# BMPs for Agricultural Water Users

BMPs for agricultural water users are combinations of site-specific management, educational, and physical practices that have proven to be effective and are economical for conserving water. BMPs have been developed which focus on increasing the water use efficiency of water users such as producers of agricultural crops and of water suppliers such as irrigation districts. BMPs have been developed which focus on conserving rainwater, such as land owners managing and controlling brush species. BMPs provide a means of measuring the success of agricultural water conservation programs, their costs, and schedules of implementation. Good agricultural water conservation practices can provide benefits to wildlife resources.

Irrigation of crops accounts for the great majority of agricultural water use in Texas. The amount of water used in irrigation of a specific crop or in an agricultural practice varies with the location, climate, type of crops grown, local cropping practices, type of irrigation systems, and institutional constraints. Likewise, the amount of water conserved by implementing a BMP for such crop or practice will also vary.

Agricultural Water Use Management BMPs may include Irrigation Scheduling to determine when to irrigate crops, Volumetric Measurement of Irrigation Water Use to provide information regarding the performance of irrigation systems, Crop Residue Management and Conservation Tillage to preserve soil moisture and On-Farm Irrigation Audits to increase water efficiency in irrigation.

Land Management Systems BMPs can include Furrow Dikes to reduce water runoff from agricultural row crops, Land Leveling to increase the uniformity with which water is applied to an irrigated field, Conversion of Supplemental Irrigated Farmland to Dry-Land Farmland which uses rainfall to irrigate agricultural lands, and/or Brush Control/Management to reduce evapotranspiration in order to improve water quality and water yield.

On-Farm Water Delivery Systems BMPs include lining of on-farm irrigation ditches and replacement of on-farm irrigation ditches with pipeline, Low Pressure Center Pivot Sprinkler Irrigation Systems for irrigation of land with flat to modest slopes, Drip-Micro Irrigation Systems for more efficient irrigation, use of Gated and Flexible Pipe for field water distribution, Surge Flow Irrigation to apply irrigation water to furrows to aid in reduction of deep percolation, and the use of Linear Move Sprinkler Systems for more efficient irrigation of certain shaped field and/or fields with elevation changes.

In Water District Delivery Systems, lining or replacement of the irrigation canals with pipeline improves efficiency and reduces or eliminates seepage, facilitating conveyance of water to a group of users.

Finally, other systems that aid in efficient use of water include Tailwater Recovery and Reuse Systems, which make use of the irrigation water that runs off the end of an irrigated field and Nursery Production Systems, which improve the efficiency of water use in the production of nursery crops.

The quantity of water and cost savings provided in each BMP are estimates, and actual values vary with location and site specific conditions.

Best-management practices contained in the BMP Guide are voluntary efficiency measures that save a quantifiable amount of water, either directly or indirectly, and can be implemented within a specified timeframe. The BMPs are not exclusive of other meaningful conservation techniques that an entity might use in formulating a state-required water conservation plan. At the discretion of each user, BMPs may be implemented individually, in whole or in part, or be combined with other BMPs or other water conservation techniques to form a comprehensive water conservation program. The adoption of any BMP is entirely voluntary, although it is recognized that once adopted, certain BMPs may have some regulatory aspects to them (e.g., implementation of a local city ordinance).

## Agricultural Irrigation Water Use Management

### Irrigation Scheduling

***A. Applicability***

This BMP is used to determine when to irrigate a crop and is intended for agricultural producers that have access to irrigation water in adequate quantities and at times required by the producer. Advanced irrigation scheduling methods are particularly applicable to nursery/floral irrigation systems that have an adequate water supply and delivery system.

