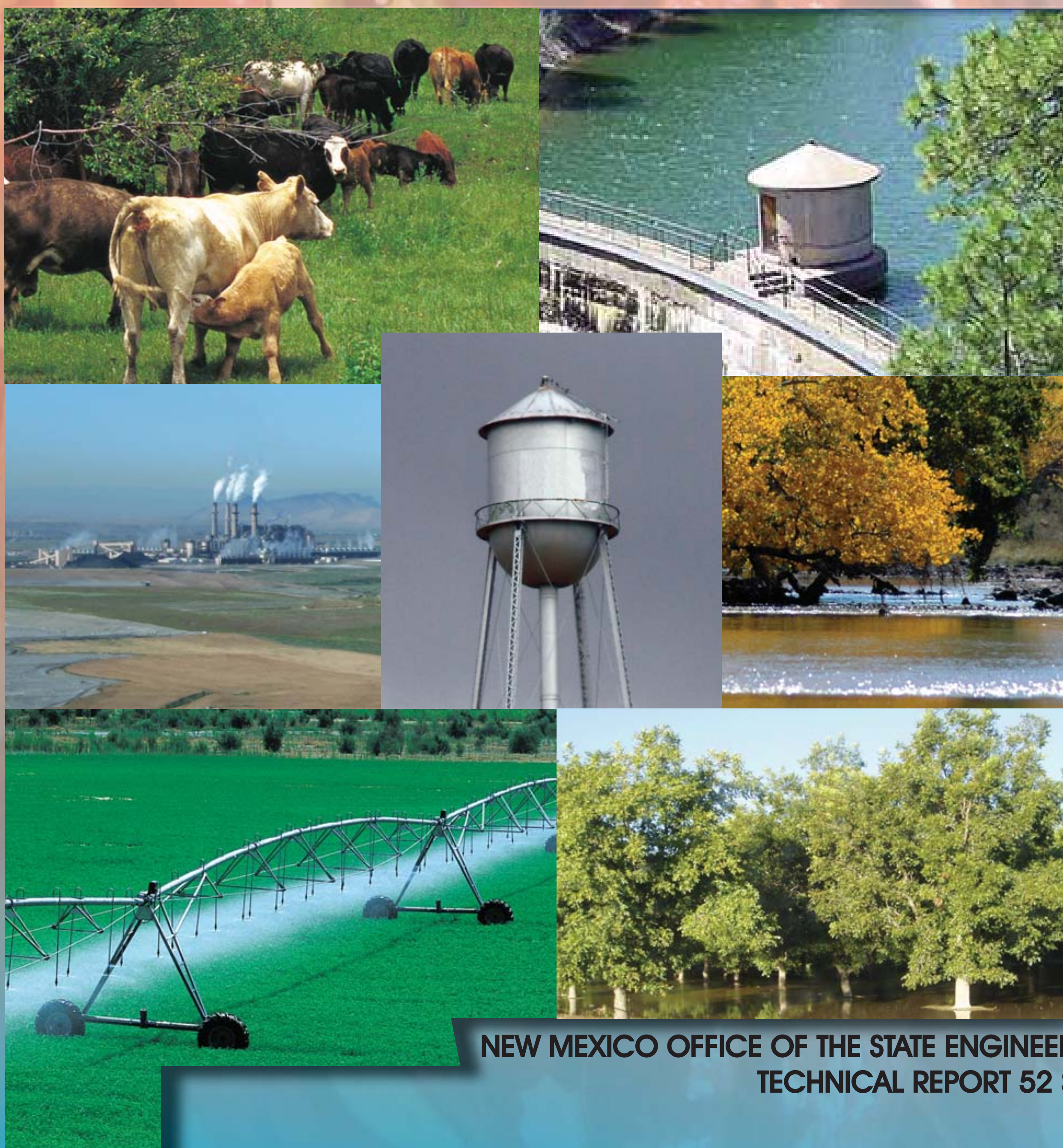
NEW MEXICO
WATER USE BY CATEGORIES
SUPPLEMENTAL REPORT
2005



NEW MEXICO OFFICE OF THE STATE ENGINEER
TECHNICAL REPORT 52 S

Office of the State Engineer
Interstate Stream Commission

NEW MEXICO
WATER USE BY CATEGORIES
SUPPLEMENTAL REPORT
2005

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1 INTRODUCTION

The Water Use by Categories Report (Report) is prepared once every five years by the Water Use and Conservation Bureau of the New Mexico Office of the State Engineer. The purpose of the Report is to make available the most comprehensive, current, and useful water use data to the public. The 2005 Report is published as Technical Report 52.

The Report contains statewide water use data for the 2005 calendar year. Water withdrawals in New Mexico counties and river basins were tabulated for nine water use categories:

1. Public Water Supply
2. Self-Supplied Domestic
3. Irrigated Agriculture
4. Self-Supplied Livestock
5. Self-Supplied Commercial
6. Industrial
7. Mining
8. Power
9. Reservoir Evaporation

Previous water use reports contained lengthy discussions on topics such as water requirements for various types of turfgrass, benchmark studies of indoor water use, factors that affect water use in communities, causes of poor irrigation efficiency, and factors that affect livestock water use, etc. That type of information was removed from the 2005 Report. However, the information is still valuable and is presented in this Supplemental Report. It can also be reviewed in its original content in Technical Report 51 (Wilson, et al 2003). Readers are encouraged to review the 2005 Report (Technical Report 52) for details on water use in the state as this Supplemental Report is in no way intended to present or explain the quantities of water use or how those quantities were calculated for the 2005 calendar year.

The Supplemental Report is organized in the same manner as the Water Use Report with chapters numbered as follows:

- Public Water Supply and Self-Supplied Domestic (Chapter 2)
- Irrigated Agriculture (Chapter 3)
- Self-Supplied Livestock (Chapter 4)
- Self-Supplied Commercial, Industrial, Mining, and Power (Chapter 5), and
- Reservoir Evaporation (Chapter 6).

Appendix A is a glossary of terms used in this report. A bibliography is included.

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2 PUBLIC WATER SUPPLY AND SELF-SUPPLIED DOMESTIC

2.1 FACTORS WHICH AFFECT WATER USE IN COMMUNITIES

Water use in communities is affected by many factors which include demographic and economic characteristics; climate; availability of electric, water, and sewer services; condition of the water system and operating characteristics; and conservation measures and incentives.

2.1.1 Demographic and Economic Characteristics

2.1.1.1 IMPACT OF GROWTH

As a result of this growth, communities are struggling to keep up with the demand for affordable housing, education facilities, water and sewer services, solid waste disposal, transportation services, and police and fire protection. Air pollution and traffic congestion is getting worse, groundwater pollution from septic systems is increasing, water tables are declining and there are signs of land subsidence in some metropolitan areas such as Albuquerque. New subdivisions are being built on prime farmland. The impact of growth on community water supplies has become critical. While some municipalities have adopted end-use water conservation measures to reduce the demand for water, without a growth management plan, the number of connections and population served may continue to rise, increasing the aggregate demand on the water supply and the rate at which nonrenewable sources are depleted.

2.1.1.2 TYPE OF COMMUNITY

Predominantly residential communities will use less water per person than highly commercialized or industrialized communities. The type of housing that is most common will also affect use. Low density residential areas, i.e., those with few housing units per acre, with large gardens and lawns will have a higher water use per person than higher density areas with multiple family dwellings such as townhouses, condominiums, and apartment complexes.

