
Chapter 10

Conservation Management Systems and Irrigation Planning

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652.1000 General

The material in chapter 10 is intended to help the consultant assist users of irrigated land plan conservation management systems that maintain productivity of the soil, water, air, plant, and animal (SWAPA) resource base as well as take into account human considerations (social, economic, and cultural). Conservation management systems consider the total farm or ranch environment, including the watershed, airshed, and environment in which it exists. Conservation management can involve one or more resource management systems. Irrigation system planning must consider the potential interactive effect on SWAPA resources plus how an action may affect the onsite and offsite human environment. **An irrigation system plan is a component of an overall farm conservation plan.** Irrigation system planning includes:

- Sustaining or improving soil condition (includes productivity)
- Maintaining or improving surface and ground water quality and quantity
- Wise use of limited water supplies
- Providing a condition healthful for growing plants without degrading other resources
- Consideration of domestic animals and wildlife
- Impacts on soil erosion and deposition
- Consideration of human needs

Conservation irrigation planning requires the development of conservation management systems. A conservation management system is a combination of conservation practices that when installed and maintained will protect the SWAPA resource base. Included are meeting tolerable soil losses, maintaining acceptable water quality, conserving limited water supplies, providing equal or greater returns, and maintaining acceptable ecological and management levels for the selected use. Conservation management systems also include conservation practices that improve the quality of the environment and standard of living of those living on the land. To an irrigator this can mean reducing water and energy use, controlling erosion, improving crop yield, improving product quality, and maintaining productivity of the land.

The art and science of planning involve working closely with the irrigation decisionmaker to understand objectives and concerns and to identify resource problems. This requires a resource inventory to develop the foundation on which to base alternative conservation management systems. Alternatives must be presented to the user in such a way that details can be easily understood and informed decisions can be made. Implementation requires quality and detailed plans. Installation of an irrigation system and components should be completed according to these plans. Daily management, operation, and maintenance of the irrigation system must be included in the plan with costs and benefits identified.

Planning is a continuing process, not an end product in itself. Planning has value only if implemented. A cooperator's objectives change as do economic conditions. Follow-up assistance may be required to address these changes and to make adjustments in conservation resource management. Even with detailed planning and design, most irrigation related recommendations are estimates and must be adjusted under actual field conditions. The management plan must take these factors into account.

652.1001 Objectives of an irrigation plan

The irrigation plan helps implement the irrigation component of an overall farm conservation resource management. The plan is the result of a joint effort between the consultant, owner, operator, and the irrigation decisionmaker in which technical knowledge and experience are pooled. An irrigation plan follows the nine steps of planning (NRCS National Planning Procedures Handbook) and encompasses all aspects of planning on irrigated land. The plan includes determining the water user's objectives and problems, SWAPA resource inventories, alternative analysis, and decisionmaking. Irrigation system operation and maintenance plans are a part of irrigation system planning. Coordination with cropping system plans, irrigation system plans, drainage plans, irrigation water management plans, and follow-up plans is essential.

(a) Written plans

Written documentation is essential for use by the decisionmaker. Documentation of the irrigation plan should be used in decisionmaking processes and as a guide to carry out the plan. Irrigation plan documentation may be presented as one document or, more likely, as several documents over a period of time depending on the stage of planning.

Written documentation should be thoroughly discussed with and understood by the decisionmaker. The type and amount of information that must be presented and when the information is needed have a bearing on the form of written documentation. The minimum content of the plan is up to the professional judgment of the persons (consultant and decisionmaker) preparing the plan. The desires of the decisionmaker should always be reflected. As a minimum, the plan should identify irrigation scheduling methods and the chosen method, the irrigation system to be used, and an operation and maintenance plan.

The individual(s) preparing the plan must decide the amount of detail that planning should involve and the

content of written plan documents. Information given to the decisionmaker must be clearly understood, usable, and not cluttered with unneeded material.

(b) Degree of planning

Irrigation planning can be complex, involving environmental assessments and impacts, agronomy, soil, animal husbandry, engineering, economics, ecology, and farm and ranch management. On the other hand, it can be direct, addressing only one concern and its effect on the environment. Plan preparation and content should be based on the irrigation decisionmaker's needs and identified resource concerns.

An conservation planning process considers the farm, ranch, or community as a whole even if the decisionmaker is interested in only one field or practice. This can ensure that delivery system components of pipelines and ditches are an adequate size and elevation to service all the unit. Should operators choose not to size a pipeline or ditch for the expanded system, they should understand the pipeline or ditch may need to be enlarged or supplemented when the current irrigation system is expanded. The conservation planning process also helps assure the irrigation operation fits into the rest of the farm or ranch operation. The total farm water supply (rate, volume, and availability) should be inventoried to help assure proper irrigation in the selected area.

Implementation of the irrigation plan may begin with one field, one ditch, or one pipeline and may continue for several years. Revisions may be needed because of the constantly changing farm economy and changing client objectives.

Clients may have strong feelings about certain irrigation methods or systems. Even so, they deserve information on the best available systems and management techniques that will meet both their needs and those of the site. Pros and cons, including labor and economic considerations, of the best fit systems need to be provided. The decisionmaker can then make an informed choice from alternatives presented.

Often the irrigation water user wants technical help, cost share, or both, on a single practice. A planner's skill is reflected in how well the opportunity is used to

promote conservation of primary soil and water resources, and how well NRCS consultants work with the water user to plan a sound conservation management system for irrigated land.

652.1002 The planning process

The planning process involves nine basic steps in the development of a total conservation management system. They involve:

- Irrigation system and components
- Soils, crops, and tillage management
- Irrigation system operation and maintenance
- Water management

Planning process steps are:

Step 1 Identify the problem including resources of concern—Water source, quality, and quantity; soil erosion; labor; energy.

