

Principles of On-Farm Water Management ¹

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On-farm water management can be defined as: **A systems approach towards controlling water on a farm in a manner that provides for the beneficial management of water for satisfying the irrigation and drainage needs of a crop under the constraints imposed by the prevailing physical social, governmental, and production systems .**

Water, or the control of water, affects most crop production activities. Sufficient water must be present in the root zone for germination, evapotranspiration, nutrient absorption by roots, root growth, and soil microbiological and chemical processes that aid in the decomposition of organic matter and the mineralization of nutrients. These factors are all necessary for sustaining crop growth on a particular field.

At the same time, the root zone must be sufficiently dry to ensure adequate aeration and root extension. The root zone must also be dry enough to allow field access for performing cultural practice activities such as planting, cultivating, fertilization, pesticide and herbicide applications, and harvesting operations. In order to realize potential yields, water movement through the soil must exist; water movement leaches excess salts from the root zone.

To satisfy the objectives of water control, an adequate soil water content must be maintained in a field. This must be done in a timely manner and within constraints imposed by characteristics of the area.

- Physical --soil types, depths, and characteristics, field layout, water sources and sinks.
- Climatic- frost potential, drought potential, rainfall amounts and intensities.
- Economic -- market prices, material availability, labor cost and availability.
- Social-- governmental regulations, environmental concerns, safety considerations.

Water budgeting (Choate and Harrison, 1977) and water management evaluations (Harrison, 1981; and Bennett, Harrison, and Smajstrla, 1984) are useful tools to help the manager operate the system effectively and efficiently. Both will be dealt with in further detail in future papers. Water budgeting is an accounting for all water entering, leaving, and remaining on a farm or field. This includes knowing the designated use of the available water as well as the losses from the system that cannot be controlled

1. This document is AE59, one of a series of the Agricultural and Biological Engineering Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date November, 1987. Reviewed March 2011 by Dorota Haman. Visit the EDIS website at <http://edis.ifas.ufl.edu>.

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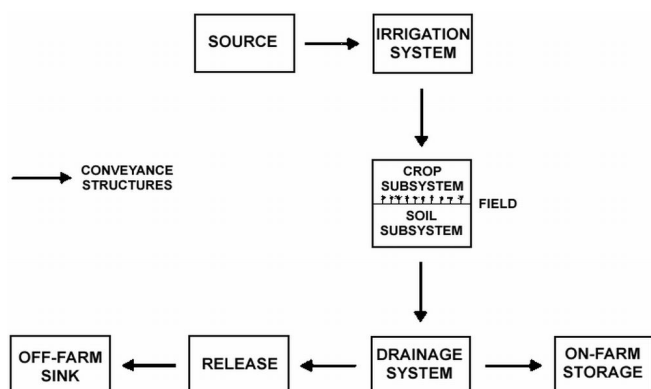
by the manager. Water management evaluations examine the efficiency with which water is conveyed, applied to a field, and made available for crop use for optimum growth. A well-managed system will, under most circumstances, not subject a crop to either drought or flood conditions that would result in yield reductions.

Systems Components

The term "management" implies that the on-farm water management concept is one involving various decision-making processes. These decisions revolve around using water to realize optimum returns from the crop. Economic and social factors place certain restrictions on optimum returns. Components of the water management system that must be managed on a farm can be broken down into several categories.

- Irrigation
- Drainage
- Conveyance to and from fields
- Water storage
- Release of water from the confines of the farm
- Water sources and sinks

The relationships between the components are shown schematically in Figure 1.



To satisfy the overall objectives of the water management program, decisions must be made concerning both the types of system components to install, as well as how, when, and how long each system should be operated. These decisions must conform to both government and other social

regulations on volumes of water entering and leaving a farm.

Irrigation

The primary purpose of irrigation is to supply crops with sufficient water to satisfy evapotranspiration needs so yield reductions will not occur. The first management decision regards the type of system that will be used to perform this function. Common irrigation systems used in Florida are varied.

- Seepage or subirrigation
- Sprinklers -- big gun, center pivot, linear move, or solid set
- Surface -- furrow or crown flooding
- Trickle or low volume-subsurface, spray, drip emitter, bubbler, or mist

When to irrigate and how much water to apply are other concerns. Both questions can be answered by considering the evapotranspiration needs of the crop, rainfall patterns, and the need for field access. Clearly, water must be applied to the root zone before drought stress can cause irreversible damage to the crop.

