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# Reclamation's Efforts to Upgrade Water Management of Existing Irrigation Systems

## Reclamation's Water Management Efforts

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# RECLAMATION'S EFFORTS TO UPGRADE WATER MANAGEMENT OF EXISTING IRRIGATION SYSTEMS

Reclamation's water management efforts

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**Abstract**

The U.S. Bureau of Reclamation (Reclamation) was established in 1902 to provide a reliable water supply to support populations and agriculture in the primarily arid western states. Early structures built to store and convey water are still being used today. Reclamation's task is now to manage these systems more efficiently and to consider multiple-uses for the water resources that were used previously for agriculture. This has become a high priority in the U.S. where many competitors vie for the use of a limited amount of water. Managing older irrigation systems requires the ability to accurately and cost effectively measure and record existing water use in systems not initially designed with water measurement in mind. Water must be measured and usage must be known before conservation and equitable redistribution can be implemented.

Reclamation is continually working with irrigation districts operating our systems to upgrade water measurement and recording capability. Procedures used to upgrade our irrigation facilities will be discussed. Case studies where upgrades have been encouraged or implemented will be presented. Reclamation research efforts involving the design of measurement devices and development of simple, accurate, low-cost water level sensors and recorders will be discussed as they apply to these irrigation systems.

Keywords: case studies, continuous water measurement and level recording, long-throated flumes, totalized discharge, U.S. Bureau of Reclamation, water management

## 1 Introduction

Reclamation's mission today is to effectively manage and operate existing resources in an efficient and environmentally sound manner. This mission has focused attention on the management practices of many of Reclamation's existing irrigation systems. Managing irrigation systems means providing the user, whether a municipality, a farmer, a household, or an environmentalist protecting habitat, with water they are entitled to when they need it. Water measurement and metering are vital to effective management of an irrigation system, especially when pressure is being applied to conserve and divide water resources for other non-traditional environmental uses. Also, water measurement and metering is an important aspect of water conservation.

The Newlands Project in Nevada and the system operated by the Pojoaque Valley Irrigation District (PVID) in New Mexico are classic cases of older irrigation projects where the delivery system is not designed for standard water measurement devices. Reclamation's efforts to upgrade these irrigation systems will be described.

## 2 Procedures to achieve water management objectives

Similar problems arise when attempting to implement better water management practices broadly across irrigation projects. The biggest challenge is often to convince the operating district or the traditional water users that changes are needed. Unfortunately, changes are often caused by the initiation of laws or because other entities are now claiming their portion of previously unused water. In addition, the knowledge of the district personnel is often not highly technical and funding to construct devices or purchase equipment is often very limited. These intangible aspects of changing water management practices are often the most difficult.

Historically poor system maintenance, whether of unlined ditches, canals, gates, or existing measurement devices, is always a problem. Maintenance includes dealing with infrastructure repairs, weed and algae growth, trash, and sediment problems. Other problems include unlined canal sections with unmeasured seepage, very little available head, old manually-operated head gates on unmetered turnouts, and no available power. The following steps must be taken to successfully upgrade an existing irrigation system.

### 2.1 Education and acceptance

Educating operators and users about the importance of knowing the total volume of water being delivered or used is paramount to addressing all other issues. There are many misunderstandings about the two parts to assuring that users receive the correct amount of water: 1) the measurement device and; 2) the metering device. The measurement device itself usually does not provide a continuous record of the total flow over or through the device. A meter or recording device accompanies a water measurement device. For example, a staff gage with a weir or flume provides only an instantaneous record of flow, whereas, electronic flow meters can provide a continuous record of the flow quantity and duration.

### 2.2 Site review

The site review includes investigation of both the physical aspects of the existing system and the vision or goals of the people operating and being served by the system. It is extremely important that the requirements for flow measurement, metering, and communication are known at this point. Also, it is important to establish how the system is operated and availability of funding to make improvements. Field evaluation of the system is then necessary to determine the general capability of the existing system and the physical barriers to performing good water measurement.

### 2.3 Design data requirements

The accuracy of the water measurement devices designed will depend upon the quality of the data collected about the flow and physical conditions of the system. The objectives of gathering design data are to ensure that nothing is overlooked and that no problems are perpetuated or created by installing new water measurement devices. Design data requirements include:

- Determining the average channel cross section, depth and invert slope with elevations of existing checks, conveyance, or control structures.
- Gathering water surface elevations through the reach for the proposed measurement site with matching discharges over the full flow measurement range.
- Determining if adequate freeboard is available by observing high water marks and inspecting banks for vegetation limits or channel erosion.
- Identifying potential backwater effects.
- Determining if debris, sediment, or weed growth is a problem.

