

## INTRODUCTION

This workshop on Basic Principles and Developments in Flow Measurement deals specifically with flow measurement concepts, devices, and instrumentation for irrigation delivery and drainage systems. A principal focus of the class is on the use of the WinFlume software for design and calibration of long-throated flumes and broad-crested weirs. This workshop provides more detailed exposure to the flow measurement concepts presented in our workshop on Modern Methods in Canal Operation and Control. The course covers open channel and closed pipe measurement methods and instrumentation. Laboratory workshop sessions involve each student in hands-on flow measurement using different techniques with various types of water measurement equipment.

A computer laboratory is included in the class with in-depth instruction on the application of WinFlume, the Windows-based software used to design and calibrate long-throated flumes and broad-crested weirs. These devices are ideal for many new flow measurement sites since they can be custom designed for the site. They are cheaper to build than Parshall flumes and are more versatile because of their extremely small head loss requirements. The computer program produces rating tables, equations, and staff gage templates at full scale.

## WHO SHOULD ATTEND

*Basic Principles and Developments in Flow Measurement* is designed for water conservation specialists, canal operators, managers, and design engineers who are interested in improved water measurement methods. The instruction is geared towards people who want to learn through active participation and “first hand” experience with the computer program and water measurement devices in the laboratory.

This year’s workshop will offer a basic curriculum for students who are attending our water measurement training for the first time. Students should have some experience with Windows-based computer systems, but an extensive technical or engineering background is not required.

## TRAINING STAFF

Workshop instructors are engineers and scientists with extensive experience and knowledge in the areas of water measurement methods, computer programming,

canal automation, operation, and control. Principal instructors are *Tony Wahl, Bob Einhellig, and Tracy Vermeyen*. These Bureau of Reclamation engineers have conducted many training programs for Reclamation and other organizations.

## SCHEDULE

The course will begin Tuesday morning at 8:00 a.m. and end Thursday afternoon at about 4:00 p.m. The following topics will be addressed:

### Basic Concepts

- Flow Measurement - Basic Principles
- Pressure and head definitions
- Discharge-area-velocity relationships
- Energy principles - (Bernoulli equation, velocity head, specific energy, critical depth)

### Devices and Instruments for Open-Channel & Closed-Pipe Flow

- Stream gaging, weirs, submerged orifices, flumes, pipe flow measurement
- Kindswater-Carter method for determining flow through sharp-crested weirs
- Propeller meters, orifice plates, venturi meters, vortex meters, electromagnetic flow meters, acoustic flow measurement instruments (Doppler and transit time), elbow meters

### Flow Measurement Lab Workshops

- Discharge Measurement Structures—Pre-fabricated flumes, sharp-crested and broad-crested weirs, submerged orifices
- Velocity Measurement Devices—ADCP, transit time open channel flow meter, ADV, ADFM, electromagnetic velocity meter, propeller velocity meter
- Head Measurement—Stilling wells, float systems, bubblers, potentiometers, pressure transducers, ultrasonic sensors, new technologies
- Use of Gates for Flow Measurement—Estimating flow through radial gates, slide gates, and overshot gates

### Introduction to Long-Throated Flumes

- History and advantages
- Stationary vs. movable-crest flumes
- Examples of long-throated flumes

- Design criteria
- $H_1/L$  ratio
- Limits on converging transition slope
- Necessary approach channel length
- Locating the gaging station

### Using the WinFlume Software

- Computer system requirements
- Tour of software and basic data entry
- The flume wizard
- The design module
- Producing output
- Example application
- Laboratory demonstration (modular limit)
- Estimating flume construction quantities

### Design Examples

- Selecting flumes with the Water Measurement Manual
- Design a flume for an existing canal with a bed drop
- Illustrate effects of measurement accuracy, freeboard, Froude number
- Illustrate how to satisfy tailwater criteria and provide factor of safety
- Students to use design module to examine headloss tradeoffs
- Flumes with compound control sections
- Determination of tailwater levels

### Construction Considerations

- Stilling wells
- Foundation treatment / Seepage cutoff
- Reinforcement and concrete placement
- Downstream erosion protection
- Off-season drainage
- Gage placement and zero setting

### PUBLICATIONS PROVIDED TO PARTICIPANTS

Outlines and summaries of presentations and other materials will be compiled into a notebook and distributed to all participants at the start of the Workshop. Participants will also receive a complimentary copy of the 2001 revised reprint of Reclamation’s *Water Measurement Manual*, 3<sup>rd</sup> edition, and a printed user’s manual for WinFlume. WinFlume itself can be downloaded from [http://www.usbr.gov/pmts/hydraulics\\_lab/winflume/](http://www.usbr.gov/pmts/hydraulics_lab/winflume/).

## LAPTOP COMPUTERS

Each student should plan to bring a Pentium-class laptop computer (at least Pentium-166 with 64 MB RAM recommended) running Windows 95 or a later Windows operating system for use during the computer labs related to the WinFlume program. We can provide a limited number of computers for the use of students; if you cannot bring your own computer, please notify us of that when you register.

## REGISTRATION & COST

Participants should register using the enclosed registration form. Course tuition for each participant is \$750. Fee payment should accompany the registration form. Payment by VISA or MasterCard credit card is accepted. Checks should be made payable to "Canal Automation Workshops". Reclamation employees may pay with an internal funds transfer by providing their cost center and a 19-digit cost authority number.

To maximize the benefit for each student, each workshop session is limited to 18 participants. *The first 18 registrations received with payment will be accepted.* Tuition will be charged to all registrants unless cancellation is made a minimum of 15 days prior to scheduled class. A substitute will be accepted to attend in place of a paid student

## TRANSPORTATION & LODGING

Course participants are responsible for their own transportation and lodging arrangements and costs. The workshop is held in Building 56 at the Denver Federal Center, on the west side of the Denver metropolitan area. Several hotels are located nearby; some of these have complementary van service to the Federal Center. Taxis or shuttle service from Denver International Airport (DIA) to hotels can be arranged at DIA. Please visit our web site for more details.

## CLIMATE/CLOTHING SUGGESTIONS

All workshop activities will take place indoors in the classroom or the heated hydraulics laboratory. Outdoors, winter weather can be unpredictable in Denver. Participants should be prepared for cold, snowy, wet weather, or bright, cool sunshine. Warm jackets, hats, and gloves are recommended. Denver's altitude is 5280 ft (1610 m). The normal high and low temperatures in late January are 43°F and 17°F (6°C and -8°C), respectively.

## CONFIRMATION

A confirmation package will be sent upon receipt of the registration form and payment. This package will include information on local transportation and lodging. If necessary, details will be communicated by fax or e-mail.

## ADDITIONAL INFORMATION

For more information contact:

Hydraulic Investigations and Laboratory Services Group  
Bureau of Reclamation  
P.O. Box 25007, 86-68460  
Denver, Colorado 80225

Telephone: 303-445-2150  
Fax: 303-445-6324  
E-mail: [twahl@usbr.gov](mailto:twahl@usbr.gov)

Additional information, registration forms, and photos from past classes are available from the *Workshops* link on our web site at: [www.usbr.gov/pmts/hydraulics\\_lab/](http://www.usbr.gov/pmts/hydraulics_lab/)

## Department of the Interior Mission

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

## Bureau of Reclamation Mission

To manage, develop, and protect water and related resources in an environmentally and economically sound manner.

**RECLAMATION**  
*Managing Water in the West*

# Basic Principles and Developments in Flow Measurement

## A Water Resources Technical Workshop

January 12-14, 2010  
Denver, Colorado



U.S. Department of the Interior  
Bureau of Reclamation