2.1.1.3 PERSONAL INCOME

The economic level of a household and the market value of a home influences the total amount of water used. Homes in affluent neighborhoods are likely to have more water using appliances (including hot tubs and multiple-head showers), ornamental shrubbery and fountains, and larger lawn areas that require irrigation.

2.1.1.4 CLIMATE AND SEASON

Water use is normally highest during the warm summer months. More water is used for lawn and garden irrigation, car washing, filling swimming pools; bathing is more frequent; and evaporative coolers (swamp coolers) are more widely used. The amount of rainfall that normally falls in a specific area will affect the amount of water required for lawn and garden irrigation. During winter months in cold climates, water use may be surprisingly high. In some areas residents run water faucets continuously to prevent water from freezing and bursting the pipes. Some public water systems follow the same practice to protect water mains above the frost line from freezing.

2.1.2 Availability of Electric and Sewer Services

2.1.2.1 RURAL ELECTRIFICATION

While not so much a factor today, historically, rural electrification has had a significant impact on water use. Up until the development of rural electrification, most rural homes lacked not only electrical appliances, but also modern plumbing due to the absence of pressurized water supply. Thus, the rural electrification program initiated the development of modern rural plumbing and greatly increased the demand for water as well as the need for septic tank waste disposal systems.

2.1.2.2 SEWERS

Linaweaver et al (1967) observed that population density **is not** an important factor affecting water use in areas with public sewers. Instead, the economic level, as reflected by the average market value of the homes, serves as the dominant factor influencing the quantity of water used for domestic purposes. However, in areas where septic tanks are predominantly used, i.e., in areas where there are no sewers, economic level does not have an effect on domestic use. Regardless of income level, households use smaller amounts of water for domestic purposes because of concern that their septic tank will require more frequent cleaning, or, if they have their own well, that the pump for their well will break down and require expensive repair service.

2.1.3 Water System and Operating Characteristics

2.1.3.1 RECORD KEEPING AND WATER AUDITS

It is imperative that the public water supplier or utility establish a recordkeeping system to monitor operation and maintenance costs, revenues, and the use of water. A water audit of the system should be performed. A water audit is a compilation of the consumptive uses and losses of the water in a single system (AWWA, 2006). It includes a detailed examination of where and how much water enters the system, and where and how much leaves it. Water system audits facilitate the assessment of current water uses and provide data needed to reduce water and revenue losses, and forecast future demand. With this information, the water utility is better equipped to target conservation efforts and system improvements where they are most needed. Estimating and reducing non-revenue is a major objective of a water system audit. Non-revenue water includes distribution-system losses through leaks, unmetered water delivered through fire hydrants, water taken illegally from the distribution system, inoperative system controls (for example, blowoff valves and altitude-control valves), water used in flushing water mains or sewers, and meters out of calibration. Unauthorized use of hydrants includes theft by chemical lawn service companies, building contractors, and water haulers who have the tools needed to open hydrants without permission.

2.1.3.2 LEAK DETECTION AND REPAIR

New water mains are generally watertight when they are first installed; however, as the system ages, settling of pipe may partially open joints causing leakage. Leakage will also increase due to pipe corrosion and deterioration of joint compounds. Systematic leak detection can greatly reduce distribution costs and wastewater treatment expenses. A leakage reduction program begins with a water audit, proceeds to a leak-detection and repair program, and, finally, includes improved system maintenance and rehabilitation.

2.1.3.3 PRESSURE REDUCTION

High water pressure at the outlets will generally result in higher water use because the flow rate is higher than under low pressure conditions. By increasing a 25 psig (pounds per square inch gauge) service pressure to 45 psig, water use can be expected to increase as much as 30% (AWWA, 1986). In new housing developments where water pressure is maintained at 50 psi (pounds per square inch) instead of 80 psi, a 3% to 6% savings in water use may be expected (Bailey, 1984).

2.1.4 Conservation Measures and Incentives

Water conservation is defined as any beneficial reduction in water loss, waste, or use; a reduction in water use accomplished by implementation of water conservation or water-efficiency measures; or improved water management practices that reduce or enhance the beneficial use of water (Vickers, 2001). Conservation measures and incentives may contribute towards a reduction in average daily water use in a community. In addition, reducing the demand may add years to the life of aquifers that are being mined, reduce the cost of wastewater treatment, save energy, postpone or eliminate the expansion of water treatment and distribution systems, and decrease the volume of wastewater discharged into rivers and streams.

2.1.4.1 PUBLIC EDUCATION

Education programs designed to increase the public's awareness about the status of a community's water supply resources and system, and measures that can be taken to conserve water may be effective in improving water use efficiency and reducing demand (Vickers, 2001).

2.1.4.2 METERING AND RATE STRUCTURING (WATER PRICING)

Whether householders are billed according to metered water use or on an unmetered flat-rate basis appears to have little influence on indoor domestic use, but it has considerable influence on landscape irrigation and other outdoor water uses. When a householder can use all the water he wants and does not have to pay any more than other water users, the duration of time on, frequency on, frequency of use, and rate of use when on all tend to increase. Converting a flat-rate, non-metered system to a metered system has been shown to reduce water use by as much as 25% (AWWA, 1986). In Denver, Colorado and Galveston, Texas, the replacement or repair of residential and commercial meters that had been reading low by 11% and 39% respectively, reduced the water demand by more than 10% after customers began paying for the actual amount of water used (Anonymous, 1980a). Increasing block-rate structures tend to make consumers more water conscious and discourage wasteful water use practices.

2.1.4.3 INDOOR PLUMBING FIXTURE AND APPLIANCE ORDINANCES, AUDITS, AND RETROFITS

The installation of water-saving plumbing fixtures (toilets, showerheads, and faucets) and appliances (dishwashers, washing machines, evaporative coolers, and water softeners) in new construction or as replacements can be very effective in reducing water use. **The federal Energy Policy Act of 1992 requires that toilets manufactured after January 1, 1994 for residential and commercial units, not use more than 1.6 gallons per flush (gpf); the maximum flow rate of showerheads shall not exceed 2.5 gallons per minute (gpm); and the maximum flow rate of kitchen and bathroom faucets shall not exceed 2.5 gpm (at 80 psi).** Manufacturers have also made significant improvements in the efficiency of appliances. In 2000, new dishwashers use 6 to 8 gallons per load; top-loading washing machines 39 to 43 gallons per load; and front-loading washing machines 20 to 30 gallons per load. (Consumer Reports, July, 1996; January, 1997; July, 1997). Improvements have also been made in evaporative coolers and water softeners that reduce water use.

2.1.4.4 LANDSCAPE ORDINANCES, AUDITS, AND RETROFITS

A landscape design ordinance enacted by a local government or water utility can be a very effective water conservation measure. Homeowners and commercial and industrial enterprises that adopt low-water use landscaping, efficiently irrigated, can significantly reduce outdoor water use. Landscaping ordinances can be incorporated into the building permit approval process. Landscape design requirements are most effective when accompanied by a design review service offered through the city or county planning office, or local water utility. Such services can help subdividers, homeowners, and businesses develop landscaping plans that are consistent with community water conservation goals. Some communities designate review boards, usually consisting of landscape architects or planners, to evaluate and approve landscape designs for certain types of new development. For example a city or county may use a review board to ensure that new landscaping and irrigation systems comply with its xeriscape requirements. After the landscape project has been completed, the site is visited and a certificate of compliance is issued if all landscape design requirements are met. To provide an incentive for low-water use landscaping, a credit or rebate may be offered toward the connection fee if homeowners comply with landscaping guidelines. Such incentives may also be offered to encourage homeowners or businesses to convert high-water using landscapes and inefficient irrigation systems to low water use landscapes and efficient irrigation systems.