### 2.4 Selection of water measurement and flow metering devices

The selection of the water measurement and recording or metering devices for each particular application is of primary importance. The designer of the measurement devices and metering plan must know the capabilities of each device being considered and how the device will operate under the given operational and/or site constraints. The device requirements to be considered include, the operating environment, accuracy needed, the range of flows to be recorded, totalizing capability, requirements for manual or remote operation, and compatibility with existing or future systems. Available water measurement and metering devices are fully discussed in Reclamation's recently published third edition of the Water Measurement Manual [1].

### 2.5 Selection of communication systems

Modern Reclamation irrigation systems are fully automated with remotely controlled gates and continuous data logging of water flow from a master station. Older systems generally want to emulate that with their communications systems, but are unable to obtain the funding. Often, situations call for providing equipment that will perform the basic needs with capability to expand at a later date. Guidance in selecting communication systems may be obtained from Reclamation's Canal Systems Automation Manuals [2].

### 2.6 Installation and operation of improved devices

Most districts that need improvements to their systems want to perform the work themselves to minimize costs. This requires that they have good drawings to follow and that they understand the important dimensions to be constructed. Quality control can also become an issue.

Of major importance is continuing to work with the districts to ensure that the system of water measurement and recording devices are working properly. This effort is minimized by proper education of the district personnel. Reclamation's Water Resources Research Laboratory (WRRL) provides training courses using our laboratory facilities.

## 3 Case studies

Some recent Reclamation experiences regarding improvements to existing irrigation systems are given. The system goals are very similar, but very different approaches are used to achieve the goals.

### 3.1 Reclamation's Newlands Project and the Truckee-Carson Irrigation District

Reclamation's Newlands Project, located east of Reno, Nevada, in the high desert (El. 1220 m), was one of the first Bureau of Reclamation projects (authorized in 1903) built to store, supplement, and distribute the Truckee and Carson River flows. Total project diversions are about 373,745,046 $m^3$ of water per year, but the project generally has not recorded using the entire allotment. The project includes major storage reservoirs, diversion dams, and 525 km of canals of which only 7 percent are lined. The Truckee-Carson Irrigation District (TCID) has operated the project under contract with Reclamation since 1926.

The project has about 1500 unmetered irrigation head gates with similar structures for the turnouts. Most of the farm turnouts are closely coupled to field water distribution ditches, with only about 61 mm to 91 mm of head available. Most turnouts have a concrete head wall with about a 1.12-m wide by 0.91-m high rectangular opening with a wooden slide gate that is usually pulled out of the water for deliveries, figure 1. The ditches frequently pass filamentatious algae, sediment, and other weed debris. Generally, only one diversion is open on a lateral at a time. Ditch riders try to supply 0.71 $m^3/s$ for the duration requested by farmers.

Figure 1. - Typical farm turnout for the Newlands Project with upstream unlined canal, fully open head gate, return to river, and little available head.

This irrigation district is a classic case of a district with no water measurement plan, a mix of old measurement and recording devices, with "experience" used to set flows. Periodic calibrations are performed by the district and Reclamation personnel with hand-held current meters. The irrigation project must now conserve water to meet domestic water needs while protecting the rivers, threatened aquatic species, and several large wetlands and lakes. Incentives and penalties are in place to encourage TCID to achieve efficiency improvements through measurement of deliveries to each farmer. The goal of the district is to show progress toward measuring deliveries to farmers, however, the diverse objectives of the water users makes advancements difficult.

Water measurement devices must be easily used with farm head gates, inexpensive, pass debris, and be easy to maintain by the local farmers. In addition, each device should be simple to operate with an electronic flow totalizer and data logger that will store and, perhaps at a later date, transmit the data to a control center.

### 3.1.1 Long-throated flume design

The typical problems encountered on the Newlands project led to the conclusion to use long-throated flumes wherever possible in the system. These flumes, also referred to as Replogle or ramp flumes, are generally inexpensive, easy to install, accurate, produce only a slight increase in canal water surface, and are easily modified for each site.