***B. Description***

Irrigation scheduling is a generic term for the act of scheduling the time and amount of water applied to a crop based on the amount of water present in the crop root zone, the amount of water consumed by the crop since the last irrigation, and other management considerations such as salt leaching requirements, deficit irrigation, and crop yield relationships. Irrigation scheduling is a water management strategy that reduces the chance of too much or too little water being applied to an irrigated crop. Extensive publications exist regarding irrigation scheduling, many of which are documented in “Evapotranspiration and Irrigation Water Requirements” by the American Society of Civil Engineers, Manual No. 70. The most common irrigation scheduling methods are:

1. Direct measurement of soil moisture content, soil water potential, or crop stress including: soil sampling, tensiometers, gypsum blocks, infrared photography of crop canopy, time domain reflectrometry, plant leaf water potential, and other methods.
2. Soil Water Balance Equations: Irrigation methods based on soil water balance equations. These equations range from very simple “checkbook” accounting methods to complex computer models that require input of climatic measurements such as temperature, humidity, solar radiation, and wind speed. The Texas Cooperative Extension Service maintains a network of weather stations that are used to determine the “Reference Evapotranspiration” in agricultural regions throughout the state.

***C. Implementation***

Each type of Irrigation Scheduling method has specific steps required for implementation. The manufacturers of soil moisture measurement equipment typically provide detailed instruction on how to operate their equipment. Soil Water Balance implementation information can be obtained from the Texas Cooperative Extension Services – Texas Evapotranspiration Network web site (texaset.tamu.edu) ET User’s Guide for Growers. This guide has step-by-step instructions for using evapotranspiration for scheduling irrigations.

***D. Schedule***

Irrigation scheduling can be implemented at any time during crop production, but normally an irrigation scheduling program is established prior to the first irrigation of the crop.

***E. Scope***

All agricultural producers, to one degree or another, schedule their irrigations. However, only a small percentage of producers use advanced irrigation scheduling methods. The producer has to balance when a crop is irrigated with both the demand by the crop for water and the amount of labor and water supply that the producer has available to irrigate. In many cases in western Texas where there is little rainfall, the producers have a limited water supply and limited capacity to deliver water to the field. Under these conditions the producer is continually using 100 percent of his water supply to irrigate, and most, if not all, of the producer’s fields are under-irrigated (deficit irrigation). Another issue to many producers is the economics of scheduling. Yield and/or quality of many irrigated crops can be very dependent on adequate soil moisture at one or more critical periods in crop growth. Often, a producer will balance the cost of irrigation with the risk of reducing crop yield and/or quality if the irrigation is delayed or no water is applied. Depending on the producer’s investment in the crop ($200 to $1,200 per acre) and the cost of water ($10 to $50 per acre per irrigation), the producer may choose to irrigate independently of any irrigation scheduling program.

***F. Documentation***

To document this BMP, the agricultural water user shall document and maintain one or more of the following records:

1. Records of the amount of rainfall, irrigation dates, and volumes of water applied during each irrigation and the method;
2. Records of the location and information collected from direct measurement of soil moisture; and/or
3. Copies of irrigation scheduling program reports or printouts.

***G. Determination of Water Savings***

The amount of water saved by implementing advanced irrigation scheduling is difficult to quantify, likely varies from year to year, and is strongly influenced by climatic variation, cropping practices, irrigation water quality, and total amount of water used to irrigate. The Pacific Northwest Laboratory (1994) attempted to verify estimates of reduction in the amount of irrigation water pumped in the Grand County Public Utility District resulting from the implementation of irrigation scheduling. The Public Utility District estimated savings of 0.3 to 0.5 acre-feet per acre, but actual savings could not be confirmed or disproved by the Pacific Northwest Laboratory’s review.

***H. Cost-Effectiveness Considerations***

The cost for implementing advanced irrigation scheduling methods depends on the method of scheduling used and the number of fields scheduled, the type of scheduling program, and the cost for technical assistance.

