AGRICULTURAL WATER CONSERVATION TOOLKIT

Pajaro Valley
Water Management Agency
pvwater.org/toolkits

The Pajaro Valley Water Management Agency (PV Water) is pleased to bring you the Agricultural Water Conservation Toolkit. The Toolkit contains information and resources to support agricultural water conservation in the Pajaro Valley. Technical experts and local resource providers have helped to develop many tools described in the Toolkit to help growers optimize irrigation practices and conserve water. The Pajaro Valley Groundwater Basin is in a state of long-term groundwater overdraft and the conservation of water is one of most efficient ways to help alleviate this problem.

Potential benefits of optimizing irrigation management include a uniform crop, water and energy savings, water quality protection, and reduced costs of fertilizer and other inputs. Use of the practices and information in this Toolkit should help growers with their bottom line.

About This Toolkit

Steps for improving water use efficiency and conserving water that are discussed in the Toolkit are listed below:

Page 4 Evaluate the irrigation system

Page 5 Implement new practices or system improvements

Page 8 Monitor and measure to assess performance and inform decisions

Page 10 Optimize irrigation scheduling

Page 13 Implement land management practices that promote conservation

The links* below lead directly to a list of professional and financial resources.

Support from the Experts to local professionals who can provide education, technical and/or financial support in identifying and implementing the best water management practices for each unique farm.

Financial Support to partners who can provide connections to financial assistance for water management projects.

* website links can be found at pvwater.org/toolkits/

The Pajaro Valley Groundwater Basin

In the Pajaro Valley, most irrigation water is pumped from underground aquifers. When groundwater is pumped at a faster rate than it is replenished, the groundwater storage depletion will reduce pressure or "head" in the freshwater aquifer and may cause groundwater levels to decline. Groundwater storage depletion resulting from overdraft may lead to a number of serious problems including but not limited to water quality degradation, seawater intrusion, and subsidence. Groundwater storage depletion and seawater intrusion are two threats currently affecting the Pajaro Valley. Wells impacted by seawater intrusion may no longer be able to produce a useable supply of water without expensive treatment.

PV Water is implementing a Basin Management Plan that establishes an agricultural water conservation target of 5,000 acre-feet per year, roughly equivalent to a 10% increase in efficiency per grower. Achieving this conservation goal will help reduce the Basin's groundwater problem.

Irrigation System Efficiency Evaluations

A logical first step in optimizing agricultural water use efficiency is to have the irrigation system efficiency evaluated. In the Pajaro Basin, irrigation system evaluations focus primarily on evaluation of the distribution uniformity, system design and operational and maintenance practices.

Irrigation system efficiency evaluations provide the following information:

- The Distribution Uniformity (DU), a calculation of how evenly water is being applied
- The water application rate
- A water and energy loss assessment
- If there are leaks
- An analysis of irrigation system pressure
- A summary of potential equipment, system design, or operating procedure improvements that could improve the performance of the system

Distribution uniformity (DU) is an important part of a system evaluation. It affects how long an irrigator must run the system to get enough water to the driest 25% of the field. Improving irrigation distribution uniformity can have the following potential benefits:

- Reduced water and energy waste
- Improved crop yield
- Reduced tail water run-off
- Reduced offsite movement of sediment, nutrients, and pesticides into surface water
- Reduced leaching of nutrients and pesticides
- Improved salinity management

The Basic Steps of an Irrigation System Efficiency Evaluation include:

1. Take flow measurements (e.g., from emitters, sprinklers or sprayers) and pressure readings at mapped locations throughout the field to identify variations. Then calculate the DU.
2. Follow the water from the source to the furthest point of the irrigation system to check for leaks and variations in pressure.
3. Create a detailed, confidential report about the system's performance and recommended improvements that are useful to the grower and irrigation system designers.
4. Discuss the report and recommendations with the grower, including irrigation scheduling, soil moisture monitoring and plant irrigation needs.

A number of local vendors and programs are available to provide technical and/or financial assistance to make improvements to an irrigation system.

More about DU and irrigation efficiency from the Center for Irrigation Technology*

Irrigation System Efficiency Evaluations are available through the Pajaro Valley Irrigation Water Management Program and details can be found at pvwater.org.

The Pajaro Valley Irrigation Water Management Program provides growers with technical and financial resources to help them increase their irrigation efficiency. The Program is a joint effort between PV Water and local partners including the University of California Cooperative Extension, the USDA Natural Resources Conservation Service, the RCD's of Santa Cruz and Monterey Counties, and private technical service providers.

