Chapter 1 Introduction

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652.0100 Purpose and objective

The Irrigation Guide provides technical information and procedures that can be used for successful planning, design, and management of irrigation systems. It is a guide only and does not imply or set Natural Resources Conservation Service (NRCS) policy.

Irrigation systems should apply the amount of water needed by the crop in a timely manner without waste or damage to soil, water, air, plant, and animal resources. This includes, but is not limited to, offsite water and air quality and desired impacts on plant and animal (including fish and wildlife) diversity. Other beneficial uses of irrigation water are frost protection, crop quality, crop cooling, chemigation, desirable saline and sodic balance maintenance, and leaching of undesirable soil chemicals.

The Irrigation Guide includes current information and technical data on irrigation systems and hardware, automation, new techniques, soils, climate, water supplies, crops, tillage practices, and farming conditions. Included are irrigation related technical data for soils and irrigation water requirements for crops. In some instances statements are based on field experiences of the primary authors.

The objective of this guide is to assist NRCS employees in providing sound technical assistance for the maintenance of soil productivity, conservation of water and energy, and maintenance or improvement of the standard of living and the environment. Basic data used will help ensure the planned irrigation system is capable of supplying the amount of water needed by plants for planned production and quality during the growing season. Procedures for optimizing use of limited water supplies are also included.

Planning for an irrigation system should take into account physical conditions of the site, producer resources, cropping pattern, market availability, water quantity and quality, and effects on local environment. Economics should provide the basis for sound conservation irrigation decisions, but may not be the ultimate consideration. This is because many other factors may influence final decisions.

652.0101 Water and energy conservation

Conservation irrigation is an integral part of a complete farm management program of soil, water, air, plant, and animal resources. It is a principal consideration in the NRCS Conservation Management System approach to conservation planning on irrigated cropland, hayland, and pastureland. Irrigation must be complemented with adequate management of nutrients and pesticides, tillage and residue, and water. Proper water management results in conservation of water quantities, maintenance of onsite and offsite water quality, soil chemical management (salinity, acidity, applied fertilizers, and other toxic elements), and irrigation related erosion control.

For the farm manager, benefits must justify the costs of purchasing and operating the irrigation system and the time required to adequately operate, manage, and maintain the irrigation system while leaving a reasonable return on investment. For the groundskeeper, park or landscape superintendent, nursery grower, or homeowner, irrigation must maintain the desired growth of grass, ornamentals, flowers, and garden crops while minimizing costs, labor, inefficient water use, and nutrient and chemical losses.

Escalating costs of energy used for pumping makes every acre-inch of excess water a concern to many irrigators. Improving and maintaining pumping plants, irrigation equipment, irrigation application efficiencies, and following an irrigation scheduling program can lead to significant reductions in pumping costs.

Escalating costs of farm equipment, fuel, seed, fertilizer, pesticide, and irrigation equipment also make every irrigation and field operation a financial concern to the farmer. Field operations should be limited to those necessary to grow a satisfactory crop. Conservation irrigation typically reduces:

- Overall on-farm energy use
- Soil compaction, which affects root development and water movement
- Water quantities used
- Opportunity for ground water and surface water pollution

Applying water too soon or in excess of crop needs results in inefficient irrigation application. Too often irrigation decisionmakers subscribe to "when in doubt irrigate," rather than scheduling irrigations based on soil moisture monitoring and measured crop need.

Another factor leading to inefficient water use is the use-it-or-lose-it perception. Some irrigators and irrigation districts feel they must divert and use all the water allocated to them whether they need it or not. This can result in less than desired crop yield and product quality. It also increases leaching of nutrients, toxic elements, and salts below the root zone and increases the potential for erosion.

The direct cost of water to irrigators, when the water is supplied by irrigation companies or irrigation districts, varies between $5 and $600 per acre per year. In many areas, however, water is relatively low in cost. Low cost water can lead to inefficient use if an irrigator uses a convenient application time rather than providing the labor to fully manage the water.

652.0102 Soil conservation, water quality, and pollution abatement

Irrigation induced soil erosion is a problem on specific soils in certain areas. Soil erosion can take the form of wind erosion when smooth and bare ground occurs between harvest and new crop growth periods. Soil erosion by water can result from high application rates in the outer part of center pivot systems, excessive furrow or border inflows, and uncontrolled tailwater or runoff. The use of surface irrigation on moderately steep to steep topography or leakage in the delivery system can also cause soil erosion by water.

