 100 [0.63 x (100 - _____)] = _____ %

Effective portion of applied water (R_e):

R_e = $\frac{\text{Average total catch, inch}}{\text{Gross applications/test, inches}}$ = _____ inches = _____ inches

Application efficiency of low 1/4 (E_q):

E_q = DU x (R_e) = _____ x _____ = _____ %

NOTE: Use for medium to high value crops.

Approximate application efficiency low 1/2 (E_h):

E_h = CU x (R_e) = _____ x _____ = _____ %

NOTE: Use for lower value field and forage crops.

Sprinkler Irrigation System Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Application efficiency, (E_a):

$$F_n = \frac{(\text{gross application per irrigation})}{100} \times E_q = \left(\frac{\text{inches}}{100} \right) \times \text{_____} = \text{_____ inches}$$

$$E_a = \frac{(\text{water stored in root zone})}{(\text{gross application per irrigation})} \times 100 = \left(\frac{\text{inches}}{\text{inches}} \right) \times 100 = \text{_____ \%}$$

Losses = (runoff, deep percolation) = gross application per irrigation minus SWD

$$= (\text{_____}) = \text{_____ inches}$$

Potential Water and Cost Savings:

Present management:

Gross applied per year = (gross applied per irrigation) x (number of irrigations) =

$$= (\text{_____ inches}) \times (\text{_____}) = \text{_____ inches/year}$$

Potential management:

Annual net irrigation requirement _____ inches/year, for _____ (crop)

Potential application efficiency (E_q or E_h) _____ % (from NEH, Part 623, Ch 11)

Potential annual gross applied = $\frac{(\text{annual net irrigation requirement})}{\text{Potential } E_q \text{ or } E_h} \times 100$

$$= (\text{_____ inches}) \times 100 = \text{_____ inches}$$

Total annual water conserved

$$= \frac{(\text{Present gross applied} - \text{potential gross applied}) \times (\text{area irrig. (ac)})}{12} = \text{_____ acre/feet}$$

$$= \left(\frac{\text{_____ inches} - (\text{_____ inches}) \times (\text{_____ acres})}{12} \right) = \text{_____ acre/feet}$$

Sprinkler Irrigation System Detailed Evaluation Periodic Move and Fixed Set Sprinkler System

Cost savings:

Pumping plant efficiency _____ Kind of fuel _____

Cost per unit of fuel \$ _____ Fuel cost per acre/foot \$ _____

Cost savings = (fuel cost per acre-foot) x (acre-feet conserved per year) = \$ _____

= (_____) x (_____) = \$ _____

Water purchase cost:

= (Cost per acre-foot) x (acre-feet saved per year) = _____ x _____ = \$ _____

Cost Savings:

= Pumping cost + water cost = _____ + _____ = \$ _____

Recommendations: _____

Sprinkler Irrigation System Detailed Evaluation Center Pivot Lateral Worksheet

Land user _____ Field office _____

Observer _____ Date _____ Checked by _____ Date _____

Field name/number _____

Center pivot number _____ pivot location in field _____

Acres irrigated _____

Hardware inventory:

Manufacturer: name and model _____

Is design available? _____ (attach copy) Number of towers _____ Spacing of towers _____

Lateral: Material _____, Inside diameter _____ inches

Nozzle: Manufacturer _____

Position _____ Height above ground _____

Spacing _____

Is pressure regulated at each nozzle? _____ operating pressure range _____

Type of tower drive _____

System design capacity _____ gpm, system operating pressure _____ psi

Nozzle data, design:	Pivot				end
Sprinkler position number	_____	_____	_____	_____	_____
Manufacturer	_____	_____	_____	_____	_____
Model	_____	_____	_____	_____	_____
Type (spray, impact, etc.)	_____	_____	_____	_____	_____
Nozzle or orifice size	_____	_____	_____	_____	_____
Location	_____	_____	_____	_____	_____
Wetted diameter (ft)	_____	_____	_____	_____	_____
Nozzle discharge (gpm)	_____	_____	_____	_____	_____
Design pressure (psi)	_____	_____	_____	_____	_____
Operating pressure	_____	_____	_____	_____	_____

End gun make, model _____ (when continuously used in corners)

End gun capacity _____ gpm, Pressure _____ psi, boosted to _____ psi

End swing lateral capacity _____ gpm, pressure _____ psi

Field observations:

Crop uniformity _____

Runoff _____

Erosion _____

Tower rutting _____

System leaks _____

Elevation change between pivot and end tower _____

Sprinkler Irrigation System Detailed Evaluation Center Pivot Lateral Worksheet

Wind: Speed _____ mph Direction (from) _____
 Line direction: From center to outer tower _____ moving _____
 Time of day _____, Humidity: _____ low _____ med _____ high, Air temp _____
 Evaporation: start depth _____ inches, end depth _____ inches, Evaporation _____ inches
 Crop _____, Root zone depth _____ foot, MAD^{1/} _____ %, MAD _____ inches

Soil-water data (typical): (show location of sample site on soil map or sketch of field)

Moisture determination method _____
 Soil series name, surface texture _____

Depth	Texture	*AWC (in) ^{1/}	*SWD (%) ^{1/}	*SWD (in) ^{1/}
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
Totals		_____	_____	_____

Comments about soils:

Present irrigation practices:

Typical system application:

Crop	Stage of growth percent	Hours per ^{2/} revolution	Speed setting	Net application (in)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Hours operated per day _____ hours
 Approximate number of pivot revolutions per season _____

1/ MAD = Management allowed depletion, AWC = Available water capacity, SWD = Soil water deficit
 2/ To calculate the hours per revolution around the field, first calculate the average speed the end tower moves per cycle (start to start) = distance in feet divided by time in seconds.

Then: hours per revolution =
$$\frac{2 \text{ (distance to end tower in feet)} \times \pi}{\text{(end tower speed in ft/s)} \times 3,600 \text{ seconds per hour}}$$

Sprinkler Irrigation System Detailed Evaluation Center Pivot Lateral Worksheet

System data:

Distance from pivot point to : end tower _____ ft, wetted edge _____ ft

* End tower speed: Distance between stakes _____

Time at first stake _____, Time at second stake _____

Time to travel between stakes _____ min

* This method is satisfactory for a continuous moving system, but need to allow for moving in start-stop cycles.

Recommend using end tower move distance and from start to star. Typically, percent speed setting for end tower represents, 60% = 36 seconds of each minute, 72 seconds of each 2 minutes, etc.