Improving Irrigation System Efficiency

Once the performance of the irrigation system has been evaluated, a grower may want to make one or more modifications to improve the distribution uniformity and overall efficiency. Recommendations that result from an irrigation system evaluation may include simple maintenance or operational procedures, installation of various types of equipment, or design modifications.

Drip Irrigation

Drip irrigation (also trickle or micro-irrigation) involves emitting water at a very slow rate directly to the soil near the roots of plants. It leaves little opportunity for water loss due to evaporation. In addition, drip irrigation allows the grower more control in order to optimize irrigation scheduling decisions.

A well-designed drip irrigation system has the highest distribution uniformity (DU). A well designed and maintained drip system can achieve upwards of 90% DU, compared with roughly 85% DU for a microsprinkler system, 80% DU for a sprinkler system and 60% DU for an unimproved surface irrigation system (Dr. Michael Cahn, UC Cooperative Extension).

Once installed, drip usually operates at much lower pressures than sprinkler, which means less pumping power is used. This usually results in significant energy savings and lower power bills. Additional potential benefits to using drip irrigation may include improved weed control, efficient fertilizer applications and reduced tailwater.

Simple ways to improve drip irrigation systems

An irrigation system efficiency evaluation will often identify relatively simple steps and procedures that can improve the efficiency and longevity of a drip irrigation system. Inspecting and replacing plugged hoses and implementing a regular maintenance program to keep hoses clear and flowing will improve water use efficiency. Maintaining a good filtration system is mandatory because the small emitters used in drip systems are easily plugged with very small bits of debris. Inadequate or poorly maintained filtration is a common source of low DU. Many times growers are not aware that the irrigation system is

not running at optimal pressure. The system should run at the pressure recommended by the manufacturer.

Converting from high pressure to drip irrigation

If appropriate for the crop, conversion from high pressure sprinklers to drip irrigation will likely improve DU and water use efficiency. Because of the energy savings, PG&E offers rebates to customers to convert from a high-pressure sprinkler system to a drip or micro-sprinkler irrigation system.

Sprinkler Systems

All components of a sprinkler system will work best if they are well designed for their application. A DU evaluation may result in recommendations for design improvements, such as reducing lateral line spacing to improve uniformity. Simple recommendations often include checking nozzle diameters for wear, ensuring uniform nozzle sizes, replacing missing or torn gaskets, checking for leaks, or adjusting pressures to achieve the appropriate application rate.

Sprinkler Nozzles

Nozzles are an important component of sprinkler irrigation systems. Good low pressure nozzles can significantly reduce the cost of pumping water, improve water uniformity when pressure and nozzle spacing are aligned, and result in higher yields, fewer line breaks and less maintenance.

Source of low-pressure nozzles:

Full Coverage Irrigation
http://fcinozzles.com/
info@fcinozzles.com
559-683-3072

Leak Management

System leaks are sources of irrigation water waste, which the Pajaro Basin cannot afford. Yet as in all systems, breakage and failures occur. Regular system checks are essential to ensure that leaks are caught early and repaired quickly.

Measuring and Monitoring: Essential Tools

A variety of tools are available to help assess the performance of the system and inform irrigation management decisions. Using these tools in concert will provide more power to control water use and apply the amount of water that matches the crop need.

Pressure Gauges and Pressure Regulators

Pressure gauges enable growers and irrigators to take simple pressure readings that can provide valuable information to improve distribution uniformity (DU) and achieve greater irrigation efficiency, conserving water. Pressure readings above and below the filter can help determine if a screen is working. Pressure readings throughout the system can help identify pressure losses and whether the system is running at the recommended pressures.

Pressure regulators help to ensure that water is being delivered through a sprinkler or drip system at pressures that are optimal for that system, which is essential for good distribution uniformity. While not the most expensive tool in the box, pressure regulators are an important element of on-farm water conservation, and are a common recommendation resulting from irrigation system efficiency evaluations.

Flow meters measure the total volume or the flow rate of water. Flow meters are vital to accurately determine the irrigation system application rate to inform irrigation scheduling. They also allow growers to measure their total water applications. When flows vary from normal, flow meters will indicate irrigation system problems. Here are two flow meter options frequently used in the Pajaro Basin.

* website links can be found at pvwater.org/toolkits/

Propeller flow meters are the most common devices used for measuring water flow rate. A propeller flow meter measures the velocity inside a pipe and shows the flow rate reading on a dial. Each of these meters are designed for a specific pipe size and work best within particular ranges of flow.

With adapters, one flow meter can be used to measure several pipe sizes. The two main types of flow meters are saddle and flanged. Saddle meters are placed through a hole in an existing or specifically used pipe. Flanged flow meters are placed in between an existing flanged joint.