Soil erosion can produce sediment loads in irrigation ditches, drains, tailwater collection systems, roadside ditches, streams, and reservoirs. Sometimes it takes careful study of a site to realize that erosion is taking place. Soil erosion on irrigated fields generally can be controlled by careful planning, proper design, and adequate water, soil, and residue management. Offsite sediment damages are often a result of soil erosion from cropland, tailwater ditches, and surface water drains.

Pollution of ground and surface water by agricultural chemicals in irrigation water runoff or deep percolation is an increasing problem. Higher amounts of fertilizers are being used today than in the past. Chemigation can improve the application of chemicals through sprinkler systems, but can also create potential environmental problems through spills and improper or careless application. Leached chemicals, including salts in irrigation water, can degrade ground and surface water qualities. All of these problems can be minimized by proper planning, design, system operation, and water management.

Inefficient irrigation can have offsite benefits. Wetland habitat can be created from conveyance system leakage and application of excess irrigation water. However, excess irrigation water may contain undesirable or toxic organic or inorganic chemicals. In some parts of the United States, local, State, and Federal regulations are such that no irrigation runoff or subsurface drainage effluent from irrigation practices shall enter public water. In these areas irrigation runoff must be contained onsite, reused, or disposed of safely.

652.0103 Using the guide

The Irrigation Guide is prepared for local use; however, it is recognized that this guide may not directly apply to all areas. This guide contains sound water and irrigation system management concepts. It is a dynamic document available in computer electronic files or looseleaf form. As new, revised, or area-specific information becomes available, the guide can and should be updated. Irrigation is a rapidly evolving science and industry. Frequent revisions and additions are expected.

(a) Using irrigation procedures

The best available procedures and data should always be used, whether they are included in this irrigation guide or available elsewhere, for example, from Agricultural Research Service, Universities, Cooperative Extension Service, Bureau of Reclamation, or private industry.

Not all tables, charts, and procedures available in other readily available references are duplicated in the guide. Also, areas of the guide that describe procedures may not include all the processes and material needed to carry out the procedure. For instance, to perform a side roll sprinkler system design requires the use of National Engineering Handbook, Section 15, Chapter 11. However, most references referred to in the guide are available for field office use.

A personal library or reference folder(s) containing specific data and examples is recommended for technicians performing procedures. This library can be used until computer software programs are available and can then be used as a reference when the procedure is accomplished. Such a library or reference folder(s) can contain the following types of material:

- Irrigation guide tables, charts, references, procedures, materials, and forms, including examples.
- Tables for local climate, soils, crops, and plant water requirements.
- Available tables and figures from the National Engineering Handbook, Part 623, Irrigation.
- Information or aids from other sources for planning, design, management, and system evaluation.
- Previous jobs that have been designed, documented and approved.

(b) Using worksheets

The use of worksheets in this guide is optional. They should only be used if they are advantageous in saving planning time and providing documentation. Only those parts of the worksheets that apply to the particular job should be used. Blank master worksheets are included in chapter 15 of this guide.

652.0104 Irrigation guide outline

(a) General

Chapter 1, Introduction—This chapter introduces the irrigation guide, its purpose and contents. It also discusses water and energy conservation needs and opportunities, soil conservation, water quality, and pollution abatement concerns and opportunities.

(b) Soil-water-plant data

Chapter 2, Soils—This chapter describes soil basics: soil surveys, physical soil characteristics, and the relation of soil characteristics to different irrigation methods and systems. Several soil properties directly influence the design, management, and operation of an irrigation system.

Basic soil-water irrigation related parameters included in chapter 2 are variables and are to be used as a guide only. The parameters include:

- Estimated available water capacity by horizons or 1 foot (0.3 meter) increments
- Water intake characteristics for furrow and border (basins) irrigation
- Intake rates or maximum application rates for sprinkle irrigation
- Up-flux or upward water movement in soil

Specific local soils and their characteristics pertaining to irrigation are included in the state supplement section.

Chapter 3, Crops—This chapter describes the crop characteristics pertaining to irrigation; i.e., growth characteristics, rooting depth, and moisture extraction patterns, Management Allowable Depletion (MAD) levels, and effects of temperature, sodicity, and salinity. Management, including critical irrigation and moisture stress periods for plants and other special irrigation considerations, is included as a primary irrigation tool.

Crops respond to irrigation when rainfall does not maintain favorable soil moisture levels. When rainfall events are spaced too far apart for optimum plant-water conditions, plant biomass, yields, and quality are affected. Knowledge of actual crop rooting depths, water requirements at different growth stages, critical moisture stress periods, crop temperature modification effect, seed germination, and pesticide control are all necessary in determining when and how much water to apply.

