Title

Reducing Runoff from Irrigated Lands: Measuring Irrigation Flows in a Pipeline

Authors

Hanson, Blaine R
Schwankl, Lawrence J
Prichard, Terry L

Publication Date

2007

DOI

10.3733/ucanr.8213

Peer reviewed

Measuring Irrigation Flows in a Pipeline

BLAINE R. HANSON, UC Cooperative Extension Irrigation and Drainage Specialist; **LAWRENCE J. SCHWANKL,** UC Cooperative Extension Irrigation Specialist; and **TERRY L. PRICHARD,** UC Cooperative Extension Water Management Specialist

UNIVERSITY OF CALIFORNIA
Division of Agriculture and Natural Resources
http://anrcatalog.ucdavis.edu

UC PEER REVIEWED

INTRODUCTION

The California State Water Code requires anyone discharging waste that could affect the waters of the state to obtain a permit or coverage under a waiver. Agricultural runoff, whether from irrigation or rainfall, that leaves a property has been determined to likely contain waste (sediment, nutrients, chemicals, etc.).

Compliance under the Irrigation Lands Conditional Waiver is available to agricultural landowners on irrigated lands who have runoff from their property caused by irrigation practices or winter rainfall. If no runoff from any source leaves a property, the California Water Code does not impact the property owner.

A major contributor to irrigation runoff can be water applied in excess of that required to refill a crop's root zone. Excess irrigation water may directly run off, or it may contribute to deep percolation losses below the crop's root zone. Deep percolation losses can reduce surface water quality under hydrologic conditions where shallow groundwater seeps into streams and rivers.

Minimizing the application of excess water requires knowing how much water is being applied by the irrigation system and practicing good irrigation scheduling (knowing when and how much water to apply). Measuring the water applied by the irrigation system is most easily done in a pipeline. Flow measurement in open channels (ditches, canals, etc.) is difficult and can be a challenge to do accurately. This publication confines itself to measuring water flow in pipelines.

TYPES OF FLOWMETERS

A number of flowmeters are appropriate for use in irrigation pipelines. They all measure the flow velocity of the water in a full pipeline. If the pipeline is not full, the meter reading will not be accurate. Combining the flow velocity with the pipe size provides the flow rate passing through the meter. Nearly all flowmeters record the total flow passing through them in gallons (gal), acre-inches (ac-in), acre-feet (ac-ft), cubic feet (ft^3), or some similar volume measurement. Some flowmeters also register the instantaneous flow rate in gallons per minute (gal/min), cubic feet per second (cfs), or other similar units of measure.

The flow rate of pumps is often determined through testing. Although these results may be good to have, the pump flow rate in the field may depend on groundwater level, location or number of open discharge valves, location and number of operating sprinklers, and location or duration of the microirrigation set. Due to these factors, it is better to determine the actual amount of water being applied by using a totalizing flowmeter, rather than by obtaining a flow rate from a pump test and then multiplying it by the operating time.

Figure 1. Propeller flowmeter.
Photo: Lawrence J. Schwankl.

Figure 2. Magnetic flowmeter.
Photo: Lawrence J. Schwankl.

Figure 3. Ultrasonic (Doppler) flowmeter.
Photo: Lawrence J. Schwankl.

Propeller Flowmeters

The most commonly used flowmeters are propeller meters (fig. 1). They should be installed in a section of pipeline that is straight and unobstructed for 8 to 10 times the pipe diameter upstream of the meter and 4 to 6 times the pipe diameter downstream. This minimizes turbulence caused by elbows, valves, and other fittings, which leads to inaccurate measurements. The pipe must be full to obtain accurate measurements. New propeller meters are accurate within 2 percent. Propeller meters present two potential difficulties: debris in the water may entangle the propeller and affect its operation, and a small amount of pressure is lost as water flows through the meter, 2 pounds per square inch (psi) or less if the meter is properly sized for the pipe diameter.

Magnetic Flowmeters

Magnetic flowmeters (fig. 2) have the advantage of not creating an obstruction in the pipe. This feature eliminates the problem of possible entanglement from debris in the water as well as any pressure loss across the metering device. They should be installed in a section of pipeline that is straight and unobstructed for 3 to 5 times the pipe diameter upstream and downstream of the meter in order to minimize turbulence caused by elbows, valves, and other fittings, which leads to inaccurate measurements. Magnetic flowmeters require less maintenance than propeller meters and have long-term accuracy. They have the disadvantages of higher initial cost and the need for external power.

