NCWCD EFFORTS TOWARD IMPROVING ON-FARM WATER MANAGEMENT

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ABSTRACT

The Northern Colorado Water Conservancy District (NCWCD) formally established an IMS (Irrigation Management Service) in 1981 to promote improved on-farm water management. Programs include:

1) Weather Station Network,
2) Field-by-Field Irrigation Scheduling Demonstrations,
3) Surge Valve Loan Program,
4) Agricultural Best Management Practices Field Demonstrations,
5) Cooperative Salinity Program, and
6) Farm Turnout Low-Cost Gate Automation.

Water measurement is a key to improved irrigation management. Needed measurements include flow deliveries to the field, crop water use (calculated from weather station data), local rainfall, tail water runoff, etc. Such measurements allow calculation of on-farm irrigation efficiency. This is a major step beyond just scheduling irrigations. It enables estimation of the volume of water used beneficially.

Increased on-farm irrigation efficiency often requires improved flexibility in water deliveries from the canal to the farm turnout or field. However, this improved delivery flexibility can result in increased spills or waste in canal operations. An appropriate balance must be achieved.

The IMS programs of NCWCD have experienced considerable success. However, institutional and economic barriers continue to inhibit needed improvements in some areas.

BACKGROUND

The NCWCD is comprised of 1.5 million acres in eight counties on the East Slope of the Rocky Mountains in northeastern Colorado. NCWCD has aggressively promoted improved on-farm water management for more than 23 years. Efforts have steadily increased each year and are now supported by nine full-time IMS staff positions.

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From its inception, IMS has been directed toward education, training, and demonstrations. It shares information regarding new technologies, increases public awareness, and enables producer confidence for implementing practical improvements. To date it has not assessed cooperators any fees to participate in the program. All property owners within NCWCD boundaries annually pay a small ad valorem tax assessment to help fund NCWCD operations and activities. The District Board of Directors has consistently supported funding allocations to continue and improve IMS programs. IMS does not focus on policies or politics. With a foundation based on information and technology, it has avoided the controversy and resistance often associated with political mandates and enforcement for regulatory compliance.

WEATHER STATION NETWORK

The NCWCD operates a network of remote, solar powered, automated weather stations throughout its service area for disseminating crop water use information. The Weather Station Network is currently composed of 21 stations. Station sites are carefully selected to ensure readings representative of crop field conditions, always well within a surface-irrigated field of alfalfa hay or over large, well-irrigated areas of urban turf grass. Stations are approximately 25 to 30 miles apart to provide the best practical coverage and are operated year-round. However, station density has increased near metropolitan areas. Each station collects air temperature, relative humidity, wind speed and solar radiation data, which are used to calculate ETR (reference evapotranspiration) on a daily basis using the ASCE standardized Penman-Montieth combination equation for both alfalfa and turf grass. Precipitation, wind direction, and soil temperature are also collected. The weather station data is automatically transmitted at least twice daily to NCWCD headquarters via modem and cellular telephone. Each sensor at each weather station is checked and calibrated annually to ensure data accuracy and to maintain high network reliability.

ETR is factored or adjusted using crop coefficients based on plant growth stages to calculate crop ET or water use for all of the area's major crops. Weather summaries and crop water guides are readily available via the Internet at www.ncwcd.org and also via a telephone voice-messaging system or “Call Center.” The “Call Center” can be accessed using a touch-tone telephone by dialing (970) 593-1605 or (888) 662-6426 (NOCOH2O) toll-free. Voice instruction and menu options allow the user to quickly access information for a selected area.

Accurate and reliable crop ET information supports efficient irrigation scheduling, thereby allowing producers to determine how much water to apply given their specific crop and irrigation practices. Using crop ET information has received wide acceptance and continues to grow. It is a key input utilized in

modern, efficient irrigation scheduling methods to maximize water use effectiveness while minimizing required inputs.

FIELD-BY-FIELD IRRIGATION SCHEDULING DEMONSTRATIONS

Since 1981, the NCWCD has provided a Field-by-Field Irrigation Scheduling Demonstration program to growers within its boundaries. This program is an aid in irrigation decision-making to accomplish efficient use of available water. It can provide irrigators with a better understanding of soil moisture management and can often give the grower needed confidence to lengthen the time between irrigations. The program is designed to help growers manage their water throughout the full irrigation season.