Measured system flow rate _____ gpm, method _____

Calculations: _____

Evaluation computations:

Circumference of end tower:

$$\text{Distance to end tower} \times 2\pi = \frac{(6.2832)}{2} \times \text{Distance to end tower} = \text{_____ ft}$$

End tower speed:

$$\frac{\text{Distance traveled (ft)} \times 60}{\text{Time in minutes}} = \text{_____} \times 60 = \text{_____ ft/hr}$$

Hours per revolution:

$$\frac{\text{Circumference at end tower (ft)}}{\text{End tower speed (ft/hr)}} = \text{_____} = \text{_____ hr}$$

Area irrigated:

$$\frac{(\text{Distance to wetted edge})^2 \times \pi}{43,560 \text{ square feet/acre}} \times \frac{(3.1416)}{43,560} = \text{_____} \times 3.1416 = \text{_____ ac}$$

Gross application per irrigation:

$$\frac{\text{Hours per revolution} \times \text{gpm}}{435 \times \text{acres irrigated}} = \frac{\text{_____}}{453 \times \text{ac}} = \text{_____ in}$$

Weighted system average application:

$$\frac{\text{Sum of: catch x factors}}{(\text{Sum of: factors}) \times \text{number of containers}} = \text{_____} = \text{_____ cc (ml)}$$

Sprinkler Irrigation System Detailed Evaluation Center Pivot Lateral Worksheet

Convert cc (ml) in measuring cylinder to inches depth in catch container:

_____ cc (ml) = 1 inch in catch container

Average application = $\frac{\text{Average catch (cc)}}{\text{cc/inch}}$ = _____ = _____ in

Weighted low 1/4 average application:

$\frac{\text{Sum of low 1/4 catch x factors}}{(\text{Sum of low 1/4 factors}) \times \text{number of low 1/4 containers}}$ = _____ = _____ cc (ml)

Low 1/4 average application = $\frac{\text{Average low 1/4 (cc)}}{\text{cc/inch}}$ = _____ = _____ in

Distribution uniformity low 1/4 a (DU):

DU = $\frac{\text{Weighted low 1/4 average applic.}}{\text{Weighted system average application}}$ = _____ = _____ %

Approximate Christiansen uniformity (CU):

CU = 100 - [0.63 x (100 - DU)] = 100 - [0.63 x (100 - _____)] = _____ %

Effective portion of water applied (R_e):

$R_e = \frac{\text{Weighted system average application (in)}}{\text{Gross applicaiton (in)}}$ = _____ = _____

Application efficiency of low 1/4 (E_q):

$E_q = DU \times R_e =$ _____ = _____ %

(Use for medium to high value crops)

Approximate application efficiency low 1/2 (E_h):

$E_h = DU \times R_e =$ _____ = _____ %

(Use for low value field and forage crops)

Sprinkler Irrigation System Detailed Evaluation Center Pivot Lateral Worksheet

Application:

$$\frac{\text{Gross application x hours operated per day x } (E_q \text{ or } E_h)}{\text{Hours per revolution x 100}}$$

= _____ = _____ in/day

Maximum average application rate:

$$\frac{\text{Maximum catch inches x 60}}{\text{Time containers are uncovered in minutes}} = \text{_____} = \text{_____ in/hr}$$

Pivot revolutions required to replace typical annual moisture deficit:

(Based on existing management procedures)

Annual net irrig. requirement _____ in, for _____ (crop)

Pivot revolutions required:

$$\frac{\text{Annual net irrig. requirement x 100}}{(E_q \text{ or } E_h) \times \text{gross applic. per irrig.}} = \text{_____} = \text{_____}$$

Potential water and cost savings

Present management:

Gross applied per year = gross applied per irrig x number of irrig

= _____ = _____ in/yr

Potential management:

Potential application efficiency (E_{pq} or E_{ph}) _____ percent (from irrigation guide, NEH Sec 15, Ch 11, or other source)

$$\text{Potential annual gross applied} = \frac{\text{Annual net irrig. requirement x 100}}{\text{Potential } E_{pq} \text{ or } E_{ph}}$$

= _____ = _____ inches

Center pivot lateral evaluation, distribution profile of catch

$E_h =$ _____

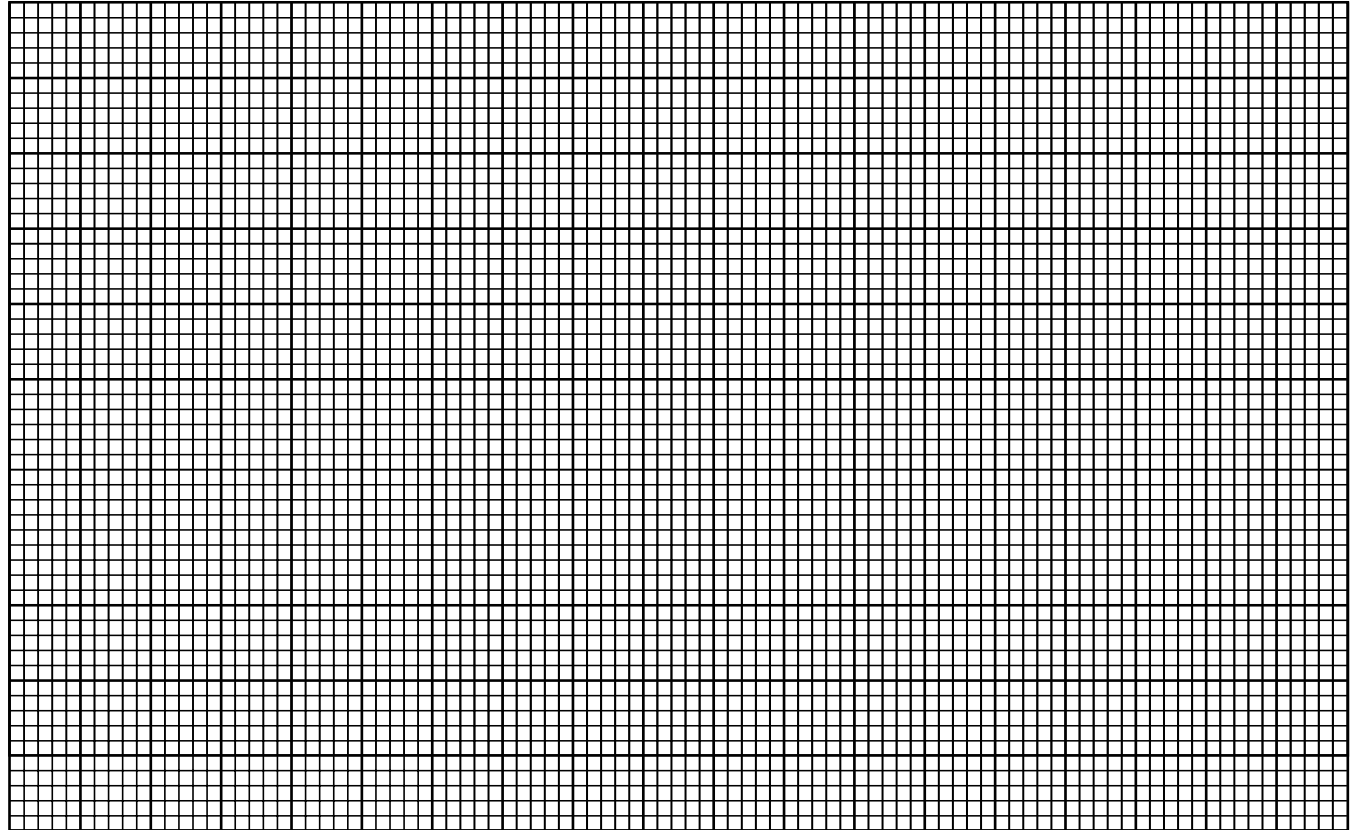
$E_q =$ _____

Land user _____

Date _____

Field office _____

Container catch (inches)