2.1.4.5 WATER WASTE ORDINANCES

Water waste is usually defined in local government ordinances as water that flows or is discharged from a residence or place of business onto an adjacent property or public right-of-way. Such discharges occur most often from landscape irrigation or leaking water pipes. Water waste ordinances may curtail waste.

2.1.4.6 IRRIGATION WITH RECLAIMED WASTEWATER

The reuse of treated sewage effluent for the irrigation of golf courses, parks, athletic fields, and greenbelts, or for industrial purposes, can reduce the demand for freshwater.

2.2 RESIDENTIAL WATER USE

2.2.1 Benchmark Studies of Indoor Water Use

Residential water use is comprised of two components: (1) indoor, i.e., uses inside of the house, and (2) outdoor, i.e., uses outside of the house. The results of several benchmark studies that have been conducted to quantify domestic water use in American homes are summarized in the text that follows.

2.2.1.1 BENNETT AND LINDSTEDT (1975)

To define the parameters that affect the design of home wastewater systems, six middle class families in Boulder, Colorado were monitored for 15 consecutive days during the month of January when there was no outdoor water use. All of these homes had been constructed since 1950, were equipped with modern appliances, and were connected to the municipal water and sewage system. At each of these residences the male head of household was away at work during the day, the older children were in school, and several of the wives were engaged in part-time employment or community work. Indoor water use for this study group ranged from 32 to 82 gallons per capita per day (GPCD) and averaged 45 GPCD. After comparing water use in two different households which were nearly identical in terms of number of family members, age of children, and size of home, it was concluded that water use depended more upon lifestyle than family size or age, as evidenced by the fact that, in the household which had the lower water use, the housewife and her youngest child were away from home in the afternoons. In general, data indicated that small families had a higher per capita water use than larger families. While participants in this study typically used 30 gallons per shower, it was also observed that a teenager may use up to 50 gallons per shower, this amount apparently being limited by the size of the hot water heater.

2.2.1.2 BROWN AND CALDWELL (1984)

In 1980, the U.S. Department of Housing and Urban Development initiated a three-year residential water conservation demonstration program. Homes of upper income families with and without water-saving fixtures were selected nationwide. To compare the effects of different types of water conserving devices on indoor water use, water fixture use data was compiled into three separate groups. Estimated per capita water use resulting from this study was as follows. Group I: homes with no water-conserving devices—78

GPCD. Group II: homes with conventional non-conserving toilets retrofitted with dams, bags, or bottles; showers with moderate flow restrictors; and dishwashers and washing machines with moderate water requirements—68 GPCD. Group III: homes with high efficiency low-flush toilets, low-flow showers, dishwashers and washing machines—60 GPCD. An important discovery in this study was that leakage from conventional as well as low-flush toilets was typically 4 GPCD and as high as 24 gallons per day per toilet.

2.2.1.3 COHEN AND WALLMAN (1974)

General Dynamics, under the sponsorship of the U.S. Environmental Protection Agency, monitored water use in eight single-family homes with three or more occupants in two New England states and California for a period of one year. Indoor water use for these households without any water saving devices installed ranged from 43 to 94 GPCD and averaged 56 GPCD. The average water use for sewered homes was 67 GPCD as compared with 44 GPCD for those with septic tanks. While the type of waste disposal system showed a definite affect upon per capita use, variations in per capita use between households with the same type of waste disposal system were attributed to differences in family habits and life styles.

2.2.1.4 COTTER AND CROFT (1974)

During the period 1971-73, researchers at New Mexico State University conducted a study of domestic water use at selected subdivisions in Albuquerque and Las Cruces, New Mexico. The residents monitored in this study were predominantly middle-income family homes served by municipal water and sewage systems. Indoor water use for all of the homes included in the study averaged 79 GPCD.

2.2.1.5 LINAWEAVER ET AL (1967)

From 1961 to 1966 the John Hopkins University, under the sponsorship of the Federal Housing Administration and in cooperation with 16 water utilities, conducted a study of 41 subdivisions representing the climatic diversity of regions throughout the United States to determine the water use patterns and demand rates imposed on water systems in residential areas. Indoor water use for all 41 study areas, including single-family homes and apartments, averaged 59 GPCD. Indoor per capita use for individual areas ranged from 39 GPCD in a low-valued area to 127 GPCD in a high-valued area. Indoor water use for specific categories was as follows: for homes with septic tanks—47 GPCD; for metered areas in the eastern United States with municipal water and sewers—51 GPCD; for apartments—62 GPCD; for flat-rate areas—66 GPCD; and for metered areas in the western United States with municipal water and sewers—67 GPCD. With the exception of the septic tank areas, variations in per capita use were primarily attributed to differences in the market values of homes and population density.

2.2.1.6 SIEGRIST ET AL (1976)

Indoor water use in 11 rural Wisconsin homes occupied by families of various sizes and economic backgrounds was monitored continuously for 434 days yielding a range of wastewater flow from 25 to 57 GPCD and an average of 43 GPCD. Comparison of winter and summer water use showed no significant seasonal differences. Siegrist observed that water use within the home has changed over the years due to the increasing number of modern appliances, e.g., automatic dishwashers, garbage disposals, and clothes washers which use more water for permanent press fabrics. Changes in the habits of householders have also affected the volume of water and how it is used. On a lighter note, Siegrist also observed that use of in-sink garbage disposals is generally less frequent in homes with big dogs because the dog is given the majority of meal scraps.

2.2.2 Outdoor Water Use

Outdoor water use varies widely depending upon the climate and irrigation requirements of lawns, gardens, trees and ornamental shrubbery; the quantity of water used for washing vehicles, driveways, sidewalks, and the exterior of homes; and filling and maintaining swimming pools, landscape ponds, etc.

Where outdoor water uses are a factor, they generally account for 50% to 70% of the total residential water use (indoor plus outdoor). In a study of 20 residents in Las Cruces, New Mexico annual water use for landscape irrigation ranged from 108,000 gallons to irrigate 3,328 square feet, to 204,000 gallons to irrigate 5,219 square feet (Cotter, 1974). Where desert landscaping has been adopted, outdoor water use may account for only 3% or less of the total residential water use.

3 IRRIGATED AGRICULTURE

3.1 CAUSES OF POOR IRRIGATION EFFICIENCY

The main body of the text that follows was adopted from a U.S. Government interagency task force report entitled "Irrigation Water Use and Management" (U.S. Department of Agriculture et al, 1979).

Off-farm conveyance losses can be attributed to permeable canals, obsolete, inadequate, or improperly maintained facilities, and excessive vegetative growth. Seepage through unlined canals is the main contributor to conveyance losses. Seepage rates are proportionately greater for canals with intermittent flows than for those under continuous operation. Obsolete, inadequate, or improperly maintained facilities result in poor control and management of water throughout the off-farm conveyance system which affects the on-farm management of water, causes seepage and transpiration losses, causes sediment to accumulate, and contributes to structural failure and poor operation of the canals.