***I. References for Additional Information***

1. *Evapotranspiration and Irrigation Water Requirements, Manuals and Reports on Engineering Practice No. 70*, 332 p., American Society of Civil Engineers, 1990
2. Texas AgriLife Research Centers. <http://agriliferesearch.tamu.edu/units/centers>
3. Texas Evapotranspiration Network, Texas A&M University-College Station, Department of Biological and Agricultural Engineering. <http://texaset.tamu.edu/>
4. *Applicability and Limitation of Irrigation Scheduling Methods and Techniques*, Iteier, B. *et al.*, United Nations, Food and Agricultural Organization. <http://www.fao.org/docrep/W4367E/w4367e04.htm>

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### Volumetric Measurement of Irrigation Water Use

***A. Applicability***

This BMP is applicable to agricultural irrigation systems and agricultural producers that irrigate. The requirements and applicability of volumetric measurement of irrigation water use varies between specific geographic regions and political subdivisions in the State.

***B. Description***

The volumetric measurement of irrigation water use provides the water user with information needed to assess the performance of an irrigation system and better manage an irrigated crop. There are numerous types of volumetric measurement systems or methods that can be used to either directly measure the amount of irrigation water used or to estimate the amount of water from secondary information such as energy use, irrigation system design, or mechanical components of the irrigation system.

1) Direct Measurement Methods

Direct measurement methods usually require either the installation of a flow meter or the periodic manual measurements of flow. Several common direct measurement systems for closed conduits (pipelines) are:

* Propeller meters
* Orifice, venturi or differential pressure meters
* Magnetic flux meters (both insertion and flange mount)
* Ultrasonic (travel time method)

Several common methods for direct measurement of flow in open channels are:

* Various Types of Weirs and Flumes
* Stage Discharge Rating Tables
* Area/Point Velocity Measurements
* Ultrasonic (Doppler and travel time methods)

2) Indirect Measurement Methods

Indirect measurement methods estimate the volume of water used for irrigation from the amount of energy used, irrigation equipment operating or design information, irrigation water pressure, or other information. Indirect measurements require the correlation of energy use, water pressure, system design specifications, or other parameters to the amount of water used during the irrigation or to the flow rate of the irrigation system when irrigation is occurring.

Several common indirect measurements for irrigation systems are:

* Measurement of energy used by a pump supplying water to an irrigation system
* Measurement of end-pressure in a sprinkler irrigation system
* Change in the elevation of water stored in an irrigation water supply reservoir
* Measurement of time of irrigation and size of irrigation delivery system

Estimating irrigation water use from an indirect method can be as accurate as a direct measurement. For example, to estimate the volume of water pumped by a new electric powered irrigation pump based on kilowatt-hours of energy used during the billing period of the electric service provider, the following equation can be used:

Acre-Feet per (Kilowatt Hours/Billing Period) x Pumping Plant Efficiency (%)

Billing Period 236.6 x Pump Pressure (psig)

**=**

Where the pump pressure is the total dynamic head (ft) of the pump converted to pressure, and Pumping Plant Efficiency (typically 55 percent to 75 percent) equals the pump efficiency (usually obtained from the pump manufacturers pump curves, typically 60 percent to 80 percent) multiplied by the motor efficiency (typically 90 percent-95 percent for 3 phase motors greater than 20 horsepower). The total dynamic head for a turbine pump installed in a water well includes the head required to lift the water from the well and head lost to friction.

***C. Implementation***

When implementing this BMP it is important to be aware that the installation of a flow meter or indirect measurement varies significantly with each site, type of measurement being made, desired accuracy of the measurement, and the volume or flow rate of the water being measured. Each type of direct measurement flow meter should be installed according to the recommendations of the manufacturer of the meter. Indirect measurement methods require the water user to determine the correlation between the indirect measurement (kilowatt hours, gallons, or ccf of fuel) and the volume of water used. Typically, the indirect measurement is correlated to the amount of water used by an engineer or technician using a portable flow meter or information from the irrigation system design. Both direct and indirect measurement methods should be periodically evaluated for the accuracy of volume or flow rate of the water being measured.