Container number

Sprinkler Irrigation System Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Land user _____ Date _____ Prepared by _____
 District _____ County _____ Eng job class _____

Irrigation system hardware inventory:

Sprinkler gun make _____, model _____, nozzle type _____
 Nozzle: size _____ inches, _____ mm
 Manufacturer rated discharge, _____ gpm at _____ psi giving _____ ft wetted diameter
 Hose: length, _____ ft, diameter _____ inches
 Towpath: spacing _____ ft
 Elevation difference between first and last location on towpath (+/-) _____ ft or _____ % slope
 Gun: height _____ ft
 Mainline: material _____ diameter _____ inches

Field observations:

Crop uniformity _____
 Water runoff _____
 Erosion _____
 System leaks _____
 Wind drift _____
 Other observations _____

Field data inventory and computations:

Crop _____, root zone depth _____ ft, MAD ^{1/} _____ %, MAD ^{1/} _____ inches

Soil-water data (typical):

(Show locations of sample on soil map or sketch of field)

Moisture determination method _____				
Soil series and surface texture _____				
Depth	Texture	AWC (in) ^{1/}	SWD (%) ^{1/}	SWD (in) ^{1/}
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
Totals		_____	_____	_____

Comments about soils and soil condition: _____

^{1/} MAD = Management Allowable depletion, AWC = Available water capacity, SWD = Soil water deficit

Sprinkler Irrigation System Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Present irrigation practices:

Typical irrigation duration _____ hr, irrigation frequency _____ days

Typical number of irrigations per year _____

Test:

Start _____, Stop _____, Duration _____ = _____ hour

Atmospheric data;

Wind: Direction: Initial _____, during _____, final _____

Speed (mph): Initial _____, during _____, final _____

Temperature: initial _____ final _____, humidity: _____ low _____ med _____ high

Evaporation container: initial _____, final _____, loss _____ inches

Pressure: _____ psi, at start of test

_____ psi, at end of test

Measured flow into the system _____gpm

Sprinkler travel speed:

at beginning _____ ft _____ min = _____ ft/min

at test site _____ ft _____ min = _____ ft/min

at terminal end _____ ft _____ min = _____ ft/min

average _____ ft/min

Calculations:

Gross average depth of water applied = $\frac{(\text{gun discharge, gpm}) \times (1.605)}{(\text{tow path spacing, ft}) \times (\text{travel speed, ft/min})}$

= $\left(\frac{\text{gpm}}{\text{ft}} \right) \times (1.605) = \text{_____ in}$

Average overlapped catches

System = $\frac{(\text{sum all catch totals _____ in})}{(\text{number of totals _____})} = \text{_____ in}$

Low 1/4 = $\frac{(\text{sum of low 1/4 catch totals _____ in})}{(\text{number of low 1/4 catches _____})} = \text{_____ in}$

Average application rate = $\frac{(\text{Flow, gpm}) \times (13,624)}{(\text{tow path spacing, ft}) \times (\text{wet sector, deg.})}$

= $\left(\frac{\text{gpm}}{\text{ft}} \right) \times (13,624) = \text{_____ in/hr}$

Maximum application rate = (average application rate, in/hr) x (1.5)

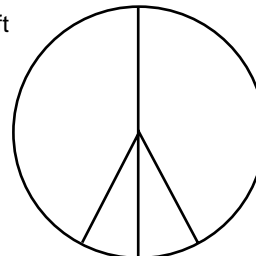
Sprinkler Irrigation System Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Container test data

Catch can type _____, _____ cc (mL)/in

Left Right

Note part circle operation
 and the dry wedge size in degrees



← 4, 3, 2, 1 Container catch row 1, 2, 3, 4 →

Path spacing (ft)	Container catch volume				Right plus left side catch totals	
	Left side of path		Right side of path		mL	inches
	Catch no.	Catch (mL)	Catch no.	Catch (mL)		
330	1		33			
320	2		32			
310	3		31			
300	4		30			
290	5		29			
280	6		28			
270	7		27			
260	8		26			
250	9		25			
240	10		24			
230	11		23			
220	12		22			
210	13		21			
200	14		20			
190	15		19			
180	16		18			
170	17		17			
160	18		16			
150	19		15			
140	20		14			
130	21		13			
120	22		12			
110	23		11			
100	24		10			
90	25		9			
80	26		8			
70	27		7			
60	28		6			
50	29		5			
40	30		4			
30	31		3			
20	32		2			
10	33		1			

Sum of all catch totals _____

Sum of low 1/4 catch totals _____

Sprinkler Irrigation System Detailed Evaluation Continuous Move, Large Sprinkler Gun Type

Potential water and cost savings:

Present management:

Gross applied per year = (Gross applied per irrigation) x (number of irrigation) = _____ in/yr
 + (_____ in) x (_____) = _____ in/yr

Potential management:

Annual net irrigation requirement _____ in/yr, for _____ (crop)

Potential application efficiency (E_q or E_h) _____ % (estimated at 55 - 65%)

Potential annual gross applied = $\frac{\text{(annual net irrigation requirement)} \times 100}{\text{Potential } E_q \text{ or } E_h}$ = _____ in

= (_____ in) x 100 = _____ inches

Total annual water conserved

= $\frac{\text{(Present gross applied, inches - potential gross applied, inches)}}{12}$ x (area irrigated, ac) = _____ ac-ft

= $\frac{\text{(_____ in) - (_____ in)} \times \text{(_____ ac)}}{12}$ = _____ ac-ft

Cost savings:

Pumping plant efficiency _____ kind of energy _____

Cost per unit of energy \$ _____ energy cost per ac-ft \$ _____

Cost savings = (energy cost per ac-ft) x (ac-ft conserved per year) = \$ _____

= (_____) x (_____) = \$ _____

Water purchase cost:

= (Cost per ac-ft) x (ac-ft saved per year) = \$ _____ x _____ = \$ _____

Cost savings:

= Pumping cost + water cost = _____ + _____ = \$ _____

Micro Irrigation System Detailed Evaluation Worksheet

Land user _____ Date _____ Prepared by _____

District _____ County _____

Crop: _____ age _____ plant and row spacing _____

Soil: mapping unit _____ surface texture _____

actual depth _____ AWC _____ inches/feet

Irrigation: duration _____ frequency _____ MAD _____ % _____ inches/feet

Irrigation system hardware:

Filter: pressure at: inlet _____ psi, outlet _____ psi, loss _____ psi

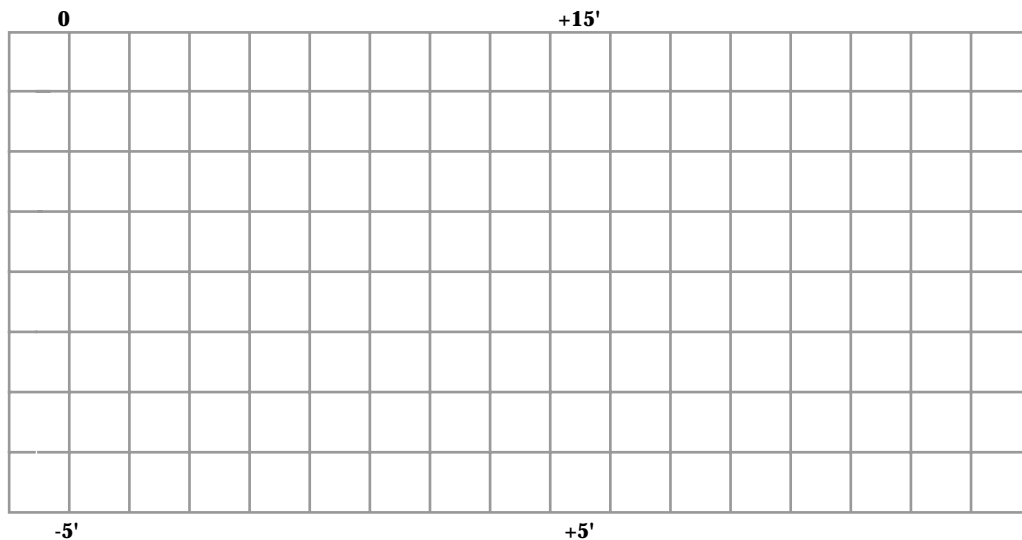
Emitter: manufacturer _____ type _____ spacing _____

Rated discharge per emitter (emission point): _____ gph at _____ psi

Emission points per plant _____ giving _____ gallons per plant per day

Later: diameter: _____ material _____ length _____ spacing _____

Sketch of micro irrigation system layout:



Micro Irrigation System Detailed Evaluation Worksheet

System discharge: _____ gpm, number of manifolds _____ and blocks _____

Average test manifold emission point discharges at _____ psi

Manifold = $\frac{(\text{sum of all averages } \text{gph})}{(\text{number of averages})} = \text{_____ gph}$

Low 1/4 = $\frac{(\text{sum of low 1/4 averages } \text{gph})}{(\text{number of low 1/4 averages})} = \text{_____ gph}$

Adjusted average emission point discharges at _____ psi

System = (DCF _____) x (manifold average _____) = _____ gph

Low 1/4 = (DCF _____) x (manifold low 1/4 _____) = _____ gph

Discharge test volume collected in _____ minutes (1.0 gph = 63 ML/min)

Outlet location on lateral		Lateral location on the manifold							
		inlet end		1/3 down		2/3 down		far end	
		mL	gph	mL	gph	mL	gph	mL	gph
inlet end	A								
	B								
ave									
1/3 down	A								
	B								
ave									
2/3 down	A								
	B								
ave									
far end	A								
	B								
ave									

Micro Irrigation System Detailed Evaluation Worksheet (cont.)

Lateral: inlet pressure _____ psi _____ psi _____ psi _____ psi
 far end pressure _____ psi _____ psi _____ psi _____ psi
 Wetted area per plant _____ ft² _____ ft² _____ ft² _____ ft²
 _____ % _____ % _____ % _____ %

Estimated average SMD in wetted soil volume _____

Minimum lateral inlet pressures, MLIP, on all operating, manifolds:

Manifold ID: Test _____ _____ _____ _____ _____ _____ _____ _____ _____ Ave.
 pressure, psi _____ _____ _____ _____ _____ _____ _____ _____ _____

Discharge correction factor, DCF, for the system is:

$$DCF = \frac{2.5 \times (\text{average MLIP} \quad \text{psi})}{(\text{average MLIP} \quad \text{psi} + (1.5 \times \text{test MLIP} \quad \text{psi}))} = \quad \text{psi}$$

or if the emitter discharge exponent, x = _____ is known,

$$DCF = \frac{(\text{average MLIP} \quad \text{psi})}{(\text{test MLIP} \quad \text{psi})} \times \text{-----} = \quad \text{psi}$$

Comments: _____

Pumping Plant Detailed Evaluation Worksheet

Land user _____ Field office _____
Observer _____ Date _____ Checked by _____ Date _____
Field name or number _____ Acres irrigated _____

Hardware Inventory:

Power plant:

Electric motor(s):	<u>Main pump</u>	<u>Booster (if used)</u>
Make	_____	_____
Model	_____	_____
Rated rpm	_____	_____
Rated hp	_____	_____

Internal combustion engine:

Make _____
Model _____
Continuous rated hp at output shaft _____ hp at _____ rpm
Comments about condition of power plant _____

Gear or belt drive mechanism:

Type: (check one) direct drive _____ gear drive _____ belt drive _____
_____ rpm at driver _____ rpm at pump

Pumps

Type: (centrifugal, turbine, submers.)	_____	_____
Make	_____	_____
Model	_____	_____
Impeller diameter	_____	_____
Number of impellers	_____	_____
Rated flow rate (gpm)	_____	_____
at head of (ft)	_____	_____
at rpm	_____	_____

Pump curves: Attached _____ (yes or no)

Comments about condition of equipment _____

Pumping Plant Detailed Evaluation Worksheet

Land user _____ Field office _____

Existing suction or turbine column set-up (sketch showing dimensions)

Existing discharge set-up (sketch showing dimensions)

Data and computations:

Total Dynamic Head (TDH):

Elevation difference - water surface to pump outlet _____ feet

Pressure reading at pump outlet _____ psi

Pressure at pump inlet (where supply is pressurized) _____ psi

Estimated friction loss in suction pipe or pump column _____ feet

Miscellaneous friction loss _____ feet

TDH = (elevation difference between water source and pump discharge) + (discharge pressure - pressure at inlet) times 2.31 + (estimated suction pipe friction loss) + miscellaneous =

_____ = _____ feet

Flow rate:

Flow meter:

Flow rate = _____ gpm

Velocity meter:

Pipe ID _____ inches

Velocity _____ feet/second

Flow rate, Q, in gpm = (Velocity, in feet/second) x (2.45) x (pipe ID²) =

= _____ = _____ gpm

Pumping Plant Detailed Evaluation Worksheet

Land user _____ Field office _____

Water horsepower:

$$\text{whp} = \frac{(\text{flow rate, in gpm}) \times (\text{TDH, in feet})}{3960} = \text{_____ hp}$$

Energy input

Electric:

Disk revolutions _____

Time: min _____ sec _____ = _____ sec

Meter constant (Kh) _____

PTR (power transformer ratio - usually 1.0)^{1/} _____

CTR (current transformer ratio - usually 1.0)^{1/} _____

$$\text{KW} = \frac{(3.6) \times (\text{disk rev}) \times (\text{Kh}) \times (\text{PTR}) \times (\text{CTR})}{(\text{time, in seconds})} = \text{_____ (kwh/h)}$$

Diesel or gasoline:

Evaluation time: hours _____ minutes _____ = _____ hours

Fuel use _____ gallons (a small quantity of fuel may also be weighed, at 7.05 lb/gal for diesel and 6.0 lb/gallon for gasoline)

$$\frac{(\text{fuel use, in gallons})}{(\text{time, in hours})} = \text{_____} = \text{_____ gallons/hour}$$

Propane:

Evaluation time: hours _____ minutes _____ = _____ hours

Fuel use _____ lb (weigh fuel used from small portable tank)

$$\frac{(\text{fuel use, in lb})}{(4.25 \text{ lb/gal}) \times (\text{time, in hr})} = \text{_____} = \text{_____ gallon/hours}$$

Natural gas:

Evaluation time: hours _____ minutes _____ = _____ hours

Meter reading: End _____ minus Start _____ = _____ mcf

$$\frac{(\text{fuel used, in mcf})}{(\text{time, in hr})} = \text{_____} = \text{_____ mcf/hr}$$

^{1/} Some power companies use a type of meter that requires a PTR or CTR correction factor. Check with local power company.

Pumping Plant Detailed Evaluation Worksheet

Land user _____ Field office _____

In the next step, the efficiency of the power plant and pump, as a unit, is compared to the Nebraska Standards for irrigation pumping plants. The Nebraska standard for a good condition, properly operated plant. If the comparison comes out less than 100%, there is room for improvement.

Nebraska performance rating:

Nebraska pumping plant performance criteria _____

Pump and Power Plant

Energy source	Whp-h/unit of energy	Energy unit
Diesel	12.5	gallon
Propane	6.89	gallon
Natural gas	61.7	mcf
Electricity	0.885	kW=kwh/hr
Gasoline	8.66	gallon

The Nebraska standards assume 75% pump and 88% electric motor efficiency.

Percent of Nebraska performance rating

$$= \frac{\text{(whp)} \times (100)}{\text{(energy input)} \times \text{(Nebraska criteria, in whp-h/unit)}} =$$

$$= \text{_____} = \text{_____} \%$$

Horsepower input:

Electric:

$$\frac{\text{(input kW)}}{(0.746 \text{ kW/bhp})} = \text{_____} = \text{_____} \text{ bhp}$$

Diesel:

$$(16.66) \times \text{(energy input, in gal/hr)} = \text{_____} = \text{_____} \text{ bhp}$$

Propane:

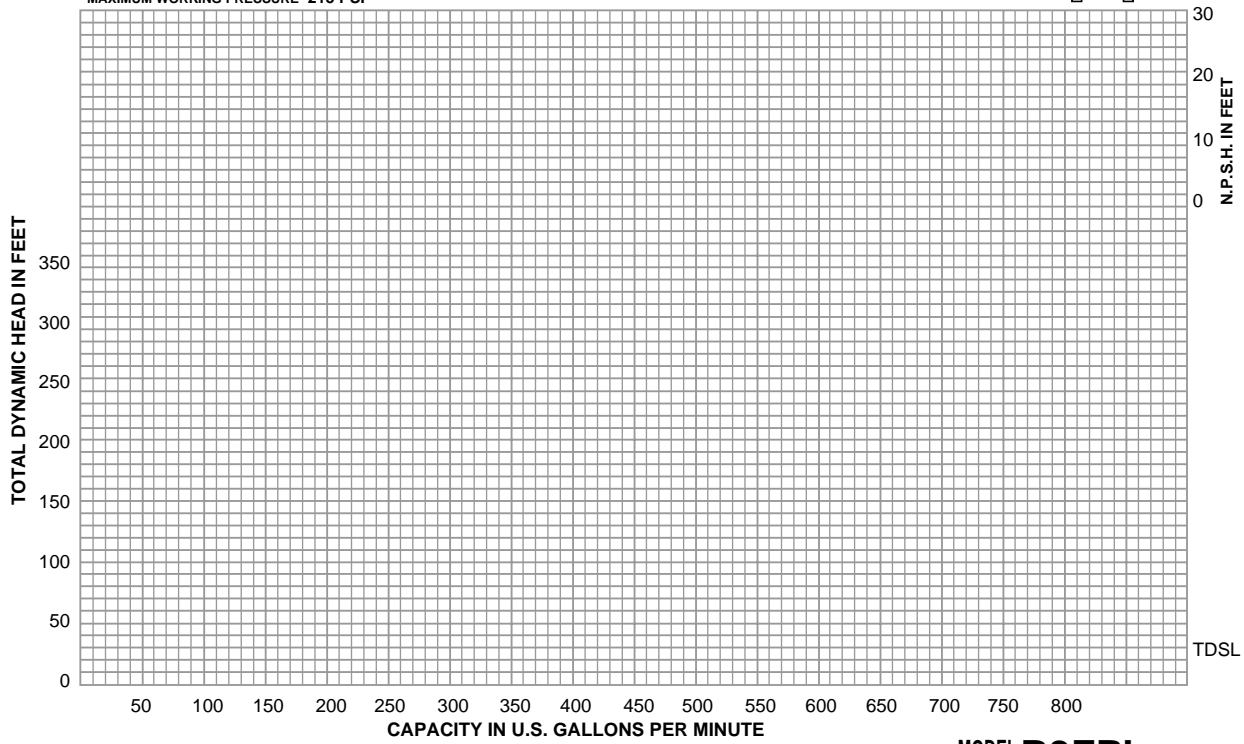
$$(9.20) \times \text{(energy input, in gal/hr)} = \text{_____} = \text{_____} \text{ bhp}$$

Natural gas:

$$(82.20) \times \text{(energy input, in mcf/hr)} = \text{_____} = \text{_____} \text{ bhp}$$

Pump performance curve

Case: Material C.I. Patt. No. H-689 Mach. No. H-689 3600 NOMINAL R.P.M. 60 Cycles
Impeller: Material BRZ Patt. No. M-3380 Mach. No. M-3380 Dia. 9" FULL T.D.B.L. for fresh water at sea level 80° F max.
MAXIMUM WORKING PRESSURE 215 PSI M-1 M-2