Physical conditions that contribute to inefficient water use on-farm include unlined farm ditches, lack of measurement structures, poor farm layout, and improper maintenance. Variability within fields of soil intake rates, water holding capacities, and erosion resistance also play a role. The method of water application (i.e., the type of irrigation system) affects irrigation efficiency, particularly if the method is not suited to the soil type or topographic conditions. On flood irrigated farms, the relationship between field slope, field length, soil characteristics, and water flow must be balanced to achieve uniform application with minimum deep percolation and surface runoff. For example, the slope and water flow rate may be acceptable, but the length of the field may be too long for the soil conditions. Flood irrigation of steep or non-uniform slopes may result in poor application uniformity, soil erosion, excess surface runoff, and deep percolation. Sprinkler irrigation on fine-textured soils produces surface runoff if the application rate of the sprinkler exceeds the intake rate of the soil.

Farm management factors that contribute to inefficient water use on-farm include lack of soil moisture data and improper timing of irrigation, lack of adequate flow measurements, incorrect application amounts, and lack of adequate facilities to control water. The timing of irrigations and the application amounts may vary because of water availability, other farm activities, or an off-farm job that requires the irrigator's attention, resulting in lower irrigation efficiencies. Farm labor hired for irrigating crops may not have the necessary experience to understand the soil, water, crop, and field relationships needed to achieve good efficiencies.

Institutional and social factors that affect on-farm irrigation efficiency include existing laws and court decrees, water and energy prices, and social attitudes related to land use. The rate schedules to assess or charge irrigators in irrigation districts for the cost of water delivered in many cases are constant and do not discourage excessive use of irrigation water.

3.2 IMPROVING OFF-FARM CONVEYANCE EFFICIENCY

The off-farm conveyance efficiency can be improved by lining canals and laterals; installing closed pipe systems; consolidation and/or realigning the distribution system; replacing or installing flow-regulating structures; scheduling regular maintenance inspections and performing necessary work; and controlling aquatic and/or ditch bank weeds.

3.2.1 Canal Linings

Materials used for linings include compacted clays, hard-surface materials such as concrete or soil cement, or membranes such as asphalt and flexible plastic. Selection of a lining material is generally based on its availability, cost, and geographic location or climate where it will be used. A compacted earth lining of silty clay has a seepage rate of about 2.394 gallons per square foot of wetted perimeter per day, while concrete lining has a seepage rate of about 0.598 gallons per square foot per day.

There are other benefits to lining systems in addition to reducing seepage. They include:

- the control of ditch bank weeds and aquatic growth which consume water and require use of herbicides
- a reduction of soil erosion
- an improvement in water quality
- a possible reduction in operation and maintenance costs
- reduced drainage requirements
- reclamation of agricultural lands lost to seepage

Pipe conveyance systems provide a means of completely enclosing a system to avoid many of the water losses that occur in an open system. In the past, pipelines to carry irrigation water were used mainly where physical barriers such as steep escarpments and canyons made open systems impractical.

Relatively few piped systems have been installed to date. Where piped systems have been installed, conveyance efficiencies greater than 95% have been attained. Additional benefits include better utilization of lands along system rights-of-way, elimination of safety hazards common to open systems, reduction of evaporation losses, and better control of water delivered to the farm, thus providing more options for the farmer.

Many conveyance systems were constructed along contours of the land to minimize excavation and fill construction activities that in the past were performed by crude and inefficient machinery. This resulted in the existence of many long and winding systems that have very high losses. Piping of such systems increases the off-farm conveyance efficiency, reduces seepage, and may reduce operation and maintenance costs.

3.2.2 Consolidation and/or Realignment

Consolidation and/or realignment is possible today because of modern construction methods. Better irrigation system features such as improved water control structures and lining and piping materials also make consolidation and/or realignment practical as effective water conservation measures. Benefits include: (1) reduced operation and maintenance activities for water users, (2) improved farm unit layout, (3) elimination of weeds along deleted waterways, (4) improved service to water users, (5) improved economic use of the land, and (6) reduction of diversion requirement.

3.2.3 Water Measurement

Water measurement accuracy is important in the operation of any water conveyance system. Measuring devices are essential if an accurate accounting of what happens to the water is to be made. Proper evaluation of losses is necessary to establish the economic advisability of providing canal linings.

3.2.4 Inline Structures

Inline structures include water measurement and regulating structures. Regulating devices are checks, check-drops, turnouts, diversion structures, check inlets, and regulating reservoirs. These structures are used to regulate the flow passing through the conveyance system and/or control the elevation of the upstream water surface. The equitable delivery of water to irrigators is dependent upon the size of the discharge openings, referred to as farm turnouts, and the water level behind the openings. If the structures of the system cannot maintain a constant or uniform water level, proper deliveries cannot be made to the irrigator. This may cause irrigators to use the water supply inefficiently. The use of proper check structures in a system also regulates the water level along the system, thus reducing operational wastes and losses.

3.2.5 Automation of Regulating Structures

The automation of regulating structures is designed to increase the overall efficiency of the system and reduce operational waste. While storage reservoirs and the outlet works of dams, diversion dams and canal headworks are often self-contained and isolated, they can be the focal point for demands of the conveyance system. The proper operation of these facilities through automation can help meet downstream diversion demands in the river (water rights and/or fish and wildlife commitments), and also lessen hydraulic fluctuations to provide smooth operation of the entire system. Automatic controls of check structures can sense deviations of water surfaces on the canal and operate adjacent checks upstream and downstream to provide a nearly constant water level. Automation of turnouts provides uniform deliveries from the distribution system to the farm. Wasteways are the traditional safety valves of the canal operation. They remove excess water and prevent overtopping of the canal. Operational wastes can be eliminated or greatly reduced when a high degree of automation is utilized on other structures within the system. Benefits that would accrue as a result of automation of facilities would be both tangible and intangible. The tangible benefits could be reduced operation and maintenance costs of the conveyance and distribution system, and more reliable water supply. Intangible benefits might include safety, and aesthetic values.

3.2.6 Maintenance of Facilities

Proper maintenance of facilities that control and regulate the flow of water is fundamental to good water management practices of the project and the water users. The accuracy of measuring devices, most important for efficient operations, can be assured through inspection and routine maintenance. Facilities designed to maintain water levels in the system need to be under a regular maintenance program to provide optimum service. The regular removal of debris from the system throughout the season and removal of sediment during the off-season will eliminate many operating problems.

3.2.7 Weed and Phreatophyte Control

A weed and phreatophyte control program can effectively minimize excessive vegetation in and along ditch banks and can be accomplished by mechanical, chemical or biological means. Any method of control will have economic and environmental impacts. Chemical control is generally the most effective and economical but may not be environmentally acceptable. Mechanical control may be less effective and more costly in manpower and equipment. Benefits of a routine weed and phreatophyte control program include increased water delivery capacity, a possible reduction in operation and maintenance costs, and reduced water consumption by ditch bank vegetation.

3.2.8 Conveyance Design

The application of any measure that may improve on-farm efficiency is often limited by the design and management of the conveyance and distribution system. Existing systems have been designed to deliver water by a continuous flow, rotation, or demand method. The continuous flow and rotation methods may discourage efficient on-farm and system water use. The rotation delivery system is designed with a capacity to deliver water for short periods of time at scheduled regular intervals. The demand system of delivery method is designed with a capacity to deliver on short notice the flow ordered by an irrigator. The demand method is best suited to promote the efficient use of water. Any improvement measures, either on-farm or in the system, should be interrelated with the delivery capacities of the system. This will provide the type of irrigation delivery system that will allow the irrigator flexibility in choosing on-farm methods to conserve water. However, to change from one method to a more efficient method may require installation of costly structural measures.