Step 2 Determine objectives—Water user's desires and needs, community resources of concern, and other such information.

Step 3 Inventory the resources—Soils, water, air, plant, and animal resources, including drainage, salinity, existing irrigation system, and labor available.

Step 4 Analyze resource data—Consider the effect each resource has on the others.

Step 5 Formulate alternatives—Irrigation method, system, components. Include irrigation scheduling methods appropriate for the user.

Step 6 Evaluate alternatives—Consider potential environmental impacts, costs, and on-farm labor and skill availability.

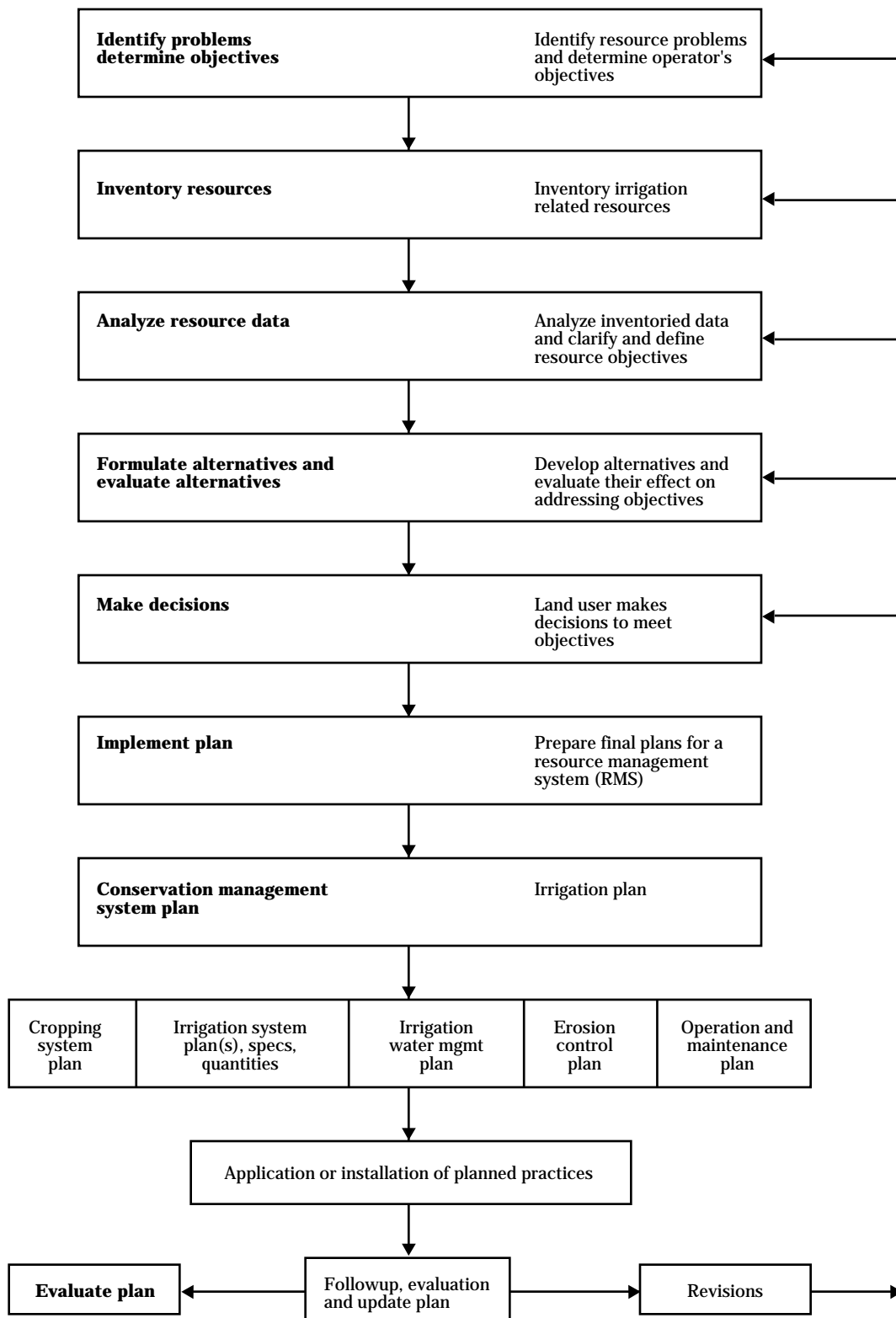
Step 7 Water user decision—Which irrigation method, system, and components to use; and, overall water management desires.

Step 8 Water user implements irrigation plan.

Step 9 Followup—Evaluating results of plan implementation, onsite and offsite. Revise plan as needed.

See NRCS National Planning Procedures Handbook (NPPH) for more detailed information on the NRCS planning process. A flowchart illustrating this process is displayed in figure 10-1.

Figure 10-1 Irrigation planning process



(a) Determining problems and objectives

One of the most important steps in the planning process is to determine the water user's objectives and concerns. One of the best ways to do this is to walk the fields to be planned with the user. Look around, look at the next field, dig or auger some holes, use a probe, check root development of previous crops, talk about what you see, and **listen**. Expand the inquiry beyond the boundary of the original request for assistance. If the request was for a specific practice or irrigation system component, what thought was given to how the practice fits into overall resource conservation operations?