Based on T-3184

Superaades C-5006 Dated 10-30-64

Date 5-19-71

MODEL **B3ZPL**

Cylinder Infiltrometer Test Data

FARM	COUNTY	STATE	LEGAL DESCRIPTION	DATE
SOIL MAPPING SYMBOL	SOIL TYPE		SOIL MOISTURE:	
CROP	STAGE OF GROWTH			

GENERAL COMMENTS

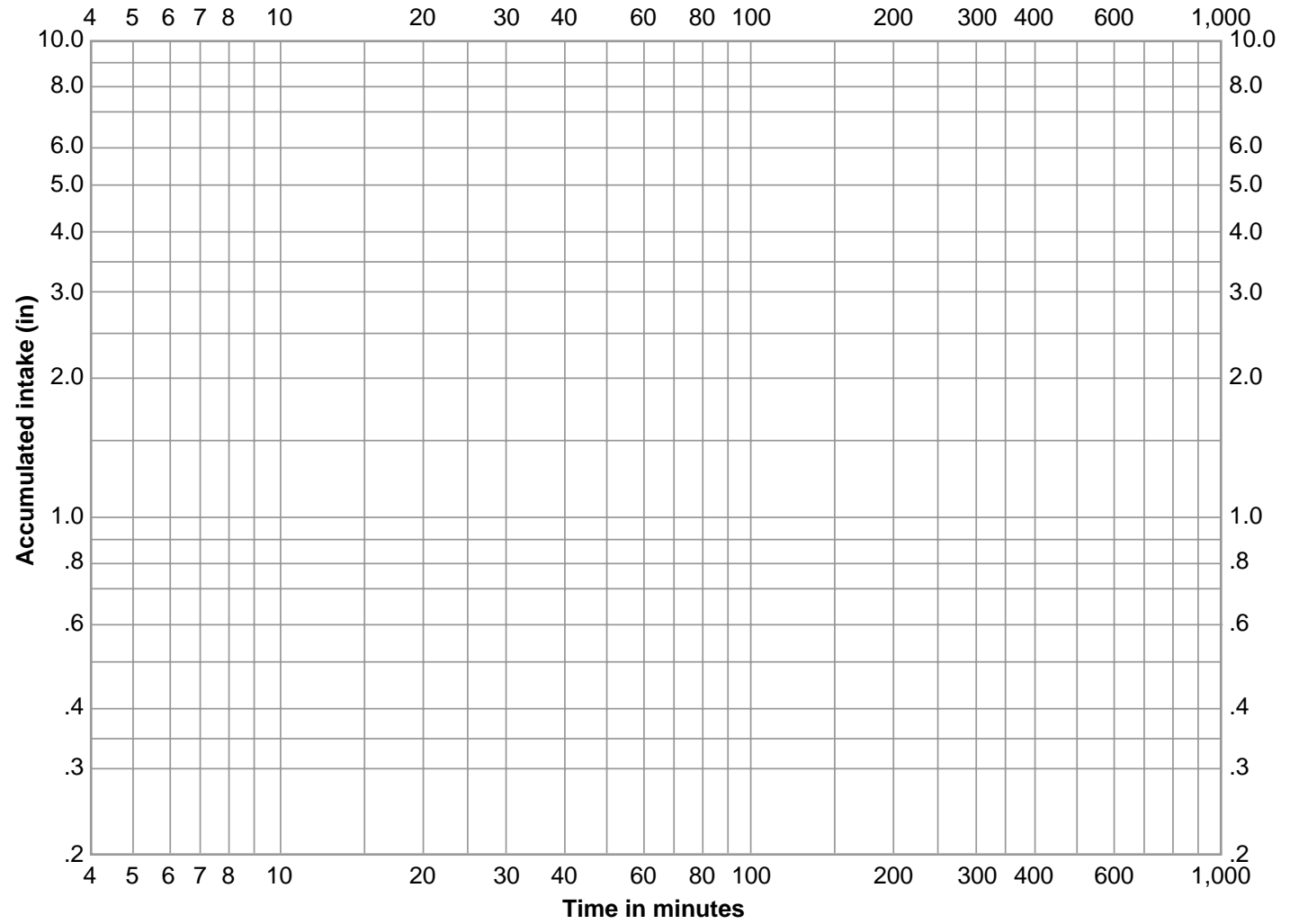
Elapsed time	Cylinder No. 1			Cylinder No. 2			Cylinder No. 3			Cylinder No. 4			Cylinder No. 5			Average accum. intake
	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	Time of reading	Hook gauge reading	Accum. intake	
	Min.	Inches		Min.	Inches		Min.	Inches		Min.	Inches		Min.	Inches		

Land user _____

Date _____

Field office _____

Soil water intake curves



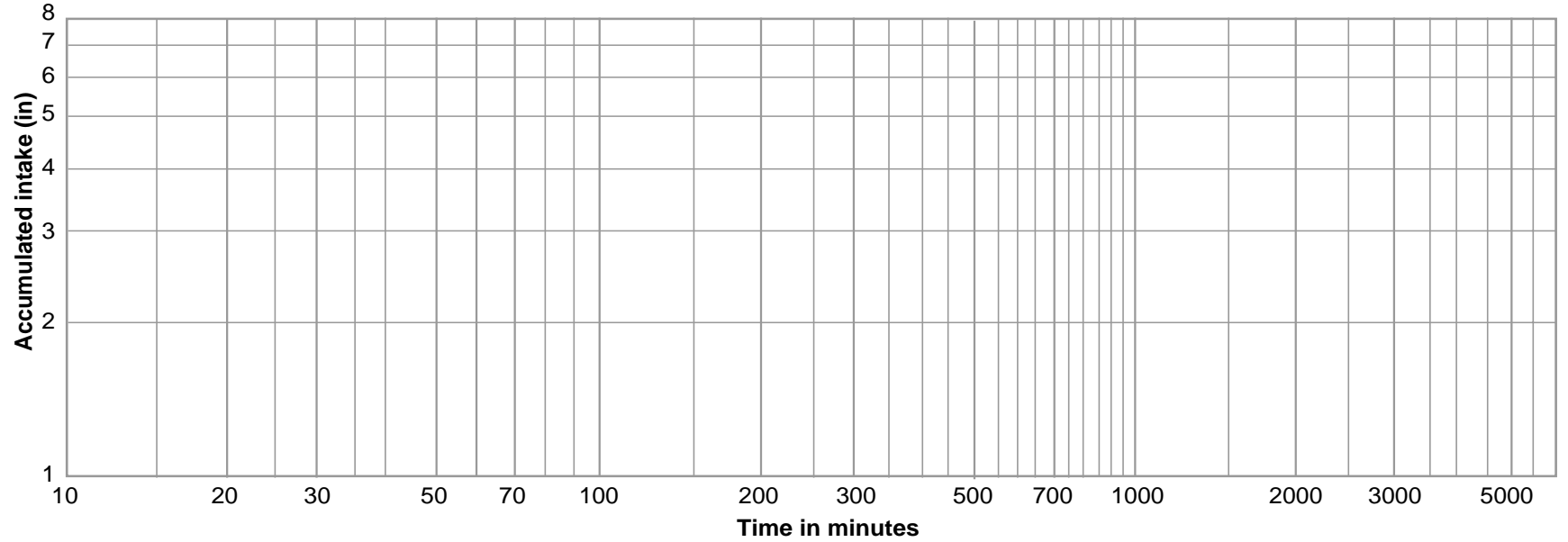
Intake curve overlay

(Clear plastic overlay is available through NRCS State Office)