3.2.9 Scheduling Water Deliveries

Scheduling water deliveries is an important water management measure. Scheduling deliveries provides for the allocation of water in accordance with actual and projected crop use, rainfall, cultural practices, delivery system carrying capacity, and field irrigation characteristics. Deliveries can be scheduled to make the most effective and efficient use of the total water supply. Use of scheduling might eliminate the need for enlargement of the conveyance system to deliver more efficient flows. Scheduling deliveries on most distribution systems can be accomplished without additional operating personnel.

3.3 IMPROVING ON-FARM IRRIGATION EFFICIENCY

The on-farm measures are those that affect the problems causing efficiency on the farm. These measures deal with the on-farm delivery system, field application system, and water management problems.

3.3.1 Ditch Lining or Piping

An effective method of reducing seepage is to line ditches or replace them with pipelines. These measures are similar to lining or piping off-farm systems. Ditch lining may be less costly to install but is not suitable to all topography and farm layouts. Piping is more effective than ditch lining in managing water because it eliminates evaporation, and when buried, can be farmed over and automated easily. Both lining and piping may reduce labor and maintenance costs of the irrigator.

3.3.2 Land Leveling

Land leveling is reshaping the surface of a field to planned irrigation grades or slopes and is most important in flood irrigation systems. Proper land grades for the field application system being used allow better control and more uniform application of water, which may result in increased efficiency. Where basin-border irrigation is practiced, fields which have not been leveled will require a greater depth of water to cover the high and low spots, and in the low spots, more water will be lost to deep percolation. Thus, the depth or volume of water required to irrigate a laser leveled field will be less than what is needed for a field that has not been leveled because the highs and lows have been removed.

3.3.3 Minimum Tillage

Crop residue left by minimum or no-tillage increases soil tilth, allows more water to penetrate the soil and prevents puddling and runoff. Deep tillage with a chisel plow also increases penetration and breaks up hardpan that can restrict root development. (Anonymous, 1980b).

3.3.4 Water Control Structures

Water control structures are those on-farm facilities that control and regulate the flow of water from the farm delivery point to the field. These facilities are similar to the off-farm inline structures, but are designed for smaller flows. Examples of water control and regulating structures are checks, drops, divider boxes, and reservoirs. The control and regulation of water flow on the farm is required to distribute water throughout the on-farm delivery system. Using divider boxes and checks, water can be diverted from one location to another. Checks are used to maintain the constant water level required to achieve efficient application of water on the fields. Drop structures allow the transportation of water along steep slopes, while maintaining a non-erosive slope in each reach of the conveyance system. Where adequate hydraulic head is available at the farm headgate, high-flow turnouts can reduce the irrigation time, the amount of water applied, and labor requirements; improve distribution uniformity of the surface application; and increase the efficiency of water-borne nutrient applications. On-farm reservoirs can accumulate low flow rates from wells or canals until sufficient volume is available for efficient application. Water control structures are most effective in the mountain meadow and intermediate valley irrigation zones where the on-farm delivery systems are relatively old and usually lacking in measuring devices and structures.

3.3.5 Flow Measurement Devices

For the irrigator to apply the specified amount of water at each irrigation, he must have some method of water measurement. Flow measurement devices can be installed in open ditches and in pipelines. Some examples are Parshall flumes, cutthroat flumes, weirs, orifice plates, and flow meters. In addition to telling farmers how much water has been pumped, meters are also useful in determining the efficiency of a pumping plant and detecting potential well and pump problems before they become a serious problem. Installation of flow measuring devices will not in itself conserve water. These devices must be maintained and used by the irrigator to control the amount of water applied. They will be most effective when used in conjunction with an irrigation scheduling program.

3.3.6 Tailwater Recovery Systems

Tailwater recovery systems are used to catch runoff resulting from irrigation and return the water into the original delivery system or onto another irrigated field. The system usually consists of a sump, pit, or collection reservoir located below the irrigated area, a pump, and a pipeline to deliver water back to the delivery system or to the irrigated field. Tailwater pits may lose a third of the inflow because of deep percolation and evaporation (Blair, 1981). They may also become a potential breeding ground for mosquitoes. A better alternative may be to adopt management practices that reduce runoff and eliminate the need for tailwater recovery.

3.3.7 Selection of Application Method

Three methods of irrigation water application—flood, sprinkler, and drip—are used in New Mexico Switching from one of these methods to another constitutes a change in method of irrigation application. This is a valid alternative for improving water use and management where the existing irrigation system is poorly suited to the site conditions and the desired degree of efficiency cannot be obtained by improving the system design.

No one irrigation method is consistently more efficient than other methods, and conversion from one method to another should be based on such a premise. The potential change in method should be based on evaluation of land slope, crops to be irrigated, water supply, water intake and water-holding capacity of the soil, labor, and other factors, including economic and environmental impacts. The method selected should conserve soil as well as water. To do this, it may be necessary or desirable to use more than one method of irrigation on any given farm. For example, crops which are drip irrigated may have to be flood or sprinkler irrigated occasionally to apply a sufficient head of water to leach salts out of the root zone.

A change from flood to sprinkler irrigation may be warranted when soils have high intake rates that cause excessive deep percolation with flood methods; fields are steep or have complex slopes; or light frequent water applications are required due to crop requirements or soil water-holding characteristics. Efficient flood irrigation is possible, except on steep slopes and coarse-textured soils, when flow rates, time of set, and length of run are properly chosen. Flood systems may be preferred when large water applications are needed for leaching to maintain salt balance; when sprinkling with low quality water would cause damage to crop foliage; when effective use of rainfall and erosion control is feasible by land leveling; or when sprinkler evaporation losses are excessive due to wind and other climatic conditions. Drip irrigation should be considered when (1) the water supply is limited, (2) there is need for a high degree of automation (reduced labor), (3) slopes are excessive, or (4) the cost of water is high.

3.3.8 Improved Application Method

The improved design of an existing application method can be effective in managing irrigation water by facilitating better control of the available water supply. Other purposes may include more effective use of rainfall and labor, reduction of energy requirements, reduction in operation and maintenance costs, and provision for safety features. Reorganization of irrigation systems should be based on analyses of the particular site conditions by personnel who have expertise in irrigation design and water management.

Examples of design changes for sprinkler systems include reorificing sprinkler heads, and changing sprinkler spacings and operating pressures to improve distribution patterns and application rates. Center pivot sprinklers may be fitted with drop down tubes which bring the spray nozzles to within a few inches of the ground. These systems which are referred to as low energy precision application systems (LEPA), can achieve application efficiencies of up to 95%. Because water is applied at low pressure directly above the furrow, wind drift and evaporation losses are virtually eliminated. To maximize uniform water activity with LEPA systems, farmers may use furrow dikes to hold the water in place until it has had time to soak in. Irrigators who have converted their irrigation systems from conventional furrow to LEPA report reduced labor costs of up to 75%, decrease of 35% to 50% in energy costs, water savings of at least 25%, and increases in yields of 25% or more because water previously lost to evaporation is available to the crops. (Anonymous, 1989).

Flood system design may often be improved by adjusting run lengths and furrow streams to prevent excessive deep percolation and runoff; changing dimensions of border strips to obtain proper advance and recession of the irrigation streams; reducing irrigation grades by land leveling; adjusting spacing of field ditches; and adding tailwater recovery facilities, automation, and measuring equipment. A time-controlled surge irrigation valve management correctly in conjunction with a furrow irrigation system can eliminate irrigation tailwater losses minimize deep percolation losses and reduce the length of time that water in the furrow is exposed to evaporation. Water savings of 10% to 40% have been measured after the addition of surge valves to conventional irrigation systems (Anonymous, 1989).