Ask the water user what the objectives, concerns, and problems are. (Problems may be real or perceived.) Consider how individual actions within one resource impact other resources, both onsite and offsite. Identify planning objectives for each resource of concern. Encourage the user to make these objectives a part of the irrigation plan. Objectives can include:

- Protecting the soil from excessive erosion
- Maintaining or improving community water quality
- Reducing dependency upon selected farm chemicals
- Sustaining productivity of soil to grow plants
- Conserving water where supply is limited, and wise use of water where supply is not limited
- Promoting fish and wildlife habitat
- Reducing energy use
- Identify the true decisionmaker involved in day-to-day (and perhaps hourly) decisions concerning operation of the irrigation system. The decisionmaker can be the owner, operator, or the irrigator. Typically all three (even if one person fills all three roles) are involved and should be a part of the planning process.

(b) Resource inventory and analysis of data

The soil, water, air, plant, and animal resource inventory is an information collection process. It provides information needed to prepare the irrigation plan. The first phase, the resource inventory, is performed during the field visit as part of the previous step. Then data must be analyzed. Some of the more important

resource data required for planning are soils, crops, topography, water supply, existing physical features, existing irrigation systems, water table presence, existing drainage systems, environmental factors, present farm operation, skill and labor available, operators desires and concerns, and energy resources.

(1) Soils

The soil survey, where available, is a prime source for soils information. The survey gives a good indication of what can be expected in a specific field; however, it generally is not in great enough detail to provide all information needed for detailed planning and design on irrigated cropland, hayland, or pasture land. Additional field investigation is generally necessary to identify actual surface soil texture(s) and plant root zone volume.

On alluvial fans the action of flowing water has resulted in many soil inclusions and variations within fields. Observation of crops and soil color sometimes gives a clue as to soil differences. The irrigator may be able to identify some of the soil problems. With use of a hand auger, and a little experience, planners can gain enough information about soils based on their own field investigations to do an adequate job of planning.

Never assume a plant root zone depth. Excavate a 12- to 18-inch-deep pit or use a soil auger to observe (and measure) onsite root development patterns and depths.

Nearly all soils are affected by field equipment caused compaction. Compaction, especially tillage pans, can limit plant root development and water measurement. Overirrigation can also limit root development patterns. An otherwise deep soil responds as a shallow soil if root zone volumes are limited by cultural practices on that field. Onsite cultural practices often limit root development to the soil volume above a tillage pan.

Critical data, such as available water capacity and intake rates, may require taking tests on soils in specific fields. These parameters vary even within the same soil series. Judgment must be used by the planner in determining how reliable existing data are and if additional detail surveying and testing are needed. Other basic considerations include crop rooting depths, soil salinity and sodicity, soil acidity, presence of a water table, drainage problems, erosion and sedimentation problems, and soil condition.

(2) Crops

Crops most likely to be grown should be identified and peak crop evapotranspiration (ET_c) by these crops determined. Net irrigation requirement and frequency of irrigation need to be determined based on soils and crops grown and the amount of risk the owner wishes to assume. Determine what crop yields and product quality have been typical in the past. Find out from the water user what cultural practices have been used. They may include cultivation sequence, equipment used, width of equipment (cultivators, haying equipment), crop varieties, fertilizer usage and time of application, crop rotations, and planting and harvest dates. Discuss crops and cultural practices that might be used in a planned cropping system.

(3) Topography

Determine high and low points in each field and the direction of irrigation for surface irrigation and surface drainage. Simple bench level surveys may be required to obtain spot elevations. A detailed topographic or grid survey is expedient for selecting alternatives for detailed planning and design of specific irrigation systems and determining if intensive land leveling or reorganization is needed. A detailed topographic map is often necessary for planning and designing micro and low pressure sprinkler irrigation systems. Small changes in elevation can have large effects on irrigation uniformity when using low pressure irrigation systems.

(4) Water supply

Determine flow rate (when available), source location, and elevation of water supply. Water quality, including chemical content, sediment, and debris loads also need to be determined. Quality of runoff water from upstream irrigators can determine its suitability for use on certain crops. Runoff water may contain certain pesticides and their metabolites, nutrients (i.e., phosphorous) and sediment.

Tailwater recovery and reuse should be a consideration where allowed by local water regulations. It may be necessary to obtain laboratory tests for chemical content and to measure water supply flow rates.

If an irrigation company or district is involved, determine their delivery schedule. Amount of lift (depth to water table with drawdown) and costs while pumping are factors when using wells. Water costs and pumping costs can be major factors in any cost-benefit analysis.

(5) Existing physical features

Determine access to all parts of the irrigated area and location of access roads, aboveground utilities, buried utilities, and other physical features. Depth to buried utilities may control excavation location and depths. Aboveground utilities may limit the use and layout of sprinkler systems (pivot and linear move systems, side-roll wheel lines, traveling gun types). Use aerial photographs and maps as plan base maps and add sketches or overlays.

(6) Existing irrigation systems

An analysis of the existing irrigation method and system, including management, helps to determine if the present system is appropriate for the resources involved. Improving management using the existing system is always the first component of improved water application. Too often the perception exists that to improve water application a new or different irrigation system must be installed. Installing a new irrigation system to improve water application efficiency is not only costly, but often unnecessary. Water application efficiency improvements are usually limited to 5 to 10 percent increase over using proper water management with the existing system. Using proper water management with the existing system often results in increasing water application efficiency more than 30 percent.

After a thorough analysis of water management practices used, make an inventory of the existing system. Gather data on equipment brands, models, and capacities. Perform a simple irrigation system analysis or a detailed system analysis if needed. The water user may have some strong feelings about certain irrigation methods and systems. Users deserve information on the best available method and systems that meet their needs and are most suitable for the site. Pros and cons, including labor requirement and costs of a best fit system, need to be provided.

(7) Water table presence

Determine availability, depth, duration, type of buried conduit system (where it exists), water quality, and if the water table can provide either part or all the crop water needs.