Land user _____

Date _____

Field office _____



Intake Grouping for Border Irrigation Design

Instructions

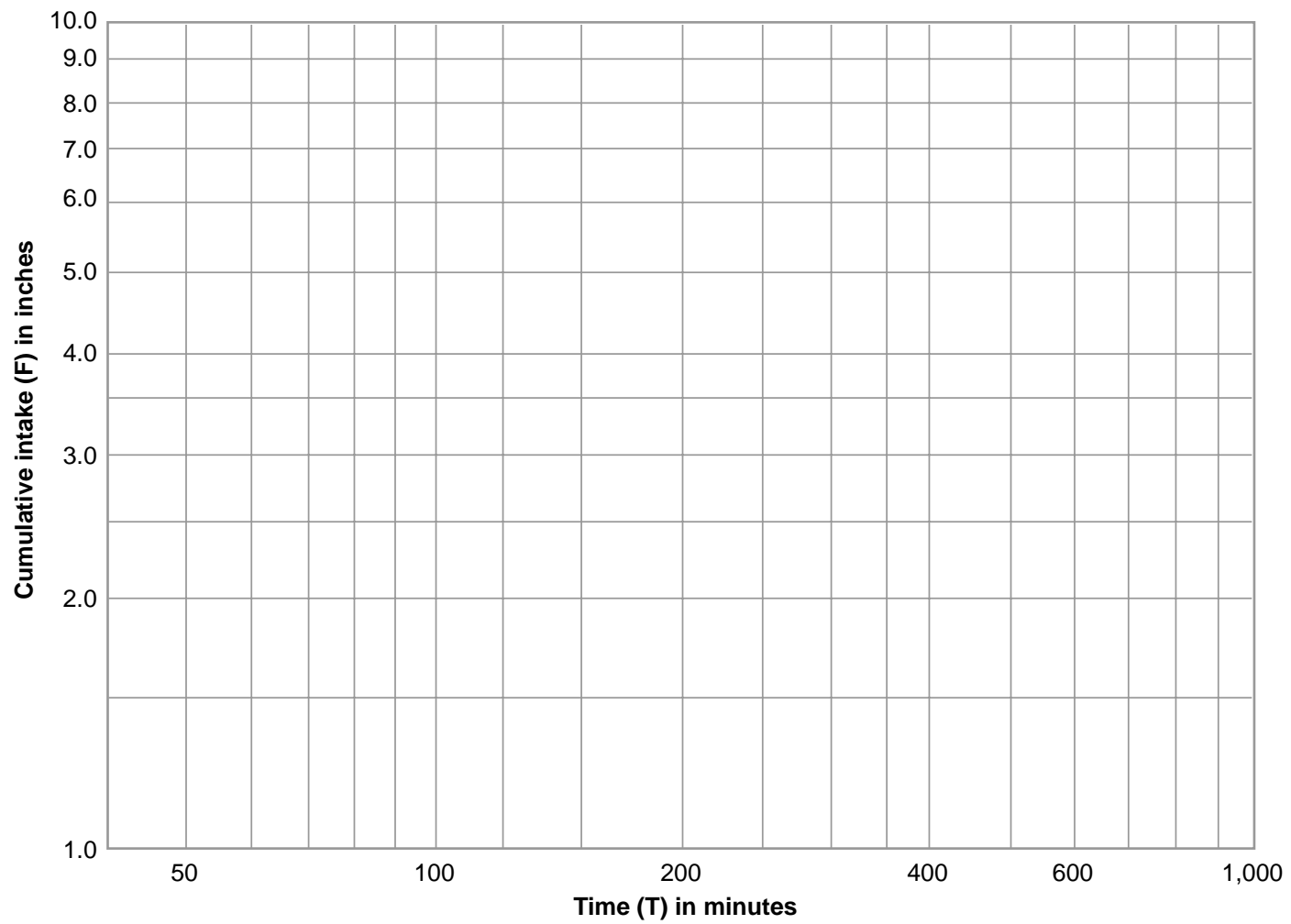
1. Plot data from cylinder intake test on matching logarithmic paper using accumulated intake (inches) as ordinates and elapsed time (minutes) as abscissas. Draw line representing test results.
2. Place overlay over plotted curve, matching the intersection of the lines for 10 minutes time and 1 inch intake. Select the intake family that best represents the plotted curve within the normal irrigation range.