The Field-by-Field Irrigation Scheduling Demonstration program utilizes the root zone water balance method, or checkbook method, coupled with soil moisture sensors. Soil moisture holding capacity and an allowable depletion percentage are estimated. Readings from the soil moisture sensors are used to calculate remaining available moisture and are compared to calculated crop ET. The NCWCD's Weather Station Network provides the needed crop ET and is key to the success of the Field-by-Field Irrigation Scheduling Demonstration program.

The program currently targets assistance to 50 area producers, with one to two fields per cooperator each season. Cooperators generally participate in the program for two to three seasons, after which new cooperators replace past participants. Past participants are encouraged to either continue irrigation scheduling activities on their own or to contract with a commercial crop consulting service. By limiting cooperator participation (both quantity of fields and duration), NCWCD has avoided conflicts with commercial crop consulting services and currently enjoys good cooperation and working relationships in this regard.

In the past, tensiometers have been the primary soil moisture device utilized by the program. Instruments were manually read and serviced during a weekly site visit. However, efforts are expanding to include automated soil moisture sensors. Automation allows continuous monitoring and recording of soil moisture at multiple levels within the crop root zone. Several manufacturers now market lower cost electronic soil moisture sensors and data loggers, including telemetry capabilities. Cooperator support for automated monitoring is increasing rapidly.

SURGE VALVE LOAN PROGRAM

Surge valves can be utilized to improve furrow irrigation application efficiency. They are a relatively simple irrigation tool that generally reduces required labor and water. Surge irrigation utilizes gated pipe and an automated butterfly valve that alternates water from one side to the other in timed advance or soak cycles.

NCWCD has provided a Surge Valve Loan Program as a free service to growers within its boundaries since 1993. The program allows growers to evaluate surge irrigation on their own field for a season at no charge. Currently NCWCD maintains an inventory of 30 valves with nearly all valves utilized each season. Valves are loaned to growers, on a first-come first-served basis, with new participants having priority. A NCWCD representative initially meets with the grower and explains the function and basic programming of the surge valve. As surge valves can be installed in many different scenarios, they also discuss installation options and emphasize constraints to ensure successful valve operation. NCWCD then provides 24-hour assistance on the programming and operation of the surge valve.

Most surge valves function in two modes, advance cycles followed by soak cycles. Generally four advance cycles (alternating from left to right) are used to push water down furrows as quickly as possible (without rupturing ditches) to increase irrigation uniformity. After the initial advance cycles, water quickly travels across the already moist soil and continues farther down the field. After the final advance cycle the surge valve begins soak cycles, during which water runs the entire length of the field before switching to the other side. Properly programmed soak cycles have minimal tail water runoff.

In conjunction with the Surge Valve Loan program, NCWCD conducts irrigation efficiency evaluations. Measurements by NCWCD staff (during a single irrigation set) allow surge irrigation to be compared to the grower's traditional practices. Growers can thus better evaluate the effectiveness of surge irrigation. The use of a surge valve generally allows a grower to run more rows on the same amount of water and complete irrigations faster. Tail water runoff is reduced, keeping more water in the field where it is needed. Surge irrigation methods generally improve application efficiency by 10 to 20 percent and often exceed other surface irrigation methods.

AGRICULTURAL BEST MANAGEMENT PRACTICES FIELD DEMONSTRATIONS

NCWCD conducts Agricultural Best Management Practices Field Demonstrations at small acreage educational farms, which it operates and manages. This program effectively promotes improved on-farm water management, including prevention of non-point source pollution. Such efforts have significantly increased NCWCD credibility, raised public awareness, and expanded understanding of improved practices.

In the past, NCWCD has operated farms in conjunction with the Thompson Valley Young Farmers near Johnson's Corner, and with the Valley Young Farmers near Gilcrest. The current demonstration farm is at the northwest corner of Water Avenue and Highway 287 near Berthoud, Colorado. This site is also the

new headquarters of NCWCD. It includes crops of small grains and alfalfa hay. Irrigation methods used at this site include surge furrow and linear sprinkler, with installation of sub-surface drip irrigation planned for the near future.