(8) Existing drainage systems

Analyze existing surface and subsurface drainage facilities. Include condition of existing ditches and underground drains, sources of water, and problems created by poor drainage. Determine if poor drainage is the result of mismanagement or natural causes. Overirrigation is by far the greatest water management problem where water supplies are adequate.

(9) Environmental factors

Among many resources, wetland areas within the planning area must be identified and assessed. Possible water pollution sources need to be identified, and floodplain hazard needs to be evaluated. This inventory process and environmental effects can be facilitated by use of exhibit 10-1, environmental effects for resource management plan (Exhibit 5, Part 600.7, NRCS National Planning Procedures Handbook).

(10) Present farm operation

Find out about the overall mix of farm enterprises and how the irrigated crops fit into the total farm management system. Determine the amount and skill of labor available. As irrigation systems become more automated and computerized, higher level of operation and management skills are necessary. Observe the level of present farm management. It is unlikely a less than adequate manager will suddenly assume high management skills and desires.

(11) Operator's desires and concerns

Determine operator's objectives, desires, and concerns. Ask the water user about desires and concerns, and **listen** to the answers. Are desires based on fact, perception, or what the neighbor has?

(12) Energy resources

Determine the availability and unit costs of electrical power. This should include power company policies concerning new installations, standby charges, demand charges, and minimum charges. Diesel, natural gas, or gasoline engines for powering pumps can be more cost effective especially where most or part of the seasonal crop water requirements is met by precipitation. Estimate efficiency of the existing power equipment. Consider the need for total pumping plant evaluations. Investigate the potential for gravity flow systems.

Exhibit 10-1 Environmental effects for resource management plan ^{1/}

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Natural Resources Conservation Service

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Environmental Effects Worksheet for Resource Management Plans

NAME _____ DATE _____ PREPARED BY _____

DISTRICT _____ COUNTY _____ ENG. JOB CLASS _____

Purpose: This form summarizes effects of the practices/systems. It also provides summary documentation for environmental evaluation of the planned actions.

Instructions: Complete the evaluation of each conservation management system (CMS). Short term refers to installation period and; long-term refers to the effects during the life span of the practice or systems. Effect codes: += beneficial; - = adverse; 0= none. For Quality criteria columns, check yes or no. Effects are to be quantified where possible.

Resource considerations*	Effects		Effects notes	Meets Q criteria				Quality criteria notes
	Short	Long		Benchmark		Planned		
				No	Yes	No	Yes	
Soil								
Erosion								
Condition								
Deposition								
Water								
Quantity								
Quality								
Air								
Quality								
Condition								
Plant								
Suitability								
Condition								
Management								
Animal								
Habitat (domestic)								
Habitat (wildlife)								
Management								

* May be amplified, if appropriate, by subcategories such as sheet erosion, wind erosion, gully erosion.

See continuation on reverse page.

Exhibit 10-1 Environmental effects for resource management plan—Continued

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Environmental Effects Worksheet for Resource Management Plans—Continued

NAME _____ DATE _____ PREPARED BY _____

Human considerations	No	Yes	Instructions: An explanation of the specific effects should be noted for each category necessary or important to decision making.
Economics			Notes:
Cost effectiveness			
Financial condition			
Markets available			
Client input (mgt., labor)			
Base acreage maintained			
Sustainability			
Social			Notes:
Public health and safety			
Social values			
Client characteristics			
Client tenure considered			

Cultural resources: (If response to the following questions is "No" implementation may proceed when documentation is complete.)

1. Do the planned alternatives include undertakings defined by NRCS GM 420-401? (Practices that may damage cultural resources.) If "Yes," see below.

2. Are cultural resources present? If "Yes," document the resource(s) on the site and determine impacts following NRCS GM 420-401.

No	Yes
<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>

Special environmental concerns: If yes to any of the following, explain in notes section or on attachment.

Consideration	Present			Effect		
	No	Yes	Unknown	No	Yes	Unknown
Prime and unique farmland						
Threatened and/or endangered plant						
Threatened and/or endangered animal						
Visual resources						
Coastal zone management area						
Natural area						
Wild and scenic river						
Wetlands						
Riparian areas						
Special aquatic sites						

	No	Yes	Met
404 permit required			
State, county, local requirements			
Mitigation planned required			

Degree of public interest/potential controversy _____

This is not a Federal action that will have significant effect on the quality of the human environment.

This may be a major Federal action that will have significant effect on the quality of human environment

1/ Source: National Planning Procedures Handbook, part 600.7, exhibit 5, United States Department of Agriculture, Natural Resources Conservation Service, 1993.

(c) Formulate and evaluate alternatives

The planner needs to consider all alternative conservation management systems that meet the needs of the water user, address resource concerns, and solve resource problems. Work through the most promising alternatives just to the extent needed to determine feasibility. Refine the most feasible alternatives, and document them in enough detail that water user can select the alternative that best meets the defined needs and desires. The most promising alternatives generally require at least a cost estimate and may require an economic analysis. The alternatives must be thoroughly discussed with the water user at the time documentation is presented and discussed.

Alternatives considered should meet all requirements of an conservation management system, the FOTG, and the objectives of the water user. An conservation management system on irrigated land may include one or more of the following practices and measures:

Irrigation method:

- Surface—Level and graded systems including border, basin, furrow, rill, corrugation, contour levee, contour furrow, and contour ditch.
- Sprinkle—Periodic move, fixed (solid) set, gun type, and continuous (self) move (center pivot or linear move including LEPA and LPIC, and gun type).
- Micro—Line source, point source, basin bubbler, and minispray.
- Subirrigation—Water table control.

Irrigation water management:

- How will the need to irrigate (when and how much) be determined?
- What irrigation system adjustments can be made to increase or decrease application?