Flume design, based upon work by the Agricultural Research Service (ARS) and Reclamation, is conducted using a computer program, FLUME [3,4]. This program is currently being updated for windows-based application by Reclamation [5]. The flumes are critical flow devices, meaning that when critical flow occurs in the throat section of the flume, a unique relationship is established between the upstream head and the discharge. The FLUME program is used to determine the dimensions of the water measurement structure for a given canal geometry using estimates of the water surfaces. The components of the flume are shown on figure 2 and may be customized for an individual site. Setting the sill height is critical to preventing submergence of the flume and maintaining accuracy. Submergence should be limited to 90 percent or less. A rating curve or table can be computed with an error of about 2 percent or less.

The use of these devices, with no side contractions to simplify the construction, was demonstrated on a farm turnout on the Newlands Project [6]. An ultrasonic water level sensor with continuous data logging was also installed to show how easy it is to accurately obtain and store data for water management. The farmer has been very happy with these devices, but TCID has been slow to develop a plan to implement water measurement throughout the district.

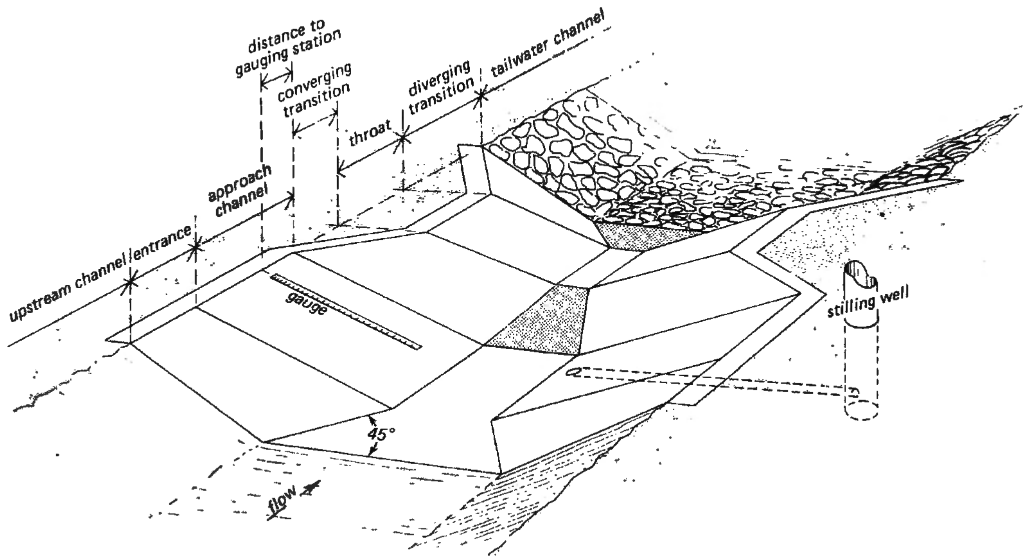


Figure 2. - Typical components of a general long-throated or Replogle flume. A ramp flume, which is a simplified version of the long-throated flume with no side convergence or downstream slope, was constructed in a trapezoidal-shaped lined canal on the Newlands Project.

### 3.2 Pojoaque Valley Irrigation District (PVID) and the Indian pueblos of Nambe, Pojoaque, and San Ildefonso

The Pojoaque Valley Irrigation District (PVID) and the Indian pueblos of Nambe, Pojoaque, and San Ildefonso receive supplemental irrigation water from Reclamation's San Juan-Chama Project from the reservoir formed by Nambe Falls Dam completed in 1976. An extensive system of small unlined ditches were in place prior to construction of the dam, however, measurement was not occurring until formation of PVID and the addition of Parshall flumes with the improvements made by Reclamation in 1979. The district area stretches about 21 km and covers 1,153 ha of land through mountainous terrain at El. 1920 m to the Rio Grande River valley.

The goals are well defined and the funding is available to perform the work. The pueblos want to add measurement sites and metering capability to define Indian and non-Indian water use. The pueblos have money for capital improvements and want to have "state-of-the-art" equipment. The district is small with few employees and a small budget, therefore, water measurement and metering devices must be relatively maintenance free, reliable, and not require recurring monthly charges. Also, the district, pueblos, and Reclamation's Albuquerque Area Office (AAO) want real-time data to better manage water in the Rio Grande River system.

Reclamation met with the concerned parties, reviewed the conveyance facilities, and made recommendations regarding possible improvements to the existing water measurement and recording sites [7]. The top priority site is upstream from Nambe Falls Dam. This site is needed to measure the year-round base flow from the Nambe River ranging from 0.09 to 2.8 $m^3/s$. Fish passage is also a concern over the structure. There are 14 existing measurement sites throughout the district with Parshall flumes, either 0.3-, 0.46-, or 0.61-m-wide constructed in earthen ditches or concrete-lined trapezoidal canals.