3.3.9 On-Farm Irrigation Water Management

On-farm irrigation water management is the determination and control of the rate, amount, and timing of irrigation water application to soils to supply water needs in a planned and efficient manner. Improvements in water management can reduce mining of groundwater supplies, reduce diversion rates from natural streams or reservoirs, reduce tailwater runoff, reduce deep percolation losses, reduce nutrient losses, improve water quality, and improve crop yields. Management improvements can be made by irrigation scheduling and applying water in desired rates and amounts. Many irrigators apply water on a set schedule without regard to crop needs or moisture-holding capabilities of the soil because of habit or other constraints. Inadequate or ill-timed applications can result in lowered crop yields. Irrigation scheduling involves use of data on soil moisture availability, crop water requirements, and rainfall to achieve a soil moisture balance for the irrigator's fields. The objective is to enable the farmer to determine when he needs to irrigate and how much water to apply. Additional labor can often allow the irrigator to better manage his water.

Scheduling is most effective when irrigation water supplies are adequate, but can be useful in managing a limited supply. If a complete scheduling program is not used, soil moisture determination by itself can improve water management. Whether the determination is made by a shovel, probe, moisture block, or tensiometer, the level of soil moisture is estimated, and irrigation water is applied if moisture is below a specified level. This specified level will vary, depending on the soil, climate, crop, and stage of crop development. Excess water application may cause surface runoff or deep percolation. Inadequate application will not maintain an optimum moisture level and will require more frequent irrigations. The timing and measurement of water are essential to determine how much is being applied.

The potential benefits of irrigation scheduling are illustrated by the following examples:

1. In 1976, farmers in central Nebraska who were cooperators in an irrigation scheduling program piloted by the University of Nebraska applied an average of 15 inches of water to about 5,000 acres of cropland; farmers who were not in the program applied an average of 24 inches of water. (Ruen, 1977). As a result, farmers in the scheduling program reduced both the amount of ground water pumped and the cost of pumping by about 38%.

   The University of Nebraska irrigation scheduling technique used a computerized scheduling program on Nebraska's AGNET computer system. Soil moisture data for the AGNET program was collected from electrical resistance blocks placed in the soil at depths of 0.5, 1.5, 2.5, and 3.5 feet. Irrigations were scheduled when the moisture in the root zone was more than 50% depleted. The irrigation water applied was less than that necessary to fill the soil profile completely, so the soil could absorb rainfall if it should occur.

2. Since 1984, at the cost of a few dollars per acre, farmers in 16 counties in California have reduced the amount of water they apply to their fields by 15% to 50% using gypsum blocks to signal when its time to irrigate. In Colorado, farmers who have installed gypsum blocks at one or two sites within each circle under center pivot irrigation have reduced their annual diversions by 30% to 40% and their pumping costs by $2,000 or more per field (Richardson, 1992).

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4 SELF-SUPPLIED LIVESTOCK

4.1 FACTORS WHICH AFFECT LIVESTOCK WATER USE

Livestock and poultry obtain water from three sources: (1) drinking water, (2) water contained in feed, and (3) water made available through metabolic processes. Many factors influence the intake of water by livestock and poultry. They include, species, size, age, sex, and production rate of the animal (i.e. gallons of milk, number of eggs, etc.); amount and content of the feed; accessibility to water; and air temperature.

There are nearly as many different waste disposal systems as there are livestock enterprises. While some manure handling does not incorporate the use of water, many waste disposal systems do. Manure generated by livestock on pasture and range is deposited directly on the land. Manure in lot areas is often dry and easily scraped and handled with loaders and spreaders. Holding ponds are often used to retain feedlot runoff until the waste can be spread. Manure in closely confined areas with slab or slotted floors is often wet, in a near liquid state. Wet manure may be collected by flushing gutters, hosing or by falling through the slats into a holding tank, lagoon, or oxidation ditch. It is either applied to the land with slurry or tank spreaders or irrigation equipment, or it is recycled. Many waste disposal systems require no additional water. However, over the years, an increasing number of hog and beef-cattle feeders and dairy herdsmen have adopted a partial or total liquid disposal system. Liquid systems may need to have water added to hose floors, flush gutters, start batch oxidation and/or dilute solid concentrations for biotic action or ease of handling.

Freshwater may also be required for animal washes and dips, animal housing washdown and disinfectant sprays, cleaning and sanitizing equipment, washing eggs, and dust control. In addition to water consumed by animals, there are watering losses that include tank and trough evaporation, tank overflows, trough spills, and continuous ripple flow discharge (to prevent freezing). Overflows of watering devices are losses incurred with drinking water; however, these losses are not intake and are in addition to drinking water requirements. Watering losses are generally estimated as 10% of animal drinking water requirements (Soil Conservation Service, 1975).

4.2 WATER REQUIREMENTS FOR BEEF CATTLE

Sweeten et al (1990) studied drinking water requirements of 28,000 beef cattle on a feedlot in Texas over a period of 11 months during 1984 and 1985. Meter records from the municipality that provided water to the feedlot indicated an average consumption of 7 gallons per head per day (GPCD equivalent) and a range from 4.2 GPCD in the winter to 10.3 GPCD in the summer. Analysis of the data showed that drinking water requirements can be estimated at 0.48 gallons of water per pound of dry feed consumed. On the basis of this criterion, the data shown in Table 4.1 was developed. Given an 80% dry matter ration, an 800-pound animal will consume 9.6 gallons of water per day. A 10,000 head feedlot would require a continuous pumping rate of 67 gallons per minute (gpm) to meet the average demand and approximately 134 gpm to meet the peak demand. The pumping rate required for an 8-hour day utilizing a storage reservoir would be at least 200 gpm for a 10,000 head feedlot, and 400 gpm to meet the peak demand.

The average weight of a steer in New Mexico is about 764 pounds (New Mexico Agricultural Statistics Service, 1991). Using the guidelines developed by Sweeten, the average water requirement per head of beef cattle on an 80% dry matter ration would be 9.2 gallons per day. Allowing for trough water losses would increase the water requirement slightly.

Table 4.1. Drinking water requirements for beef cattle in gallons per capita per day (GPCD). (Source: Sweeten et al, 1990).

Liveweight (lbs/head)	Dry Feed Consumption (lbs/head/day)	Water Required (GPCD) Dry matter in Ration (%)		
		70	80	90
600	12	8.2	7.2	6.4
800	16	11	9.6	8.5
1000	20	13.7	12	10.7
1200	24	16.5	14.4	12.8
Note: To get GPCD, divide dry feed consumption by the percent of dry matter in ration expressed as a decimal and multiply the result by 0.48.				

4.3 WATER REQUIREMENTS FOR MODERN DAIRY BARNS

New diaries today typically operate with 1,000 or more head and maintain high animal concentrations in confined lots or corrals on small acreages relative to the number of cows. Typical animal spacings in open lots are 600 square feet per cow. Large amounts of water are used for manure removal and milk sanitation (Sweeten and Wolfe, 1990).

Frank Wiersma (1988), Professor of Agricultural Engineering and Cooperative Agricultural Extension Service Dairy Specialist at the University of Arizona, developed the following guidelines for estimating water requirements of dairies.

Total daily water consumption by lactating cows is influenced by ambient climatic conditions and by milk production level. There is a compensating interaction between these two parameters in that high temperatures reduce milk production level. Based on current studies, daily water consumption per lactating cow is given by the following equation:

$$GPCD=26+0.3(MP-40)$$

where GPCD is water consumed in gallons per capita per day and MP is fluid milk production in pounds per day. Since this equation is based on the premise that milk production is not less than 40 pounds per day, at which level the GPCD is 26, water requirements for lactating cows should be 26 gallons per day or the value produced by the above equation, whichever is greater. For a dairy operation to be profitable, cows must generally produce 65 to 75 pounds of milk per day. Substituting 75 pounds per day into the equation yields an average drinking water requirement of 36.5 GPCD.