When meters will be used on more than one site, irrigators have found it convenient to couple them to a designated section of aluminum or PVC pipe.

Electromagnetic flow meters measure the velocity of water (or other conductive liquids) in pipes by producing an electrical signal proportional to the flow rate. This type of flowmeter does not obstruct flow and does not require much upstream and downstream straight run. Electromagnetic flowmeters typically require 3-5 pipe diameters of upstream straight run and 0-3 pipe diameters of downstream straight run measured from the plane of the magnetic flowmeter electrodes.

Rain Gauges

A rain gauge will indicate how much water is applied to the field through precipitation, which can be included in irrigation scheduling decisions. Types of rain gauges range from simple catch cans which must be manually monitored to automated gauges that require data loggers to record information.

The irrigation schedule refers to when to irrigate and how much water to apply. A grower who is satisfied with the distribution uniformity of the irrigation system, and is measuring and monitoring the performance of the system, is well positioned to collect information that can help optimize irrigation scheduling. This section describes tools to help with irrigation scheduling, including soil moisture monitoring, determining crop evapotranspiration rates, and using web-based irrigation scheduling tools

Efficient irrigation scheduling has the following benefits:

1) Maximizes water use efficiency
2) Saves energy from reduced pumping costs
3) Minimizes runoff and percolation losses
4) Reduces nutrient leaching

Soil Moisture Monitoring

Growers and irrigators who monitor soil moisture levels in the field greatly increase their ability to conserve water and energy, optimize crop yields, and avoid soil erosion and water pollution. Low-cost soil moisture monitoring tools and methods, ranging from using a shovel or relying on hand feel, to a new generation of sophisticated electronic devices, can help growers make use of soil moisture information. Whatever method used, the key to irrigation efficiency is a system where the grower can relate soil moisture to crop water need, and make irrigation decisions accordingly.

Soil moisture monitoring devices and methods include:

Tensiometers

Portable moisture probes

* website links can be found at pvwater.org/toolkits/

Electrical resistance devices

USDA 'feel' method

Determining Crop Evapotranspiration:

How much water does the crop need?

Estimates of crop evapotranspiration are necessary for designing systems and optimizing irrigation scheduling. Evapotranspiration (ET) is the loss of water to the atmosphere by the combined processes of evaporation from soil and plant surfaces and transpiration from plant tissues. It is an indicator of how much water the crop needs for healthy growth and productivity.

Evapotranspiration is frequently provided as a standardized, reference evapotranspiration, or ETo. A crop factor, known as a crop coefficient (Kc), is used to convert ETo into crop-specific evapotranspiration, or ETc. ETc data for many sprinkler and drip irrigated crops during a wet, dry and typical year can be downloaded directly from www.itrc.org/

California Irrigation Management Information System (CIMIS) is a California State Program that provides statewide coverage of ETo data, free of charge.

Site-specific ET can be measured using automated weather stations or ET gauges. Providers of this equipment and related services are included the list of service providers which is available in the online version of the Ag Toolkit at pvwater.org.

CIMIS

The California Irrigation Management Information System (CIMIS) was developed by the California Department of Water Resources with help from UC Davis to assist California's irrigators manage their water resources efficiently. It includes a network of over 145 automated weather stations located throughout the state of California. It makes standard evapotranspiration (ETo) information available to the public, free of charge.

CIMIS data can be accessed using the CIMIS website cimis.water.ca.gov/WSNReportCriteria.aspx

Local technical advisors and private vendors are available to help growers include CIMIS data into their irrigation scheduling decisions.

Web-Based Irrigation Scheduling Tools

Applications to assist in irrigation scheduling have been developed that growers can access both on their electronic and mobile devices. A few of these systems are free to use and the others are privately developed for use by paid license. All of them provide growers with a great deal of increasingly accurate information to aid in making irrigation scheduling decisions.

CropManage is a free, online, irrigation scheduling decision support tool developed by UC Cooperative Extension with support from CDFA.

Wateright is another free, online decision support tool developed by the Center for Irrigation Technology at California State University, Fresno with support from the US Bureau of Reclamation.

Other irrigation scheduling tools and service providers, including private vendors are available in the online version of the Ag Toolkit at pvwater.org.

