MANAGEMENT OF WATER SUPPLIES FOR IRRIGATION

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PROJECT SUMMARY

Water supplies are limited in many areas of the country, particularly in the arid west where irrigated agriculture is the largest user of fresh water. Expanding urban populations and environmental water needs will potentially reduce water available for irrigation in the future. Water users are faced with requirements to more accurately document water uses and return flows. Water measurement and control in irrigated agriculture has experienced significant advances over the last two decades, yet further advancement is both possible and needed. Under this research project, we intend to develop improved water measurement technology, improved water accounting methods, and improved water control technology. New measurement methods will be developed for steep, sediment laden channels, channels with little or no head available, low-head pipelines (culverts), and submerged radial gates. A new canal automation system will be released to a CRADA partner to provide greater water control and operational flexibility to meet user needs. Water balance methods will be further developed to assist water purveyors with documenting water use, including methods to determine sources of error, which indicate where measurement effort should be focused.

OBJECTIVES

1. Flow Measurement and Accounting: We will develop a series of improvements to existing methods for measuring water flow rates and volumes in rivers, streams, canals, and culverts (low pressure or not flowing full). A series of laboratory studies is planned for currently identified water measurement problems (see research approach). We will continue to support software developed for design and calibration of long-throated flumes, will cooperate with customers to evaluate their water measurement and accounting methods, and will work toward solutions to their flow measurement problems.

2. Water Control: We will develop a series of methods, hardware, and software for improving the control of water in open-channel distribution systems typical of irrigation projects or large water supply projects. A new canal automation system currently under development will be turned over to our CRADA partner. The mechanical/hydraulic controller (DACL), used to maintain constant flow rates at canal offtakes, will be improved to make it more usable in remote sites.

NEED FOR RESEARCH

Description of Problem to be Solved

Competition for limited water resources among various users is increasing in many areas of the country, but particularly in the arid west. Irrigated agriculture is the largest user of fresh water resources and, thus, it needs to improve its water management (CAST 1996, National Research Council 1996). Important elements for improving agricultural water management are improved measurement, control, and ultimately, accountability of water resources at the irrigation project level. Water uses at the project or hydrologic unit scale are often poorly documented making meaningful management of water supplies difficult. Also, water supplies for agriculture from large irrigation projects are often not controlled well, resulting in over-delivery to individual users and ineffective use at the farm level. As water moves downstream through various projects and uses, its

quality degrades as salts, trace metals, and other contaminants are concentrated, often to the point of being unusable or having a negative impact on the environment. The objectives of this project are to develop tools for improving the management of water supplies, particularly for irrigation.

Relevance to ARS National Program Action Plan

The research is part of National Program 201, Water Quality and Management. The project falls under Component 2, Irrigation and Drainage Management. Both objectives deal with agricultural water conservation and fit under Problem Area 2.3 (Water Conservation Management), Goal 2.3.1 (Water Conservation Technologies). The research also supports Goal 2.3.3 (Agricultural Water Conservation and Environmental Quality).

Potential benefits

Large-scale water supplies will be better managed in arid regions with the tools developed here. Water measurement, accounting, and control will be improved in irrigated agriculture, supporting more rational analysis of the impact of irrigated agriculture on the environment and allowing more rational decisions by society about water allocation and use.

Anticipated Products

New technology is provided for improving the operation and management of water projects, including canal automation/control and water measurement/accounting technology.

Customers of the research and their involvement

Based on past successful technology transfer and the anticipated products, customers will include the U.S. Bureau of Reclamation (USBR), Natural Resources Conservation Service, U.S. Geological Survey, Army Corp of Engineers, Bureau of Indian Affairs, State Departments of Water Resources (particularly Arizona and California), land-grant universities, civil and agricultural consulting engineers, and water purveyors (water conservancy districts, irrigation districts, municipalities, etc.). We have cooperated with NRCS staff on the application of flow measurement technology and related research needs at all levels (field office to national) and in states across all regions of the country. Our main point of contact is Tom Spofford, Water and Climate Center, Portland OR (letter attached), who disseminates information widely within NRCS. With USBR, cooperation on water measurement and control has been mainly with the Water Resources Research Lab, Denver CO (Cliff Pugh, letter attached). They transfer our technology to regional and area offices through manuals and technical assistance programs. Research on water-balance methods has primarily been with the Lower Colorado Region of USBR (Steve Jones), who along with other regions are transferring this technology to water purveyors through their water conservation plans. Further planned activities with Paul Matuska (letter attached) are expected to have additional impact on water conservation plans. Several water purveyors (e.g., Salt River Project, Maricopa Stanfield I&D District, Imperial Irrigation District) have been directly involved in various studies and technology transfer activities since much of this research must be conducted within real, full-size water systems. Water meter, remote monitoring, and hydrologic instrumentation manufacturers have been

customers, which is expected to continue with this project (e.g., Automata, Global Water, Micrometer, Nu-Way Flume Co., Plastifab, etc.). Individual water users also will be customers, particularly for the water measurement devices.