Irrigation system distribution components:

- Irrigation field ditches
- Pipelines (surface and buried)
- Structure for water control (including measuring devices)
- Irrigation water conveyance, ditch, and canal lining
- Irrigation system tailwater recovery and reuse
- Irrigation land leveling, grading, and smoothing
- Irrigation pit or regulating reservoir
- Irrigation storage reservoir
- Water table control
- Well

Drainage system:

- Controlled drainage
- Subsurface drain
- Surface drainage
- Irrigation tailwater disposal

Conservation cropping sequence:

- Crop residue use
- Conservation tillage
- Pasture and hayland management
- Field windbreaks
- Nutrient management
- Pest management
- Pumping plant for water control
- Wildlife wetland habitat management

Other:

- Access road
- Field arrangement
- Obstruction removal

Water budget or balance

A representative or specific water budget or balance taken from the FOTG or developed for the specific farm can be displayed in table or graph form. A water budget is a planning or predictive tool. Water balance is most often a daily operational tool. A water balance for any period can show:

- When and how much water is used by the crop(s).
- When and how much water is available or applied for crop use—from ground water, precipitation, irrigation, or a combination of these.
- When and how much water is available for deep percolation below the plant root zone, and to runoff.

A water budget is a useful planning tool in comparing effects of different irrigation systems and levels of management of what water goes where, on a monthly and yearly basis. Where daily crop water use data are available, the more detailed water balance can display effects of water availability, nutrient and pesticide application, and management. For design and management purposes, the field water balance can be written mathematically as:

$$F_g = ET_c + D_p + SDL + RO - P - GW - \Delta SW$$

where:

- F_g = gross water required during the period
- ET_c = crop evapotranspiration during the period
- D_p = deep percolation from the crop root zone during the period
- SDL = spray and drift losses from irrigation water in air and evaporation from plant canopies during the period
- RO = surface runoff that leaves the field during the period
- P = total precipitation during the period
- GW = ground water contribution to the crop root zone during the period
- ΔSW = change in soil water in the crop root zone during the period (this may be plus or minus)

Note: The above equation provides for all losses when computing F_g . If net application (F_n) is used instead of gross application (F_g), then losses would be estimated by using overall irrigation efficiency (IE).

(d) Decisions and implementation

After decisions are made by the water user, they need to be documented. Technical assistance required for implementation and followup can be tentatively identified. Definite decisions for irrigation method and type of system, system components, and operation and management practices are essential, but timing of implementation is sometimes not totally predictable.

652.1003 Irrigation system, operation, and water management plan

Once decisions are made regarding the irrigation method and system to be used, a detailed irrigation system installation plan along with operation and management plans can be prepared. These parts of the overall irrigation plan may include engineering drawings, specifications, resource data, quantity estimates, and other data needed by the water user to implement, operate, maintain, and properly manage the selected irrigation system. Some major detailed plan segments are:

- Conservation plan for crops, pasture, or hayland
- Irrigation system application plan
- Irrigation water management plan
- Installation
- Maintenance
- Followup and evaluation

(a) Conservation plan for crops, pasture, or hayland

This plan should provide recorded decisions for crops to be grown, crop rotation, varieties, planting depth and rates, nutrient and pesticide management, weed control, residue management, establishing crops, and cultivation and harvest procedures. It may include such practices as:

- Conservation cropping sequence
- Crop residue use
- Conservation tillage system
- Mulching
- Chiseling and subsoiling
- Cover and green manure crops
- Toxic salt reduction
- Contour farming
- Nutrient management
- Pest management

(b) Irrigation system application plan

Details relating to the installation of the irrigation system (including method of handling tailwater and drainage) are translated into drawings, specifications, quantity and cost estimates, and operation and maintenance procedure details. As in other parts of the overall irrigation plan, irrigation system improvements are often designed and installed in stages. When this is the case, enough design must be done initially on the overall system to assure that all the subsequently installed components operate satisfactorily when the complete system is installed and operating.

Construction drawings and specifications should be tailored to the user to some degree. Drawings should be neat, complete, and professional. Depending on skill and construction experience of the water user or contractor, more detail, including more drawings, may be needed on how to do the job.

Details of the drawings and specifications must be reviewed with each water user at the time the plans and specifications are provided. This will help ensure that there is full understanding of what is to be installed and how it is to be done. The water user can also be an important part of the construction inspection process where NRCS or a consultant does not provide full time inspection.

An irrigation system operations plan is a part of every irrigation system applications plan. The operating plan should detail how the system is to be operated including: charging and draining the system, opening and closing valves, winterizing motors, engines, and pumps, and making application rate changes.

(c) Irrigation water management plan

The irrigation water management plan covers the details needed to manage the irrigation system. Such details may include the following information.

- How fast the soil absorbs water (intake and application rates), including how to determine when adjustments are necessary and how to make the needed adjustments.

- The operations plan should detail how they system is to be operated including: changing and draining the system operating and closing valves; winterizing motors, engines, and pumps; and making application rate changes.
- The method for determining when (frequency) and how much water (normal depth of application per irrigation) to apply. This information is based on peak period use rate and on soil water content or plant water use (stress) levels. The peak period use rate should include enough water to meet the use rate for all months during the irrigation season. The following basic equation is applicable:

$$Q T = D A$$

where:

- Q = flow rate (ft³/s)
- T = time (hr)
- D = depth of application (in)
- A = area (acres)

A useful relationship for converting flow rate to depth of application is:

$$1 \text{ ft}^3/\text{s for 1 hr} = 1 \text{ in depth over 1 acre}$$

or

$$1 \text{ ft}^3/\text{s} = 24 \text{ ac-in/d}$$

or

$$1 \text{ ft}^3/\text{s} = 2 \text{ ac-ft/d}$$

- Know the relationship between gross irrigation depth and the net irrigation depth for each field.
- Recommend design flow rates, how to measure flows, effects of advance times, how to make adjustments, and irrigation set times for borders, levees, furrows, sprinklers, and micro system emitters, bubblers, or hose. For example, misapplying adjustment in flow and set time for eliminating or reducing runoff may inadvertently increase deep percolation. Flow measurement is a primary management tool along with being a regulation tool.
- Details of irrigation scheduling method and how to prepare a day to day schedule, accounting for effective precipitation, automation setting and adjustment, and computerized scheduling.
- How to check field for adequacy of irrigation.
- Guidelines for self-evaluation of irrigation effectiveness.
- Know cost of each irrigation and anticipated benefits.