Land user _____

Date _____

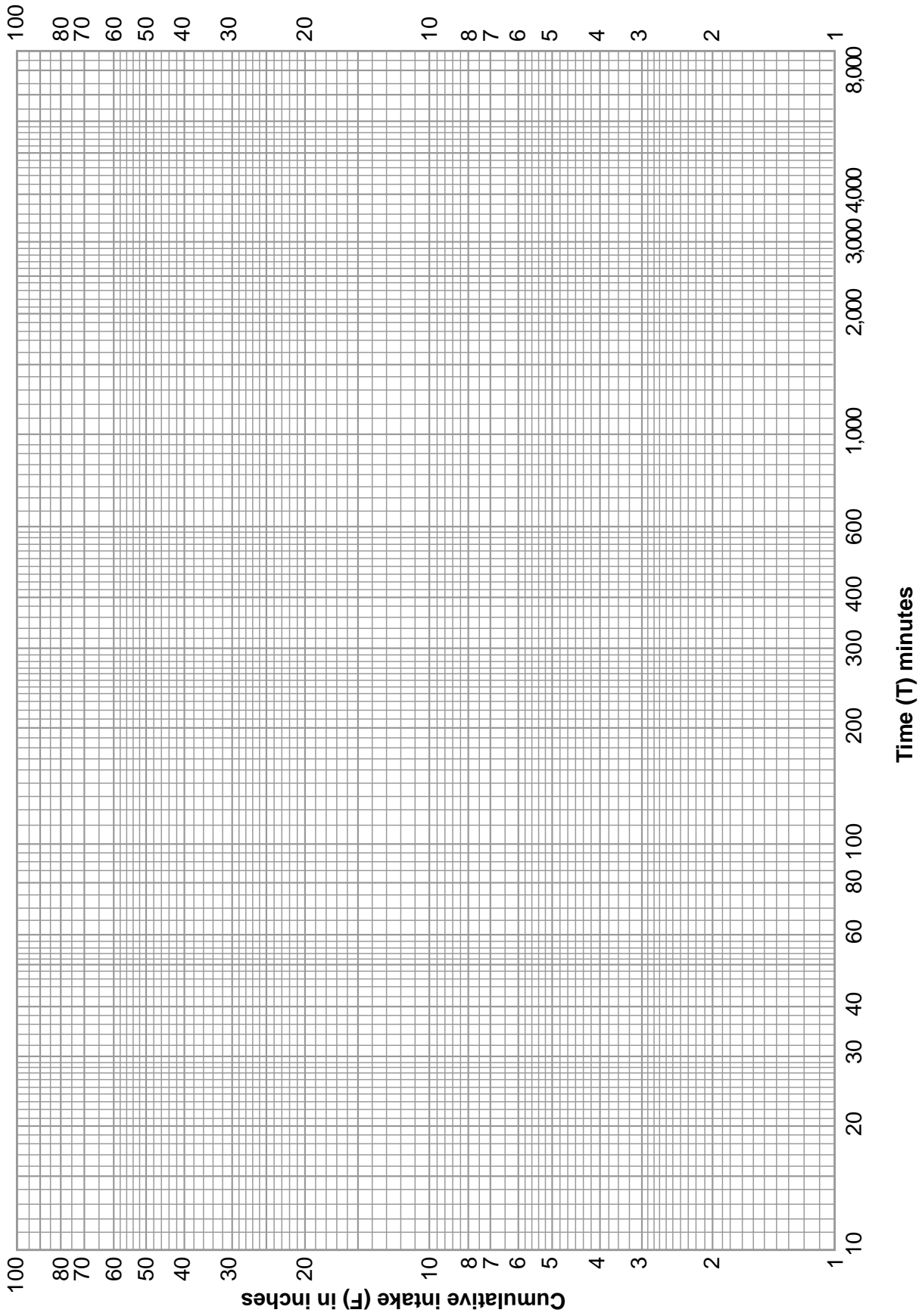
Field office _____

Accumulated intake vs. time



Land user _____
Date _____
Field office _____

Intake families as used with furrow irrigation





Natural Resources Conservation Service

Estimating Soil Moisture by Feel and Appearance

Irrigation Water Management (IWM) is applying water according to crop needs in an amount that can be stored in the plant zone of the soil.

The feel and appearance method is one of several irrigation scheduling methods used in IWM. It is a way of monitoring soil moisture to determine when to irrigate and how much water to apply. Applying too much water may cause excessive runoff and/or deep percolation. As a result, nutrients and chemicals may be lost or leached into the ground water.

In applying this method, you determine the amount of irrigation water needed by subtracting water in soil storage (estimated using the feel and appearance method) from the available water capacity (AWC) of the soil. (See the example computation below.)

The feel and appearance of soil varies with texture and moisture content. Water available for plant use can be estimated, with experience, to an accuracy of about 5 percent. Soil moisture is typically sampled in

1-foot increments to the root depth of the crop at three or more sites per field. You vary the number of sample sites and depths according to: crop, field size, soil texture, and soil stratification. For each sample the feel and appearance method involves:

1. Obtaining a soil sample at the selected depth using a probe, auger, or shovel;
2. Squeezing the soil sample firmly in your hand several times to form an irregularly shaped ball;
3. Observing soil texture, ability to ribbon, firmness and surface roughness of ball, water glistening, loose soil particles, soil/water staining on fingers, and soil color;
4. Comparing observations with photographs and/or chart to estimate percent water available. (Note: A very weak ball disintegrates with one bounce of the hand. A weak ball disintegrates with 2 to 3 bounces.)

Example for a uniform soil

Sample depth (inches)	Zone (inches)	USDA texture	Field capacity* (percent)	AWC for layer (inches)	Water available (inches)	Water need (inches)
6	0-12	sandy loam	30	1.4	.42	.98
18	12-24	sandy loam	45	1.4	.63	.77
30	24-36	loam	60	2.0	1.20	.80
42	36-48	loam	75	2.0	1.50	.50
				6.8	3.75	3.05

* Determined by feel and appearance method




Summary of estimation

	(inches)
AWC in 48" root zone at 100% field capacity	6.8
Actual water available for plant use	3.7
Net irrigation requirement or need	3.1

Fine sand and loamy fine sand soils

Appearance of fine sand and loamy fine sand soils at various soil moisture conditions.




Available water capacity 0.6–1.2 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, will hold together if not disturbed, loose sand grains on fingers.	
25-50	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remain on fingers.	
50-75	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, light uneven water staining on fingers.	
75-100	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.	
100 (field capacity)	Wet, forms a weak ball, light to heavy soil/water coating on fingers, wet outline of soft ball remains on hand.	

Sandy loam and fine sandy loam soils




Appearance of sandy loam and fine sandy loam soils at various soil moisture conditions.

Available Water Capacity 1.3–1.7 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, forms a very weak ball, aggregated soil grains break away easily from ball.	
25-50	Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers.	
50-75	Moist, forms a ball with defined finger marks, very light soil/water staining on fingers, darkened color, will not slick.	
75-100	Wet, forms a ball with wet outline left on hand, light to medium staining on fingers, makes a weak ribbon.	
100 (field capacity)	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers.	

Sandy clay loam and loam soils




Appearance of sandy clay loam and loam soils at various soil moisture conditions.
 Available Water Capacity..... 1.5–2.1 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, soil aggregations break away easily, no staining on fingers, clods crumble with applied pressure.	
25-50	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.	
50-75	Moist, forms a ball, very light staining on fingers, darkened color, pliable, forms a weak ribbon.	
75-100	Wet, forms a ball with well defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.	
100 (field capacity)	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, thick soil/water coating on fingers.	

Clay, clay loam and silty clay loam soils

Appearance of clay, clay loam and silty clay loam soils at various soil moisture conditions.

Available Water Capacity 1.6–2.4 inches/foot

Available Soil Moisture	Description	Illustration
0-25	Appears dry, soil aggregations separate easily, clods are hard to crumble with applied pressure.	
25-50	Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.	
50-75	Moist, forms a smooth ball with defined finger marks, light staining on fingers, ribbons between thumb and forefinger.	
75-100	Wet, forms a ball, uneven medium to heavy soil/water coating on fingers, ribbons easily.	
100 (field capacity)	Wet, forms a soft ball, free water appears on soil after squeezing or shaking, thick soil/water coating on fingers, slick and sticky.	