When rainfall occurs in adequate amounts during major portions of the crop season, irrigation is used on a supplemental basis (in the event that rainfall is not timely or adequate). In this case, the cost of installing a sophisticated irrigation system must be weighed against the level of protection that the irrigator wishes to maintain. Irrigations must also be scheduled around the times needed to gain access to fields in order to perform cultural practice activities.

Other reasons for irrigation may also exist. Three such reasons are frost protection, pest management, and salinity control. Additional considerations are the coexistence of the irrigation system with cultural practices necessary for crop growth, the permanence of the system, and the source of water. The latter item is extremely important because quality and quantity of water may preclude the use of a particular irrigation method.

Drainage

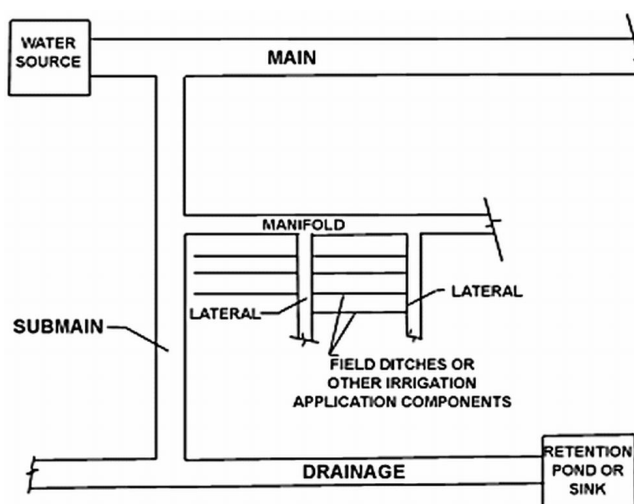
In areas of high rainfall, adequate drainage is mandatory for crop production. In more and more regions, drainage may still be necessary to remove any excess irrigation water applied. The function of a drainage system is to remove water from a field root zone whenever necessary, and fast enough to avoid permanent root damage resulting from lack of oxygen in the soil.

Drainage systems must be compatible with crops grown, field layouts, and cultural practices such as crop rotation and cultivation. System choices include open ditches, tile drains, mole drains, and land forming for increased surface runoff. The four methods can be used separately or in different combinations. The system design must be capable of removing excess water at a high enough rate to ensure a level of protection against flood damage to crops.

Drainage system choices and operational decisions are limited by timely access to the field, economically advantageous field sizes, depths of root zones, depths of soil profiles, natural water table levels, amounts of water to be removed in a given time frame, and susceptibility of the particular crop to flooded conditions. Since drainage structures are relatively permanent, the system installed should be capable of handling the needs of all crops included in the grower's rotation.

Conveyance

Conveyance structures transport water to and from various locations on the farm, and include laterals, manifolds, submains, and mains. These delivery structures can be either open ditches or closed conduits, depending on the water source and the irrigation and drainage systems. The primary purposes of these structures are to transport water from the source (either surface or ground water) to the irrigation system, or from the field to the sink where runoff is deposited. A typical field conveyance system layout is shown in Figure 2 . A particular field does not need every component of the conveyance system. Devices such as furrows or other open ditches, sprinkler heads and drip emitters draw water from the laterals and spread it over the field surface.



The conveyance structures must be large enough to handle the maximum irrigation or drainage volumes foreseen for the areas they serve, given a certain desired level of protection from flood and drought. Pressurized irrigation systems will generally require closed conduits for at least part of the conveyance or delivery system. Surface systems may use buried closed conduits to transport water in order to avoid taking land out of production. For drainage systems, open ditches, closed conduits attached to subsurface drain lines, or a combination of both may be used. If a combination is used, open ditches could carry surface runoff and subsurface drain discharge to the appropriate on- or off-farm sink. The selection of a conveyance system should be based on land availability, access to parts of the farm (open ditches may impede ready access), volumes of water handled (burying very large conduits may be infeasible as well as expensive), rainfall amounts and intensities, water source, and type of irrigation system used. The manager or installer must then decide on how, when, and how much water will need to be routed to different parts of the farm to determine what the capacities of the structures should be. These decisions must be made to ensure that the crop is irrigated and drained in a timely fashion. To do this, a manager must know crop water needs, areas served by each structure, and the time that it takes to transport a certain volume of water in the system from one point to another.