Management aspects of irrigation should be discussed throughout the planning process. Different irrigation scheduling methods, soil-water content determination procedures, flow measurement procedures, and pros and cons of different set times should all have been thoroughly discussed and perhaps demonstrated. The final written management plan should contain details on procedures selected by the irrigation decisionmaker. All irrigation application amounts, set time, and scheduling periods are estimates. Procedures must be provided for making adjustments in frequency, quantities, and times of application. Every water user has a different learning level, operation and management desire, and skill level. The planner must develop an accurate feel for the level of irrigation water management appropriate for the individual water user. Remember a below average manager will seldom become an above average manager overnight.

(d) Installation

Installations of the irrigation system, system components, and agronomic practices need technical support. Planning and design are of no value if practices are not installed, operated, and managed properly. Sufficient time for technical assistance needs to be provided to ensure that the job is done right. Consider all sources of installation technical assistance including farm consultants, irrigation dealers, and private engineers.

Operation and management of irrigation by the water user are much easier and less time consuming if planning was thorough. This includes working closely with the water user to assure documentation is complete and has been thoroughly explained and discussed.

(e) Maintenance

Maintenance of the irrigation system and all components is essential for satisfactory long-term economical operation. Maintenance items need to be presented and discussed in the irrigation plan. This includes:

- Annual (or between crops) laser leveling or grading of surface irrigated fields
- Maintenance of pump, well, valves, and pipeline
- Replacement of worn or malfunctioning sprinkler/spray nozzles and heads, and micro emitter devices.

(f) Followup and evaluation

Planned followup is essential for an irrigation plan because soil, water, and crop conditions change. Adjustments must be made in management of the system. Data and technical design procedures rely upon best available and average values, which are never fully accurate, to make absolute predictions of how irrigation systems will function. Typically, some technical help is needed to make adjustments. All sources of followup and evaluation technical assistance should be considered. The need for adjustments during system use needs to be fully explained to the water user during the planning process.

652.1004 Planning aids

Worksheets can aid in planning and documentation; however, they should be used only if they facilitate the planning effort. Other methods of documenting the planning processes should be used if they better serve the planner and water user. Many computer assisted irrigation planning and design software programs provide a summary of irrigation system design or evaluation.

Irrigation Inventory Worksheet—A step-by-step process in recording needed resource inventory data is necessary. Exhibit 10-2 provides an example inventory of resource data. It is not all inclusive and should be supplemented with other records as needed. Only information on those items that apply and are needed should be collected and recorded. See chapter 15 of this guide for a copy of blank example worksheets.

Irrigation Planning Worksheet—Soil and crop evapotranspiration data and irrigation system capacity requirements can be recorded and computed using the worksheet shown in exhibit 10-3. See chapter 15 of this guide for a copy of blank example worksheets.

Irrigation Plan Map—Exhibit 10-4 displays an example plan of a simplified irrigation system. The plan should be only as detailed as is necessary to display pertinent features of the irrigation system. Things to show include delivery facilities, structures, pump, mainlines, laterals, ditches, ponds, and methods of irrigation.

Irrigation Water Management Plan—An example irrigation water management plan for a sprinkler irrigation system is displayed in exhibit 10-5. Exhibit 10-6, Guide for Estimating Soil Moisture for Plant Use (Feel and Appearance Method), is included as a part of the IWM plan. See chapter 15 of this guide for a copy of blank example worksheets.

Exhibit 10-2 Irrigation system inventory worksheet

U.S. Department of Agriculture
Natural Resources Conservation Service

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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				

Exhibit 10-2 Irrigation system inventory worksheet—Continued

U.S. Department of Agriculture
Natural Resources Conservation Service

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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