Chapter 4, Water Requirements—This chapter describes methods for determining crop evapotranspiration (ET_c) and net irrigation water requirement. Water budget and balance analysis use are also described. Estimated evapotranspiration values for peak daily, monthly, and seasonal periods for locally grown crops are included in the state supplement section.

(c) Irrigation and distribution systems

Chapter 5, Selecting an Irrigation Method (Surface, Sprinkle, Micro, or Subsurface)—This chapter includes factors that affect irrigation method selection and system adaptation. The factors are largely functions of crop selection and rotation, soils, topography, climate zone, tillage practices, labor availability (including skills), economics, water availability in quantity and quality, type of delivery schedule, and the irrigation decisionmaker's personal preference.

Chapter 6, Irrigation System Design—Criteria and references for the implementation of the more commonly used irrigation methods and applicable systems are included in this chapter.

Chapter 7, Farm Distribution Components—This chapter describes alternatives and various components of the farm distribution system. Water measurement should be a part of any distribution system as it is the key to proper water management.

(d) Irrigation planning and management

Chapter 8, Project and Farm Irrigation Water Requirements—Procedures for determining large scale water requirements are described in this chapter. It also includes the application of water budget analyses to group and project level water requirement versus availability.

Chapter 9, Irrigation Water Management—Good irrigation water management should be practiced with all irrigation application systems. New techniques for irrigation scheduling and system automation are available and are a part of the information in this chapter. Field and climatic data should be accurately collected and an analysis of irrigation need, timing, and application amount made available to the irrigator promptly. Procedures for establishing soil intake characteristics and evaluation of existing irrigation are described.

Chapter 10, Conservation Management Systems and Irrigation Planning—This chapter contains the basic steps for planning ecosystem-based resource management systems including irrigation system planning. The planning process as it pertains to irrigated cropland is described.

Chapter 11, Economic Evaluations—This chapter includes the criteria that can be used in evaluating pumping plant operating costs. It also describes the procedures for making economical pipe size determinations and other economic factors and processes that can be used in planning.

Chapter 12, Energy Use and Conservation—This chapter reviews alternative energy sources and costs used in pumping and gives examples of irrigation system comparison and tillage and residue management that relate to overall on-farm energy requirements. Improving water management almost always decreases water and energy use except where inadequate irrigation has occurred and more water is needed to meet yield and quality objectives.

Chapter 13, Quality of Water Supply—Quality of water to be used for irrigation of crops is briefly described in this chapter. To meet crop yield and quality objectives, a reliable supply of high quality water is desired. However, with proper management, applying saline water on salt tolerant crops, liquid waste from agricultural related processing and products, treated municipal sewage effluent, and other low quality water should be considered as an irrigation water source.

Chapter 14, Environmental Concerns—A direct relationship can be established between downstream water quality and irrigation. This relationship is presented in chapter 14. Improper selection of an irrigation method and system for a given site or the mismanagement of any system can result in poor water distribution uniformity, soil erosion, excessive runoff, and excessive deep percolation. Runoff can carry agricultural chemicals and plant nutrients in solution or attached to soil particles (e.g., phosphates). Excess irrigation water moving below the plant root zone (deep percolation) can carry soluble salts, nutrients (nitrates), pesticides, and other toxic elements that may occur in the soil profile. Excess irrigation water and whatever it contains in solution generally ends up either as ground water recharge or returns to downstream surface water.

(e) Special tools

Chapter 15, Resource Planning and Evaluation Tools and Worksheets—Included in this chapter are aids, tools, and processes that can facilitate irrigation system planning, design, and evaluations. Example Irrigation Water Management or Irrigation Water Conservation Plans are also included. Master blank worksheets are included to help the technician or water user.

Chapter 16, Special Use Tables, Charts, and Conversions—This chapter contains special use tables, charts, and conversion factors that are useful in the planning, design, and evaluation processes. English units are used along with metric conversions as they reasonably apply. A complete metric conversion table relating to irrigation is included.

Chapter 17, Glossary and References—This chapter contains a list and definition of the more commonly used irrigation terms. Many terms are local, and some duplication is necessary. References available and used in irrigation system planning, design, management, and evaluation are included.

652.0105 Use of computers

Only state approved computer software is available to the field office for official use. These programs help to facilitate planning, design, and evaluation of irrigation systems and related components. The technician or engineer is fully responsible for plan or design integrity, adequate documentation, and obtaining necessary reviews and engineering approval.

Information contained in this guide describes availability and use of computer software for performing certain tasks. Additions or revisions to the guide including instructions or references to user manuals will be made as new software becomes available.

652.0106 State supplement