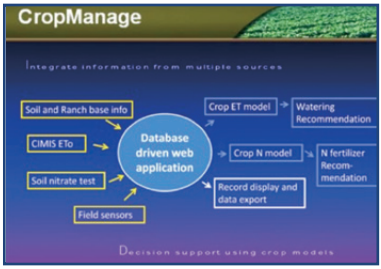
CropManage

CropManage is a free, online database-driven tool that is developed to assist growers in determining water and nitrogen fertilizer applications on a field-by-field basis, using multiple sources of information including:

- Soil tests
- Evapotranspiration rates (from CIMIS)
- Soil physical characteristics
- Crop models
- Flow meter
- Soil moisture sensors

* website links can be found at pvwater.org/toolkits/

The software calculates crop water need using CIMIS evapotranspiration data and estimates nitrogen fertilizer needs using inputted results of soil tests. It helps growers track irrigation schedules and nitrogen fertilizer applications on multiple fields and allows users from the same operation to view and share data. It also serves as a valuable record-keeping tool. Crops that are currently supported by CropManage include head and romaine lettuce, broccoli, cauliflower, cabbage, and strawberries. CropManage has strict privacy protections in place and does not share any information about users with other entities.



Most growers participating in the Pajaro Valley Irrigation Water Management Program choose to use CropManage for one or more of their ranches, with technical assistance from numerous partners. The CropManage tool is increasingly being utilized by Central Coast growers.

Conservation and Land Management Practices

When it comes to water conservation and groundwater recharge, the approach of many land management practices is to increase infiltration of rainfall, slow and retain run-off so that it has a chance to infiltrate, and increase soil moisture retention.

Rotational Fallowing with Cover Crop

Incorporating a rotational fallow period into a grower's management practices provides many benefits including water conservation. Cover crops can help improve the infiltration of water into the soil, potentially contributing to groundwater recharge, and improving soil health and soil moisture retention. The mulch that results from a killed cover crop increases water infiltration and reduces water evaporation from the soil surface. Soil cover reduces soil crusting and subsequent surface water runoff during rainy periods.

Full-season cover crops are those that are planted in the fall and incorporated into the soil in late winter or early spring. They increase infiltration by creating root pathways that facilitate downward movement of water. In addition, they slow the movement of water over the soil surface giving it more time to infiltrate. Low residue cover crops are planted in the fall and killed 60 days later. They may be a more practical option for vegetable operations or for strawberry production operations during the winter.

Local experts offer assistance with cover cropping and a list of experts is available in the online version of the Ag Toolkit at pvwater.org.

Row Arrangement for Crops Planted on Hills

Proper row arrangement is necessary to optimize water management on sloped land. Gently sloped furrows help the water soak into the soil. The water that leaves the field flows slowly, leaving the soil in place. Good row arrangement also helps to achieve more uniform irrigation, fertigation and drip fumigation by reducing potential for extreme pressure differences along rows.

Hillslope Management Runoff Guide has more information about row arrangement and other techniques for farming on hills from the RCD of Monterey County.

Variable Frequency Drives (VFDs)

Pumping water for irrigation can be a major expense for irrigated farms. Increasing the efficiency of irrigation pumps by replacing a fixed speed pump with a variable frequency drive (VFD) can improve flow control, and increase the profitability of the farming operation by reducing costs of energy and water lost through inefficient pumping.

A VFD allows for pump speed control, giving optimal control of the volume and pressure of the water pumped for irrigation. Because fixed speed drives are usually designed to operate over a range of flow rates and pressures, standard procedure is to design them to be oversized in order to meet the greatest potential demand. Therefore, they operate inefficiently within the range of typical demands. In order to operate an irrigation system with the optimal levels of water pressure and volume, excess water may be "bled off" or released by the grower. A VFD can address this inefficient use of water by scaling back the pressure and volume of water pumped to match the need for the target irrigation event. Controlling pump speed with a VFD may not be appropriate for all pumping systems. Contact a local expert for technical assistance with improving pump efficiency.

The Financial Support page in the online version at pvwater.org includes local technical and financial resources for VFD installation.

Or more specifically:

Technical and financial assistance for installing VFDs is offered through the NRCS Environmental Quality Incentives Program (EQIP) (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/)

Rebates for VFD installation and pump efficiency tests are offered through PG&E Agricultural Rebates

VFD installation is a conservation practice that is eligible for grant funding though the CDFA State Water Efficiency & Enhancement Program (SWEEP)

Comments, Feedback and Updates

The Agricultural Water Conservation Toolkit is a "living document" subject to review and updates on a regular basis. PV Water intends to keep the Toolkit as current and relevant as possible.

We encourage everyone who uses the Toolkit to help us make this the most useful resource possible, and to contribute new information, corrections, and ideas for improvement. Please send your comments to feedback@pvwater.org and include the word "Toolkit" in the subject line.

If you are a service provider and would like to be considered for inclusion in our resource listings, please send us the following information:

- Business name
- Website URL
- Contact email address
- Contact phone number
- A brief description of the services you provide

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