In addition to lactating cows, dairies also have dry cows, bulls, springer heifers, young calves, and replacement heifers on the premises. One-quarter to a third of the dairy herd is generally retired each year and replaced with younger stock. Most of the water used exclusively by non-lactating animals on the dairy is for drinking. However, water is also used for hospital treatment, foot baths, water trough cleaning, and equipment washing. Total water requirements for non-lactating animals are about 20 gallons per animal per day or the equivalent of 6.6 gallons per lactating cow per day assuming there is one non-lactating animal for every three lactating cows (i.e., 6.6 GPCD=20GPCD/3).

Many of the milking center operations requiring water use are dictated by sanitary codes. All milk lines and associated equipment must be washed, rinsed and sanitized after each milking operation. Both hot and cold water are used. Parlor and holding area grates, floors, and walls must also be hosed down to remove manure after each milking. Hoses with spray nozzles must be available at all milking stalls for teat and udder cleansing prior to attachment of milking equipment.

A small number of dairies in New Mexico prewash the udders of lactating cows prior to entry into the parlor with a grid of jet sprayers at floor level in the holding area. Most dairies in New Mexico however, wash the udders with hand-held hoses before milking. This practice requires much less water than an automated sprinkler wash. For dairies with sprinkler udder washing systems, the total water requirement for the milk room, parlor and holding pen is 35 to 40 gallons per milking per lactating cow. Corresponding water requirements for dairies which employ manual udder washing practices are 23 to 25 gallons per milking per lactating cow.

Other milking center water uses may include coolant for vacuum pumps—2 gallons per milking per cow, cooling towers for precooling milk—0.25 gallons per milking per lactating cow, and cooling towers for refrigeration system condensers—3 gallons per day per lactating cow. Water used for cooling in dairies is generally recycled, however, a small amount of fresh water must be introduced to make up for evaporation losses.

There are many other water uses that may occur in a dairy operation. Water is used as an additive for the feed ration, for washing, for washing the milk truck ramp located forward of the milk room, for separate maternity facilities, for laboratories, for the employees, for the occasional flushing of manure sump, for the cow hospital or treatment area, and for the occasional line breaks. Though most of these requirements are rather small, they are cumulatively quantitatively significant. Ten gallons per day per lactating cow should be allotted for these water uses.

In some areas of the Southwest where summers are extremely hot (primarily Arizona) it is common practice to use evaporative shades to cool cattle down. Water may also be used to sprinkle traffic lanes and cattle corrals for dust control. However, these practices are not common in New Mexico.

Dairy wastewater from the holding areas, milking parlor, milk storage tank and equipment is routed to lagoons which typically have a surface area ranging from three to five acres. To comply with state regulations to protect groundwater quality, these lagoons may be evaporated. However, after primary treatment in holding ponds, irrigation systems are often used to dispose of the wastewater. Because the salinity of the wastewater may cause crop damage, freshwater may be introduced to dilute the wastewater before it is used for irrigation.

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5 SELF-SUPPLIED COMMERCIAL, INDUSTRIAL, MINING, AND POWER

5.1 GOLF COURSE INFORMATION

Cool-Season Grasses. These grasses have an optimum growing temperature of 60-70 degrees Fahrenheit and are best suited to the cooler regions of New Mexico. Cool-season grasses include Kentucky bluegrass, tall fescue, perennial ryegrass, and creeping bentgrass.

Warm-Season Grasses. These grasses have an optimum growing temperature of 80-95 degrees Fahrenheit, or above, and are best suited to southern New Mexico and elevations below 4,500 feet. Warm-season grasses include Bermuda grass, Tifgreen, Santa Ana, zoysiagrass, St. Augustine grass, and buffalo grass. Warm-season grasses are generally susceptible to injury by cold weather.

During the warmest months of the year, cool-season grasses normally exhibit evapotranspiration rates that are typically 30% to 40% higher than warm-season grasses (Borrelli et al, 1981; Texas Agricultural Experiment Station, 1986). Thus, warm-season grasses will consume less water than cool-season grasses. For the purpose of Technical Report 52, consumptive irrigation requirements for golf courses were computed using the original Blaney-Criddle method and the following consumptive use coefficient (K): For cool-season turf grasses, 1.05 inside the frost-free period, and 0.50 outside the frost-free period; for warm-season turf grasses, 0.80 and 0.50, respectively.

To keep irrigation water requirements to a minimum, developers who are planning the construction of a new golf course should explore the research that has been conducted on turf grasses and adopt a species of grass that has low water requirements and is well adapted to the local climate. *The importance of carefully selecting an appropriate turf grass cannot be overemphasized.* In southern New Mexico, there are several golf courses planted in cool-season grasses that are not well suited to the climate. During the hot summer months, large volumes of water are required to prevent these grasses from wilting. The annual water demand and stress on the aquifer would be much less had these golf courses been seeded with warm-season grasses. To prevent new developments from planting turf grasses that have high water requirements where an alternative species of grass with low water requirements is viable, local governments and regulatory agencies can formulate guidelines, which would discourage the use of certain species of turf grass.

On a golf course with an irrigation system that has been carefully designed to conserve water, water is applied strictly according to plant needs. A vast array of electronic equipment is available to help maintenance personnel apply the right amount of water at the right time. Sprinklers can be turned on automatically by a system that uses tensiometers to measure soil moisture, therefore applying water only when it is needed. Greens, fairways, and rough areas may be irrigated on different schedules to satisfy the water demands of each species of vegetation. To minimize evaporation, an anemometer may be installed to monitor windspeed and postpone irrigation until winds are calm.

These efforts may sound extreme, but the financial benefit to a business maintaining a large area of turf grass can be substantial. A golf course in California that adopted the irrigation scheduling practices just described reduced its irrigation withdrawals by 70% and saved $32,000 per year in pumping costs.

(California Department of Water Resources, 1984). An additional benefit resulting from the implementation of water conservation measures on a golf course is that when less water is applied, turf disease is minimized and fertilizer requirements are reduced because a smaller percentage of the nutrients percolate below the root zone.

6 RESERVOIR EVAPORATION

6.1 FACTORS WHICH AFFECT THE EVAPORATION RATE

The body of water from which evaporation takes place may be small or large, exposed or protected from the wind, shallow or deep, or at high or low elevation. It may have a high or low plant population or concentration of salts. If exposed to wind movements, or if small, shallow, or densely populated with plant growth, evaporation will be increased. In the summer, when evaporation is at a maximum, more water will evaporate from small and shallow bodies of water than from deep large bodies due to the increased temperature in the small bodies of water. The presence of aquatic plants will also add to the amount of water loss as evaporation will be augmented by the transpiration of the plants. Dissolved salts in saline bodies of water reduce the vapor pressure of the water surface, tending to promote condensation while inhibiting evaporation to a slight degree. Because air temperature decreases with altitude, evaporation from water bodies at high elevations will generally be less than from a body of water at the same latitude but at a lower elevation.

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APPENDIX A. GLOSSARY

Acre-foot (AF)
The quantity of water required to cover one acre (43,560 square feet) of land with one foot of water. There are 325,851 gallons in one acre-foot of water.