SCIENTIFIC BACKGROUND: Refer to 2001 Annual Report **APPROACH AND RESEARCH**

PROCEDURES: Refer to 2001 Annual Report **PHYSICAL AND HUMAN RESOURCES:** Refer

to 2001 Annual Report **MILESTONES AND EXPECTED OUTCOMES**

Expected outcomes include: (1) improved water measurement devices, (2) new canal automation technology, and (3) improved water use assessment methods and performance indicators.

Milestone Timeline

ResearchComponent	end of year 1	end of year 2	end of year 3	end of year 4	end of year 5
Water Measurement and Accounting	Lab study on flow conditioning for pipes/culverts completed (Replogle)	Lab study on debris-shedding propeller meter completed (Replogle)	Field studies on surface-velocity-based method completed (Replogle)	Lab study on high sediment load flume completed (Replogle)	
		Laboratory studies on submerged radial gates completed (Clemmens)	Verification of radial gate calibration method completed (Clemmens)		Field study on water balance accuracy completed (Clemmens)
Water Control	Initial version of canal automation system turned over to CRADA partner (Clemmens)	Improved interface for canal automation system provided to CRADA partner (Clemmens/Bautista)	Final version of canal automation technology given to CRADA partner (Clemmens)		New DACL control system developed and lab testing completed (Replogle)
		Field studies of canal automation on steep canal (WM at MSIDD) completed (Clemmens)	Field application of feedforward routing method completed (Bautista)		Field studies of canal automation on canal with mild slope complete (Clemmens)
	Feedback control method for branching canals developed and simulation testing completed (Clemmens)	Simulation testing of Model Predictive Control for branching canal completed (Clemmens)		Upstream control method developed and simulation testing completed (Clemmens)	

PROGRESS

Improving the operation of large water projects is an important step in water conservation efforts to spread limited available water supplies. Engineers from the U.S. Water Conservation Lab, in cooperation with CRADA partner Automata Inc., have developed and canal automation system, which includes Software for Automated Canal MANagement – SacMan. The first version of SacMan was provided to Automata Inc. in 2002, covering manual control with intelligent assistance. This software, including future versions with full automatic control, has significant potential for improving water management in irrigation projects and the CRADA partner has already sold one copy and has interest from several other districts.

Laboratory studies on flow conditioning in pipes and culvert is ongoing. The bugs have been worked out the the measurement methods and the pipe has been set up to handle the variety of tests planned. Several instrument manufacturers have cooperated in various tests and more such cooperation is expected.

The main features of the SacMan canal automation software have been field tested. An initial version of the software, handling manual control systems, was turned over to our CRADA partner. The control system is being installed at the Central Arizona Irrigation and Drainage District, Eloy, AZ. The initial installation is manual control, with full automatic control being phased in over the next year or so. The first full version of the software will be provided in early FY03.

Initial studies on the control of branching canals were successful. Both Linear Quadratic Regulators and Model Predictive Control were successfully applied to one of the ASCE test canals through computer simulation. The controller design methods were able to account for the interacting influences of the various branches.

Through cooperation with the Bureau of Reclamation, Water Resources Management Lab, we were able to analyze the data collected on radial gates by the Bureau in the early 1980s. This data supported our approach in calibrating submerged radial gates, but also showed that a wider range of data is needed to provide useful calibration. Preliminary field studies at the Salt River Project also supported our approach.

Publications:

Bautista, E., A.J. Clemmens, and T. Strelkoff. Routing demand changes with volume compensation: An update. In USCID/EWRI Conference, San Luis Obispo, CA, July 10-13, 2002.

Bautista, E., R.S. Gooch, B.T. Wahlin, R.J. Strand, and A.J. Clemmens. 2001. Evaluation of a canal control method by volume compensation at the Salt River Project, Arizona. CD ROM, unpaginated. In XI Congreso Nacional de Irrigation, Guanajuato, MX, Sept 19-21, 2001. WCL# 2298.

Clemmens, A.J. New calibration procedure for submerged radial gates. In USCID/EWRI Conference, San Luis Obispo, CA, July 10-13, 2002.

Clemmens, A.J., E. Bautista, R.J. Strand, and B.T. Wahlin. Canal automation pilot project: Phase II Report. WCL Report #24, U.S. Water conservation Lab, Phoenix, AZ. Dec. 2001.

Clemmens, A.J., R.J. Strand, L. Feuer, and B.T. Wahlin. Canal automation system demonstration at MSIDD. In USCID/EWRI Conference, San Luis Obispo, CA, July 10-13, 2002.

Replogle, J.A. Correcting unreliable velocity distributions in short culverts and canal reaches. In USCID/EWRI Conference, San Luis Obispo, CA, July 10-13, 2002.

Wahl, T.L., A.J. Clemmens, M.G. Bos, and J.A. Replogle. Tools for design, calibration, construction and use of long-throated flumes and broad-crested weirs. In USCID/EWRI Conference, San Luis Obispo, CA, July 10-13, 2002.

Wahlin, B.T. and A.J. Clemmens. Preliminary results for downstream feedback control of branching canal networks. In USCID/EWRI Conference, San Luis Obispo, CA, July 10-13, 2002.