Exhibit 10-2 Irrigation system inventory worksheet—Continued

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<p>Irrigation System Inventory Worksheet—<i>Continued</i></p>																						
<p>NAME _____ DATE _____ PREPARED BY _____</p>																						
<p>Water supply and distribution system Supply system to field (earth ditch, lined ditch, plastic pipeline, etc.):</p>																						
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Type</td></tr> <tr><td>Size</td></tr> <tr><td>Capacity (ft³/sec, gpm, miners inches, mgal/day)</td></tr> <tr><td>Pressure/Elevation at head of field or turnout (lb/in²) (ft)</td></tr> <tr><td>System condition</td></tr> <tr><td>Estimated conveyance efficiency of supply system (%)</td></tr> </table>		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 (%)															
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 (%)																						
<p>In-field distribution system (earth or lined ditch, buried pipe, surface portable pipe, lay flat tubing):</p>																						
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Type</td></tr> <tr><td>Size</td></tr> <tr><td>Capacity</td></tr> <tr><td>Total available static head (gravity) (ft)</td></tr> <tr><td>System condition</td></tr> <tr><td>Estimated efficiency of delivery system (%)</td></tr> <tr><td>Comments</td></tr> <tr><td> </td></tr> <tr><td> </td></tr> </table>		Type	Size	Capacity	Total available static head (gravity) (ft)	System condition	Estimated efficiency of delivery system (%)	Comments														
Type																						
Size																						
Capacity																						
Total available static head (gravity) (ft)																						
System condition																						
Estimated efficiency of delivery system (%)																						
Comments																						
<p>Water application system Existing sprinkler system (attach design and/or system evaluation, if available):</p>																						
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Type system (center pivot, sidewheel-roll, hand move, traveler, big gun)</td></tr> <tr><td> </td></tr> <tr><td>Manufacturer name and model</td></tr> <tr><td>Tower spacing (pivot or linear) (ft) End gun (pivot)?</td></tr> <tr><td>Wheel size (sidewheel-roll) diameter</td></tr> <tr><td>Type of drive</td></tr> <tr><td>Pressure at lateral entrance (first head) (lb/in²)</td></tr> <tr><td>Mainline diameter/length</td></tr> <tr><td>Lateral diameter/length</td></tr> <tr><td>Lateral spacing (S₁) Sprinkler head spacing (S_m)</td></tr> <tr><td>Sprinkler make/model</td></tr> <tr><td>Nozzle size(s) by type</td></tr> <tr><td>Design nozzle pressure (lb/in²) Wetted diameter (ft)</td></tr> <tr><td>(Attach sprinkler head data for pivot)</td></tr> <tr><td>Maximum elevation difference: Along lateral</td></tr> <tr><td>Between sets</td></tr> <tr><td>Application efficiency low 1/4 (E_q) (%) (Estimated or attach evaluation)</td></tr> <tr><td>Wind - Prevailing direction and velocity</td></tr> <tr><td>Comments</td></tr> <tr><td> </td></tr> <tr><td> </td></tr> </table>		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		
Type system (center pivot, sidewheel-roll, hand move, traveler, big gun)																						
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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																						

Exhibit 10-2 Irrigation system inventory worksheet—Continued

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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	ft	Furrow/corrugation/rill spacing	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:			

Exhibit 10-3 Irrigation planning worksheet

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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)		

¹Actual 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 _____.

Exhibit 10-4 Irrigation plan map

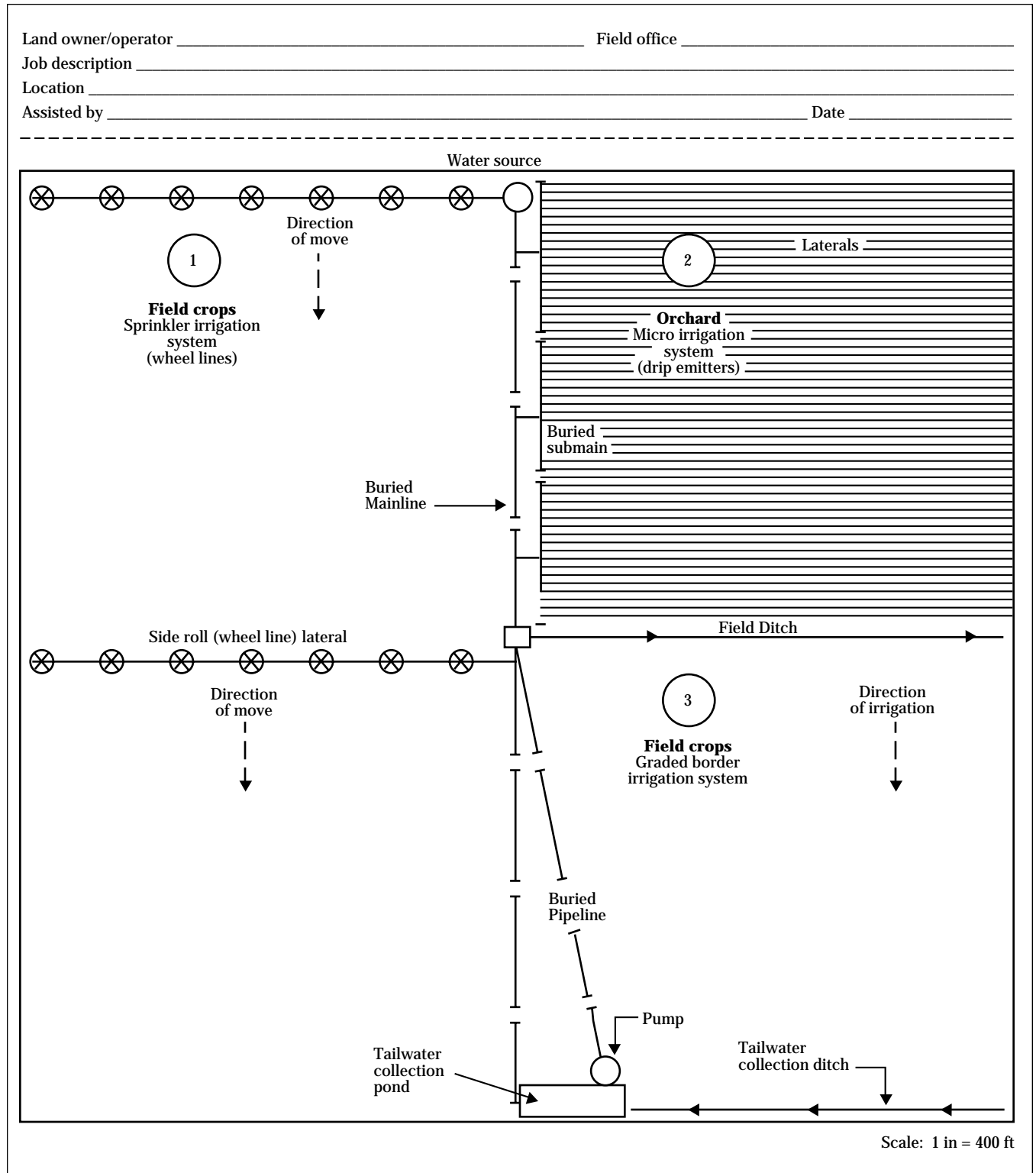


Exhibit 10-5 Irrigation water management plan for sprinkler irrigation systemU.S. Department of Agriculture
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Irrigation Water Management Plan—Sprinkler Irrigation System