Aquifer
A saturated underground formation of permeable rock or unconsolidated materials, such as gravel, silt, or clay, capable of storing water and transmitting it to wells, springs, or streams.

Combined water
When both ground and surface water are used on-site for the same purpose, such as crop irrigation.

Consumptive irrigation requirement (CIR)
The quantity of irrigation water expressed as a depth or volume, exclusive of effective rainfall, that is consumptively used by plants or is evaporated from the soil surface in a specific period of time. It does not include water requirements for leaching, frost protection, wind erosion protection or plant cooling. Such requirements are accounted for in on-farm efficiency values. The consumptive irrigation requirement may be numerically determined by subtracting effective rainfall from the consumptive use.

Consumptive use (U, u_m) or evapotranspiration (ET)
The unit amount of water consumed on a given area in transpiration, building of plant tissue, and evaporated from adjacent soil, water surface, snow, or intercepted rainfall in a specific period of time. The term includes effective rainfall. Consumptive use may be expressed either in volume per unit area, such as area-inches or acre-feet per acre, or depth, such as in inches or feet.

Crop distribution ratio (CDR)
The crop distribution ratio is computed by dividing the acreage planted in a specific crop by the total acreage for all crops included in the cropping pattern.

Cropping pattern
Distribution of the total irrigated acreage in a specific area according to the acreage planted in each individual crop.

Diversion
The quantity of metered water taken from a surface or groundwater source.

Drip irrigation
Drip, or trickle, irrigation is defined as the precise application of water on, above, or beneath the soil by surface drip, subsurface drip, bubbler, spray, mechanical move, and pulse systems. Water is applied as discrete or continuous drops, tiny streams, or miniature spray through emitters or applicators placed along a water delivery line near the plant(s).

Effective rainfall (R_e, r_e)

Rainfall that occurs during the growing period of a crop that becomes available to meet its consumptive irrigation requirements. It does not include rain that is intercepted by the plant canopy, surface runoff, or deep percolation below the root zone.

Evapotranspiration (ET)

See consumptive use.

Farm delivery requirement (FDR)

The quantity of water exclusive of effective rainfall, that is delivered to the farm headgate or is diverted from a source of water that originates on the farm itself, such as a well or spring, to satisfy the consumptive irrigation requirements of crops grown on a farm in a specific period of time. The farm delivery requirement is computed by dividing the consumptive irrigation requirement, expressed as depth or volume, by the on-farm irrigation efficiency, expressed as a decimal.

Field application efficiency

The ratio of the volume of irrigation water added to the root zone to the depth or volume of water applied to the soil. The application efficiency does not account for conveyance losses that may occur between the farm headgate and the fields that are irrigated. (See on-farm irrigation efficiency.)

Flood irrigation

Flood irrigation includes furrow, border-strip, level-basin, and wild flooding. It is often referred to as “surface irrigation,” because the water applied flows over the surface of the irrigated field, or “gravity irrigation,” because free water runs downhill.

Gallons per capita per day (GPCD)

The average quantity (gallons) of water used per person or per head of livestock, per day.

Groundwater

Water stored in the zone of saturation of an aquifer.

Idle and fallow

Acreage plowed and cultivated during the current year but left unseeded or acreage that is left unused one or more years.

Instream use

Water use that occurs within a stream channel. Instream use is not dependent on withdrawal or diversion from ground or surface water sources; it is usually classified as a flow use. Examples of flow uses that depend on water running freely in a channel are hydroelectric power generation, recreation, fish propagation, and water quality improvement.

Irrigable acreage

The sum of irrigated crop acreage and idle and fallow acreage. Such acreage is developed for farming and irrigation works to apply water to the land. It does not include farmstead, feedlots, road areas, ditches and the like.

Irrigated acreage (net)

Includes agricultural land to which water was artificially applied by controlled means during the calendar year. It includes pre-plant, partial, supplemental, and semi-irrigation applications. Land flooded during high water periods is included as irrigation only if the water was diverted to agricultural land by dams, canals, or other works. It is equal to the sum of all irrigated crop acreage minus the multiple-cropped acreage.

Multiple-cropped acreage

The same acreage used to produce two or more crops in the same year. When conducting inventories of irrigated acreage, each irrigated crop is included as part of the planted acreage, but the multiple-cropped acreage is subtracted from the sum of all crop acreage to obtain the net acreage irrigated.

NMSA

New Mexico Statutes Annotated (1978).

Off-farm conveyance efficiency (E_c)

The ratio, expressed as a percentage of the quantity of water delivered to the farm headgate by an open or closed conveyance system, to the quantity of water introduced into the conveyance system at the source or sources of supply.

On-farm distribution system

A system that conveys diverted water to the appropriate field on the farm. On-farm distribution systems may consist of a series of ditches or pipes.

On-farm irrigation efficiency (E_f)

The ratio, expressed as a percentage, of the volume of irrigation water infiltrated and stored in the root zone to the depth or volume of water diverted from the farm headgate or a source of water originating on the farm itself, such as a well or spring. The on-farm irrigation efficiency reflects the efficiency of the on-farm distribution and application system, and includes deep percolation losses necessary as a beneficial use for leaching excess salts from the root zone. The on-farm irrigation efficiency is used to calculate the farm delivery requirement.

Pre-plant irrigation

Water applied to fields before seed is sown to provide optimum soil moisture conditions for germination and for storage in the soil profile for later consumptive use by plants during the growing season.

Project diversion requirement or off-farm diversion requirement (PDR)

When the source of irrigation water does not originate on the farm, the project diversion requirement, or off-farm diversion requirement, is defined as the quantity of water, exclusive of effective rainfall, that is diverted from an off-farm source to satisfy the farm delivery requirement in a specific period of time. An additional quantity of water must be diverted from the ultimate source of supply to make up for conveyance losses between the farm headgate and the source of water. Estimated conveyance losses are added to the farm delivery requirement to arrive at the project diversion requirement. The off-farm diversion requirement may also be calculated by dividing the farm delivery requirement by the off-farm conveyance efficiency, expressed as a decimal.

Project or system irrigation efficiency (E_i)

The combined efficiency of the entire irrigation system, from the original diversion point to the crop root zone. It is the product of the on-farm efficiency (E_f) and the off-farm conveyance efficiency (E_c) and is expressed as a percentage. When the irrigation source originates on-farm, such as from a well or spring, the off-farm conveyance efficiency does not apply; therefore, the project or system efficiency is the same as the on-farm irrigation efficiency.

River basin (RVB)

The entire area drained by a stream (or river) or system of connecting streams so that all the streamflow originating in the area is discharged through a single outlet.

Self-supplied

Water users who withdraw water directly from a ground or surface water source.

Sprinkler irrigation

A method of applying irrigation water (similar to rainfall) to farm crops, golf courses, and residential yards and gardens. On a farm, the water is distributed through a system of pipes, by a pump, and is sprayed through the air. Sprinkler irrigation systems can be divided into periodic move systems that remain at a fixed position while irrigating, and continuous move systems that move in either a circular or straight path while irrigating.

Surface water

Water stored in ponds, lakes, rivers, and streams.

Transpiration

The process by which water in plants is transferred into water vapor in the atmosphere.

Weighted consumptive irrigation requirement (WCIR)

A weighted consumptive irrigation requirement is the CIR for a crop, multiplied by the crop distribution ratio for that crop. Summing the WCIR for all the crops in a cropping pattern equals a WCIR for that cropping pattern.

Withdrawal

The quantity of calculated, metered or estimated water taken from a surface or groundwater source.

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