***D. Schedule***

For direct measurement systems, the time required to install a flow meter can vary from an hour or two for a saddle mount or insertion meter to several days for the construction of a metering vault and fabrication of associated piping or the construction of a weir, flume, or open channel metering station. For indirect measurement, once the indirect measurement (such as energy usage) is correlated to the volume of water used, no additional installation or construction is required. However, the indirect measurement correlation may need to be repeated periodically to verify pumping capabilities due to normal wear on irrigation equipment.

***E. Scope***

The methods for volumetric measurement of irrigation water and the associated scope vary from site to site, and each site and method may have unique limitations or requirements. The scope for volumetric measurement ranges from very simple (recording the amount of energy used per month from an energy bill), to complex (installation and management of a large open channel flow measurement station). Furthermore, metering requirements vary by geographic region and by political subdivision (River Authorities, Irrigation Districts, Water Improvement Districts, Groundwater Conservation District, etc.).

***F. Documentation***

The water user should record the total quantity of water used per site, field, or system on a periodic basis as determined by the water user to be necessary for implementing other BMP practices. At a minimum, recording of the volume of irrigation water used should be done every year. Indirect measurements, such as energy use, are often documented by a monthly bill or statement from the supplier of the energy (i.e. the electric service provider), which becomes the record of the amount of water used during such billing period.

***G. Determination of Water Savings***

This BMP is used in coordination with other BMPs and in itself does not directly conserve any water. However, the information gained helps better inform the user of costs associated with water use and will assist the user in implementing voluntary conservation measures.

***H. Cost-Effectiveness Considerations***

Cost for volumetric measurement of irrigation water use varies greatly from application to application. Typical impeller meter installations for irrigation pipelines with diameters between 4 inch and 15 inch cost between $600 and $1,000 per meter. Cost for installation of a large open channel flow meter (flume, weir, or metering station) can be in the tens of thousands of dollars. Cost for indirect measurements, such as energy use, depends on the amount of time required to correlate the indirect measurement to the amount of water used and the time required to compile and record such information. The cost and the benefits of statewide implementation of this BMP are significant. The TWDB’s 2001 *Survey of Irrigation in Texas* reported that there were approximately 6.4 million acres of land irrigated in 2000 in Texas and 115,857 irrigation wells. Most of these wells do not have flow meters, and the exact number of unmetered irrigation wells is unknown.

***I. References for Additional Information***

1. *Water Measurement Manual,* U.S. Bureau of Reclamation, 1997, U.S. Government Printing Office, Washington, D.C. 318 p.
2. *Techniques of Water Resource Investigation Reports, Book 3 Application of Hydraulics*, U.S. Geological Survey.
3. *Energy Use for Pumping*, Center for Irrigation Technology, California State University at Fresno. <http://www.wateright.org/site2/advisories/energy.asp>
4. *Survey of Irrigation in Texas, R*eport 347, 102 p., Texas Water Development Board, August 2001.

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### Crop Residue Management and Conservation Tillage

***A. Applicability***

This BMP is applicable to irrigated crops and most agricultural producers using irrigation water. Conservation tillage in general is applicable to both irrigated and dryland farming and can be used to preserve soil moisture in areas where there is significant winter precipitation to allow conversion of irrigated land to dryland farming.

***B. Description***

This BMP includes tillage methods such as no till, strip till, mulch tillage, and ridge till. Residue management and conservation tillage allow for the management of the amount, orientation and distribution of crop and other plant residue on the soil surface year-round on crops grown where the entire field surface is tilled prior to planting. Conservation tillage improves the ability of the soil to hold moisture, reduces the amount of water that runs off the field, and reduces evaporation of water from the soil surface.

***C. Implementation***

The number, sequence and timing of tillage and planting operations and the selection of ground-engaging components shall be managed to achieve the planned amount, distribution and orientation of the residue after planting or at other essential time periods. Loose residue shall be uniformly distributed on the soil surface. Tillage implements shall be equipped to operate through plant residues to maintain residue on or near the soil surface by undercutting or mixing. Planting devices shall be equipped to plant in the distributed residue on the soil surface or mixed in the tillage layer.