NAME J.P. Farmer DATE 12/14/94 PREPARED BY Joe Technician
DISTRICT Lower Power COUNTY Eagle Point ENGR JOB CLASS _____**Resource inventory****Crop information**

Field number(s)					#1
Crop irrigated					Pasture Grass
Acres Irrigated (acres)					30 ac
Normal rooting depth (feet, inches)					30 in
Management allowable depletion (MAD) (percent, inches)					50%
Peak daily crop requirements (ac-in/day)					0.22 ac-in/da
Average annual net irrigation requirements (ac-in/ year)					22 ac-in/yr

Soil Information

Soils series and surface texture	Jackson Silt Loam- 33A (0-1% slope)		
Capability class	II (irrigated)		
Allowable soil loss (T=tons per-acre per year)	T = 5		
Wind Erodibility Group (WEG)	WEG=4		
Actual on-site (observed and measured) average root zone depth	48 in		
Total available water capacity (AWC) of soil plant root zone	9.6 in		
Soil intake (Maximum application rate for sprinkler system)	0.35 in/hr		
Available water capacity (AWC) for crop rooting depth:	Depth (inches)	AWC	
		(inch/inch)	(total inches)
	0-24	0.20	4.8

Irrigation system management information

Irrigation system	Periodic move side roll wheel line sprinkler
Source of water	well
Delivery schedule	continuous
Estimated overall irrigation efficiency	60%
Management allowable depletion for pasture	50%
Irrigation set time to apply full irrigation and replace full MAD	11.5 hours
Gross application	4.0 inches
Net application	2.4 inches
Actual gross sprinkler application rate	0.35 in/hr
Irrigation system flow capacity requirement for full time irrigation, Q (gpm)	216 gpm

Exhibit 10-5 Irrigation water management plan for sprinkler irrigation system—ContinuedU.S. Department of Agriculture
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Irrigation Water Management Plan— Sprinkler Irrigation System—*Continued*NAME J.P. Farmer DATE 12/14/94 PREPARED BY Joe Technician**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	1.0	0.03	30	0
May	2.8	0.09	26	1
June	4.0	0.13	18	2
July	6.5	0.21	11	3
August	5.0	0.16	15	2
September	2.1	0.07	30	1
October	0.5	0.03	30	0
Total	21.9			9

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.

Exhibit 10-5 Irrigation water management plan for sprinkler irrigation system—Continued

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Irrigation Water Management Plan—Sprinkler Irrigation System—Continued

NAME J.P. Farmer DATE 12/14/94 PREPARED BY Joe Technician

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 = 38 lb/in² (use a pressure gage to check operating pressure)
- nozzle size = 13/64 inch (use shank end of high speed drill bit to check nozzle wear)
- average sprinkler head discharge 7.2 gpm
- sprinkler head rotation speed should be 1 - 2 revolutions per minute
- sprinkler head spacing on lateral = 40 ft; outlet valve spacing on main line 50 ft
- lateral, number(s) 2, 1,280 ft, 4 inch diameter side roll wheel line
- main line = 2,600 ft 6 inch diameter, type PVC, class 160 lb/in²
- pump = 30 hp electric, 475 gpm @ 175 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.

Exhibit 10-6 Guide for estimating soil moisture conditions using feel and appearance method

Available soil moisture (%)	Texture			
	Coarse fine sand loamy fine sand	Mod coarse sandy loam fine sandy loam	Medium sandy clay loam loam, silt loam	Fine clay loam silty clay loam
	Available water capacity (in/ft)			
	0.6 – 1.2	1.3 – 1.7	1.5 – 2.1	1.6 – 2.4
0 – 25	Dry, loose, will hold together if not disturbed; loose sand grains on fingers.	Dry, forms a very weak ball ^{1/} , aggregated soil grains break away easily from ball.	Dry, soil aggregations break away easily, no moisture straining on fingers, clods crumble with applied pressure.	Dry, soil aggregations easily separate, clods are hard to crumble with applied pressure.
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.	Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers.	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers few aggregated soil grains break away.	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 weak ball with loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon ^{2/} .	Moist, forms a ball with defined finger marks, very light soil-water staining on fingers, darkened color, will not slick.	Moist, forms a ball, very light water staining on fingers, darkened color, pliable, forms a weak ribbon between thumb and forefinger.	Moist, forms a smooth ball with defined finger marks, light soil water staining on fingers, ribbons between thumb and forefinger.
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.	Wet, forms a ball with wet outline left on hand, light to medium water staining on fingers, makes a weak ribbon between thumb and forefinger.	Wet, forms a ball with well defined finger marks, light to heavy soil water coating on fingers, ribbons between thumb and forefinger.	Wet, forms a ball, uneven medium to heavy soil water coating on fingers ribbons easily between thumb and forefinger.
Field capacity (100)	Wet, forms a weak ball, light to heavy soil-water coating on fingers, wet outline of soft ball remains on hand	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking medium to heavy soil water coating on fingers.	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil water coating on fingers.	Wet, forms a soft ball free water appears on soil surface after squeezing or shaking thick soil water coating on fingers, slick and sticky.

1/ Ball is formed by squeezing a hand full of soil very firmly with one hand.

2/ Ribbon is formed when the soil is squeezed out of the hand between thumb and forefinger.

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