Ultrasonic (Doppler) Flowmeters

Ultrasonic (Doppler) flowmeters (fig. 3) measure flow velocity (and thus flow rate) by directing ultrasonic pulses diagonally across the pipe and measuring the reflected pulse frequency shift, which is proportional to flow velocity. Ultrasonic meters should be installed on a section of pipeline that is straight and unobstructed for 8 to 10 times the pipe diameter upstream of the meter and 4 to 6 times the pipe diameter downstream. This minimizes turbulence caused by elbows, valves, and other fittings, which leads to inaccurate measurements. The accuracy of ultrasonic flowmeters is comparable to that of propeller meters, and, since they have no moving parts, they require little maintenance. Because all attachments are external, these meters can be moved easily to different locations. Since the ultrasonic meters work by bouncing ultrasonic pulses off particles in water, irrigation waters without sufficient suspended particles may not be appropriate for these meters. High-quality well water may fall into this category, but many other well waters can still be measured using an ultrasonic meter. Ultrasonic flowmeters generally cost more than other types of meters and require external power.

Turbine Flowmeters

Turbine flowmeters (fig. 4.) operate on the principle of a rotor assembly, turning at a rate proportional to the flow rate in the pipelines. The rotor is suspended near a magnetic pickup that records a pulse on its readout unit as each rotor blade passes. The accuracy of turbine flowmeters is comparable to that of propeller flowmeters (within 2%) under the correct flow conditions, and they require a section of pipe that is straight for 10 times the pipe diameter upstream of the meter and 6 times the pipe diameter downstream. Turbine flowmeters are more sensitive than propeller flowmeters to nonuniform flow conditions, such as exists downstream of an elbow or constriction. Some turbine flowmeters can be installed in a range of pipe diameters, which provides flexibility in their use. The applicability and cost are comparable to that of propeller meters.

Figure 4. Turbine flowmeter.
Photo: Lawrence J. Schwankl.

MAINTENANCE OF FLOWMETERS

Electromagnetic and Doppler flowmeters should need minimal maintenance, but propeller and turbine flowmeters require inspection, maintenance, and recalibration at a minimum of every 4 years.

USING FLOWMETER MEASUREMENTS

The most accurate way to use a flowmeter is to obtain the totalized flow reading at the beginning and end of a recorded time period. If the total applied water is measured in gallons or cubic feet, the following formulas may be used to determine the inches of applied water.

If the total applied water is measured in gallons:

applied water (in) = total water applied (gal) ÷ [area irrigated (ac) × 27,152]

If the total applied water is measured in cubic feet:

applied water (in) = total water applied (ft^3) ÷ [area irrigated (ac) × 3,630]

If an average flow rate, usually in gallons per minute (gpm) or cubic feet per second (cfs), is known, the following formula may be used.

applied water (in) = [average flow rate (gal/min) × irrigation time (hr)] ÷ [acres irrigated × 449]

For example, if an average flow rate of 750 gallons per minute is used to irrigate 20 acres in 24 hours, the applied water would be:

applied water (in) = [750 gal/min × 24] ÷ [20 ac × 449] = 2.0 in

METRIC CONVERSIONS

English	Conversion factor for English to Metric	Conversion factor for Metric to English	Metric
foot (ft)	0.3048	3.28	meter (m)
cubic foot (ft^3)	28.317	0.353	liter (l)
acre (ac)	0.4047	2.471	hectare (ha)
acre-inch (ac-in)	102.8	0.00973	cubic meter (m^3)
acre-foot (ac-ft)	1,233	0.000811	cubic meter (m^3)
pounds per square inch (psi)	6.894	0.145	kilopascal (kPa)
gallon (gal)	3.785	0.264	liter (l)

SUMMARY

The amount of irrigation water applied should match the amount of soil water used by the crop since the last irrigation. Additional water is often applied during an irrigation set since no irrigation system in 100 percent efficient, but this additional water should be kept to a minimum. The goal is to minimize the runoff caused by applying too much water.

FOR FURTHER INFORMATION

Storing Runoff from Winter Rains (ANR Publication 8211), 2007.

Understanding Your Orchard's Water Requirements (ANR Publication 8212), 2007.

Causes and Management of Runoff from Surface Irrigation in Orchards (ANR Publication 8214), 2007.

Managing Existing Sprinkler Irrigation Systems (ANR Publication 8215), 2007.

Soil Intake Rates and Application Rates in Sprinkler-Irrigated Orchards (ANR Publication 8216), 2007.

To order or obtain printed ANR publications and other products, visit the ANR Communication Services online catalog at http://anrcatalog.ucdavis.edu. You can also place orders by mail, phone, or FAX, or request a printed catalog of our products from:

University of California
Agriculture and Natural Resources
Communication Services
6701 San Pablo Avenue, 2nd Floor
Oakland, California 94608-1239
Telephone: (800) 994-8849 or (510) 642-2431
FAX: (510) 643-5470
E-mail inquiries: danrcs@ucdavis.edu

An electronic version of this publication is available on the ANR Communication Services Web site at http://anrcatalog.ucdavis.edu.

Publication 8213

ISBN-13: 978-1-60107-432-4
ISBN-10: 1-60107-432-8

UC PEER REVIEWED

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Land, Air, and Water Sciences.

pr-1/07-SB/RW