***D. Schedule***

Residue management and conservation tillage may be practiced continuously throughout the crop sequence or may be managed as part of a residue management system that includes other tillage methods such as no till.

***E. Scope***

For furrow irrigation, crop residue in furrows can impede the flow of water down the field and cause problems with irrigation uniformity and application efficiency. Conservation tillage is more appropriate with some types of irrigation systems than others. For example, conservation tillage works well with low-pressure center pivot irrigation and subsurface drip irrigation.

***F. Documentation***

Establishment and operation of this practice shall be prepared for each field and recorded using jobs sheet, narrative statements in the conservation plan or other acceptable documentation.

***G. Determination of Water Savings***

The amount of water saved by conservation tillage will vary by climate and irrigation method. Increased spring soil moisture content resulting from conservation tillage may allow a farmer to conserve one or more irrigation applications per year (typically 0.25 to 0.50 acre-feet per acre). Reduction in soil moisture loss during the irrigation season may save an additional 0.5 acre-foot per acre.

***H. Cost-Effectiveness Considerations***

The cost of conservation tillage depends on the type of field operation used to manage crop residues. Some conservation tillage programs are less expensive than conventional tillage.

***I. References for Additional Information***

1) *Conservation Practice Standard for Residue and Tillage Management, No Till/Strip Till/Direct Seed (Acre), Code 329*, Natural Resources Conservation Service, March 2011.

2) *Conservation Practice Standard for Residue and Tillage Management, Mulch Till (Acre), Code 345*, Natural Resources Conservation Service, March 2011.

3) *Conservation Practice Standard for Residue and Tillage Management, Ridge Till (Acre), Code 346*, Natural Resources Conservation Service, April 2011.

4) *Conservation Practice Standard for Residue Management, Seasonal (Acre), Code 344*, Natural Resources Conservation Service, July 2011.

### On-Farm Irrigation Audit

***A. Applicability***

This BMP is applicable to agricultural producers that currently use on-farm irrigation and should be thought of as the initial BMP for agricultural water users to increase water efficiency in irrigation. Under this BMP the water user will collect information about water that is used to irrigate farm crops.

Once an agricultural water user decides to adopt this BMP, the water user should follow the BMP process in order to achieve the maximum benefit from this BMP.

***B. Description***

Water audits are an effective method of accounting for all water usage for on-farm irrigation and to identify opportunities to improve water use efficiency. Benefits from implementation of this BMP may also include energy savings and reduced chemical costs.

On-farm irrigation audits include measurement of water entering the farm or withdrawn from an aquifer, the inventory and calculation of on-farm water uses, calculation of water-related costs, and identification of potential water efficiency measures. The information from the on-farm irrigation audit forms the basis for implementing measures to increase efficiency of current farming practices and the basis for deciding which additional BMPs to implement. The conservation program may consist of one or more projects in different areas of the agricultural operation.

The audit will consist of gathering information on the following (source: NRCS):

* Field size(s) and shape, obstructions, topography, flood vulnerability, water table, and access for operation and maintenance;
* Type of pump equipment and energy source and pumping efficiency, if any;
* Type of irrigation equipment, age and general state of repair;
* Records of previous and current crops and water use; and
* Human assets - Available technical ability and language skills of laborers. Time and skill level of management personnel.

***C. Implementation***

The agricultural water user should conduct an on-farm irrigation audit that generally follows the guidelines as outlined in this section. NRCS procedures for an on-farm irrigation audit will result in the same or similar results. References that provide more detailed audit procedures are listed in Section I below.

1. Preparation and information gathering

The material collected to implement this BMP will be useful for other BMPs as well. Information that should be collected before beginning the audit includes maps of the agricultural operation with field sizes and locations of main water supply, meters or measuring points, inventories of irrigation equipment, and irrigation schedules. Also, information about crop types, field slope, soil types and textures, and infiltration rates should be collected. Water use data for the past year should be collected. Additionally, any prior water use audits should be obtained and reviewed since these reports may include useful and relevant information to determine the most appropriate water saving measures to implement.