Storage

Water can be stored on farms in various ways. The conveyance system generally provides a certain

amount of storage to hold drainage amounts in excess of that removal amount planned for during design. Holding excess water in the conveyance structure may result in inadequate hydraulic head differences for drainage, or excessive seepage into a field.

The soil root zone is also a viable storage facility in which water in excess of crop needs can be held for short periods of time. The amount of water that a soil can store will depend on the soil type and the flood tolerance of the crop, both of which provide only a limited amount of storage for a limited amount of time.

On a larger, long-term basis, on-farm reservoirs or ponds can provide water for irrigation either as primary sources or to augment the primary source in times of need. These reservoirs or ponds can hold agricultural runoff for later use, thus reducing the demand on the basin-wide system in times of drought. These ponds hold nutrient-laden water for reuse and also prevent degradation of public water supplies.

The selection of an on-farm storage facility is not always necessary. However, storage facilities provide the grower with additional insurance in the event of unduly large rainfalls or drought conditions. The use of these reservoirs is also restricted by the topography of the land and the type of irrigation system used. For example, in areas where shallow soils overlying bedrock exist, or in areas where there are no natural catchment areas, the construction of a reservoir would be costly and only marginally beneficial since large amounts of land would have to be taken out of production. This is especially true in cases where irrigation systems require the movement of relatively large volumes of water through leaky open ditches. However, the reservoir is the most useful and powerful on-farm storage system under suitable conditions. Soils and conveyance structures can provide only temporary, small-scale relief for both irrigation and drainage needs.

Release

The final component of the on-farm water management system is the manner in which water is released from the confines of the farm. Some water will seep out of the system through the soil or

percolate beneath the root zone. Water will also exit the system through evaporation from open conveyance or storage structures. However, to remove large volumes of water from a farm requires a structure capable of artificially channeling water to a point where it can either flow by gravity or by pumping to a sink outside the system. This is particularly important in areas of high rainfall.

Pumps can be used to move large amounts of water quickly. Alternatively, ditches or conduits on grades, and positioned above the water level of the sink, can perform the function adequately. Again, these structures must have the capacity to remove enough water, fast enough, to prevent crop damage given a selected level of protection.

The water manager must then make decisions for releasing water based on the drainage system capacity, crop tolerance to flood or drought, level of insurance desired in the event of needing more or less water on the farm in the future, and governmental or other special restrictions placed on water release to the public water supplies. Regulations and restrictions often involve limitations on the quality of water released to the public water supplies. The amount of nutrient-laden water that leaves a farm should be of concern to the grower, since it may be possible to reuse that water to his benefit.

Source and Sink

Two additional components of a farm water system are the water source and the sink. The source can be surface water from reservoirs, lakes, ponds, and canals, or ground water from wells. The sink can be on- or off-farm ponds, reservoirs, lakes, or canals. Once properly cleansed, excess water may also be used to recharge deep aquifers. Either gravity flow or mechanical pumping can be used to obtain water from the source and to pass runoff to the sink. In both cases, water quality must be considered an extremely important consideration.

Summary

All of the components discussed make up an on-farm water system. How the components interact constitute an on-farm water management program. Each component must be selected and operated in

accordance with the needs and limitations of the other components. The overall system must support the crop system as well as conform to the physical, social, economic, and governmental systems within which it operates.

References

- Bennett, J. M., D. S. Harrison, and A. G. Smajstrla. 1984. Water use and management of agronomic crops. Institute of Food and Agricultural Sciences Circular No. 586. University of Florida, Gainesville, Florida.
- Choate, R. E. and D. S. Harrison. 1977. Irrigate by the accounting method. Institute of Food and Agricultural Sciences Circular No. 431. University of Florida, Gainesville, Florida.
- Hagan, R. M., H. R. Haise, and T. W. Edminster, eds. 1967. Irrigation of agricultural lands. ASA Monograph No. 11. American Society of Agronomy, Madison, Wisconsin.
- Harrison, D. S. 1981. Irrigation efficiencies. Agricultural Engineering Fact Sheet No. AE-21. University of Florida/IFAS, Gainesville, Florida.
- Jensen, M.E., ad. 1983. Design and operation of farm irrigation systems. ASAE Monograph No. 3. American Society of Agricultural Engineers, St. Joseph, Michigan.
- Luthin, James N., ad. 1957. Drainage of agricultural lands. ASA Monograph No. 7. The American Society of Agronomy, Madison, Wisconsin.