Staff gage data (both $H_a$ and $H_b$) are manually recorded and a Stevens chart recorder with a stilling well provides a written record. The ability of these sites to produce good measurements is hampered by sediment buildup, trash, overgrowth of vegetation, and submergence ratios routinely at or above 95 percent. The two main conveyance canals typically convey up to 0.57 $m^3/s$ and the other small ditches currently supply about 0.03-0.2 $m^3/s$. Figure 3 shows a typical Parshall flume and equipment installation.

The goal of this study was to design long-throated flumes for the new sites and for the existing sites where the Parshall flumes are not producing accurate results [8]. The long-throated flumes allow recording of only the upstream head, pass sediment better, and are simple to construct. At other existing sites, specific maintenance (removal of large trees and restoration of the invert in the ditch) will be performed and the Parshall flume performance reevaluated. The pueblo is investigating the use of prefabricated long-throated flumes to possibly make installation simpler. Bubblers and ultrasonic flow meters will be installed with remote terminal units (RTU) to convert the head measurements to discharge and store the data. Data will transmitted with radios to a central location at PVID's office. A cellular phone and modem will be used by the AAO to access the data as needed. Also, the RTU system is capable of providing remote control of diversion head gates, if wanted, at a later date. The system goals will be met once the installation is complete. An important aspect will be the availability of continued technical assistance to ensure that all the devices are functioning properly. Unlike the Newlands project, the managers involved with this project knew what they wanted and had the funding available to achieve their goals.

Figure 3 - Typical PVID Parshall flume installation on a small lined ditch with equipment housing shown. Note the general lack of maintenance which includes heavy vegetation growth..

## 4 Reclamation's Water Resources Research Laboratory research program

The WRRL in Denver maintains an active role investigating water measurement, metering, and communication systems. Measurement devices are tested in the laboratory facilities for non-standard applications. Metering devices are tested, and in some cases developed. In addition, a Flow Measurement Technology web page is maintained and it provides access to the third edition of the Water Measurement Manual. The web site address is http://ogee.do.usbr.gov.

## 5 Summary

Reclamation's older irrigation projects are now being required to provide multiple use of the water. This requires accurately measuring and metering the deliveries and return flows. Typical problems encountered and the usual procedures followed to address updating the systems have been discussed. The two case studies presented show different approaches by the districts operating the projects in solving their problems. Both have the eventual goal of measuring the water used so that the river system may be managed more effectively.

## 6 References


1. "Water Measurement Manual, Revised Third Edition," U.S. Department of the Interior, Bureau of Reclamation, U.S. GPO, Denver, CO 1997.
2. "Canal Systems Automation Manual, Volumes I and II," U.S. Department of the Interior, Bureau of Reclamation, Denver Office, 1991 and 1995.
3. Clemmens, A.J., M.G. Bos, J.A. Replogle, "FLUME Design and Calibration of Long-Throated Measuring Flumes, Version 3," International Institute for Land Reclamation and Improvement/ILRI Publication 54, P.O. Box 45, 6700 AA Wageningen, The Netherlands, 1993.
4. Dodge, R.A., "Ramp flume Model Study - Progress Summary," GR-82-14, U.S. Bureau of Reclamation, Denver, CO, 1983.
5. "Improved Software for the Design of Long-Throated Flumes," Tony Wahl, Bert Clemmens, USCID 14th Technical Conference, Phoenix AZ, June 1998.
6. "Water Measurement Problems and Reclamation's Newlands Demonstration Project," by Kathleen H. Frizell, Brent W. Mefford, and James Lively, U.S. Bureau of Reclamation Water Operation and Maintenance Bulletin No. 177, Sept. 1996.
7. "Site Review and Water Measurement Recommendations for the Pojoaque Valley Irrigation District (PVID) and the Indian Pueblos of Nambe, Pojoaque, and San Ildefonso," by Kathleen H. Frizell, Denver CO, November 1996.
8. "Water Measurement Device Design Recommendations, Data Recording, and Communications Equipment for the Nambe, Pojoaque, and San Ildefonso Pueblos and the Pojoaque Valley Irrigation District (PVID)," by K. H. Frizell and Blair Stringam, January 1998.