1. Conduct on-farm irrigation audit

The on-site physical examination and water use audit should identify and verify all equipment that uses water. Water usage for each major water use area should be determined. If possible during the audit, the performance of the irrigation equipment should be evaluated while it is being used to irrigate farmland.

1. Prepare a cost-effectiveness analysis

The cost-effectiveness analysis should determine the water efficiency opportunities that are cost-effective to implement. The analysis may also identify water efficiency opportunities that should be implemented even if not cost effective due to high visibility, ease of implementation, or general goodwill. After confirming the cost-effectiveness of the BMP, the action plan should then be prepared.

1. Prepare an action plan

The action plan should identify the conservation goals and recommend specific technology or actions that must be implemented by the agricultural producer to meet such goals. The plan should include estimates of the time required to implement the proposed technology or actions and list any governmental or non-governmental programs or services needed to implement the plan.

5) Preparation of an on-farm irrigation audit report

The data gathering and the on-site audit should be incorporated into an audit report that includes an updated set of field diagrams and water flow charts broken down by water use areas, a current list of all water using equipment including actual and manufacturer recommended flow rates, a current schedule of irrigation for all areas and equipment, an analysis of water costs by each field and for the entire farm, and calculations of the difference between water coming into the agricultural operation and a list of identified water uses throughout the operation. (Note: This is the amount of water that is potentially being lost by leaks and other losses.) The on-farm irrigation audit report should contain a proposed timetable to implement selected water efficiency measures.

***D. Schedule***

1. The audit will be completed in a timely manner.
2. The recommendations should be implemented within the first normal budget cycle following the conclusion of the audit. For most farms, this should be a reasonable time period to implement the recommendations. Major projects may take additional time for implementation.
3. If determined to be necessary for very large or complex agricultural operations or for more comprehensive conservation plans, the schedule can be extended. BMPs will be initiated in the second year and continued until the targeted efficiency is reached.

***E. Scope***

To accomplish this BMP:

1. Agricultural water users with one farm, or several farms with the same or very similar irrigation practices, should conduct a water audit following the schedule outlined in Section D above.
2. For agricultural water users with multiple farms sites, or multiple types of agricultural operations, a progressive implementation schedule should be followed, implementing the BMP at successive farms until all farms have been audited and conservation measures implemented.

***F. Documentation***

To track the progress of this BMP, the agricultural water user should gather and have available the following documentation:

1. The audit report;
2. Cost-effectiveness analysis;
3. The action plan;
4. Schedule for implementing the action plan;
5. Documentation of actual implementation of water efficiency measures contained in the action plan; and
6. Estimated water savings and actual water savings for each item implemented.

***G. Determination of Water Savings***

This BMP in and of itself does not save any water but helps identify other agricultural water conservation BMPs that may be implemented by the agricultural water user to save water.

***H. Cost-Effectiveness Considerations***

The cost of a farm audit varies from minimal to significant with the extent of the audit and if the audit is done internally, by a consultant, or using assistance from a governmental entity. The Texas State Soil and Water Conservation Board (“TSSWCB”) prepares Water Quality Management Plans which often address water conservation measures for agricultural land, and the NRCS can assist agricultural water user in implementing conservation plans.

***I. References for Additional Information***

1. Edwards Aquifer Authority, Groundwater Conservation Plan, September 2000, Rev. January 2004, *Appendix F- Water Savings Assumptions*.
2. Texas State Soil and Water Conservation Board, *Water Quality Management Plans*, http://www.tsswcb.state.tx.us/programs/wqmp.html
3. Natural Resources Conservation Service, September 1997, Irrigation - Handbooks and Manuals - National Engineering Handbook Part 652 - Irrigation Guide.
4. *Conservation Practice Standard for Irrigation Water Management (Acre), Code 449,* Natural Resources Conservation Service, October 2011.