Current or planned field demonstrations include:
1) Surge furrow irrigation vs. conventional furrow irrigation,
2) High efficiency linear sprinkler irrigation,
3) Sub-surface drip irrigation of field crops,
4) Turnout gate automation,
5) Soil additives such as PAM (PolyAcrylaMide) to increase furrow stability and prevent erosion,
6) Grass filter strips and waterways,
7) Turbulent fountain or 'bubble' trash screens to prevent clogged sprinkler nozzles,
8) Improved on-farm water measurement, and
9) Soil moisture monitoring for improved irrigation scheduling and management.

COOPERATIVE SALINITY PROGRAM

The quality of applied irrigation water can directly impact crop growth and yield. Crop selection may become limited and/or yields reduced if the salinity of available irrigation water exceeds critical levels.

In cooperation with the U.S. Bureau of Reclamation, NCWCD is completing the fourth year of a multi-year study to assess salinity and its impacts on agricultural crop production in northeastern Colorado and to promote appropriate irrigation management. Monitoring of salinity levels in the surface waters, groundwater, and agricultural soils of the Lower South Platte River Basin is ongoing. This study will build a foundation for development of localized best management practices adapted to preserve productive farm ground in northeastern Colorado. Other institutions, such as Colorado State University, U.S.D.A. Natural Resources Conservation Service, and the West Greeley Soil Conservation District also collect salinity data and collaborate to avoid duplication of efforts.

Beginning in the spring of 2001, NCWCD began monitoring salinity levels in surface waters throughout its delivery area. Coupled with flow data from existing U. S. Geological Survey and State of Colorado stream gauging stations, total salt load and transport is calculated. At present, surface waters of all major tributaries (Boulder Creek, St. Vrain Creek, Little Thompson River, Big Thompson River, and Cache la Poudre River) are monitored.

Continuous, specific conductivity is obtained from 26 newly installed automated salinity monitoring stations. Each station monitors water EC (electrical conductivity) in the range of 0.005 to 7.0 dS/m. Initial EC measurements are temperature corrected to 25C, providing specific conductivity (proportionally

related to total dissolved solids). Additional station sensors measure rainfall (tipping bucket rain gauge) and air temperature. Data are sampled at 3-second intervals and averaged (rainfall is totaled) over 15-minute intervals. This continuous monitoring records variability in river/stream or canal EC not obtained by periodic manual sampling. The detection and interpretation of salinity trends and sources is thus facilitated.

InSitu mini-TROLL and Hydrolab Quanta multi-sensor units are used for periodic manual sampling of surface waters at approximately 100 sites (irrigation canals, ditches, reservoirs, and other sources) on a weekly to monthly basis throughout the year. These mobile units contain several sensors, including specific conductance, dissolved oxygen, temperature, and pH. Preferred sampling sites are county road bridges near a stream gauging station.

Groundwater levels are monitored via existing well networks and 20 additional wells newly installed by NCWCD personnel to fill in spatial coverage. A Grundfos Redi-Flo pump draws water from the monitoring wells. An InSitu mini-TROLL or Hydrolab Quanta unit is then used to obtain water quality readings from a representative sample while still at the well site.

Soil salinity is measured and mapped utilizing a Geonics EM38-DD electro-magnetic induction unit mounted on SAM (Salinity Assessment Module, modified diesel powered spray rig, articulated with hydraulic drive wheels). Field sites were selected using a stratified random sampling plan based on a 5-mile grid. Soil sampling procedures closely follow those developed at the U.S. Salinity Laboratory and used by the Lower Colorado Region Salinity Assessment Network. As the EM38-DD can infer salinity distribution with soil depth, valuable insight is obtained regarding the effects of irrigation and drainage within sampled fields.

The raw data from the EM38-DD is analyzed by ESAP software to optimize locations for soil core samples to be obtained. The cores are used to determine soil texture classification and soil moisture, and for laboratory EC analysis. The soil cores are analyzed in 1-foot increments using the Hach Salinity/Sodicity Kit developed by the U.S. Salinity Laboratory. The laboratory analyses are fed back into the ESAP software for the final calibration and spatial mapping of soil salinity.

The severe drought conditions in Colorado during the 2002 and 2003 seasons significantly reduced soil salinity mapping activities. Soil conditions were generally drier and often precluded valid electromagnetic readings using the EM38-DD. Potential field entry for soil salinity mapping is, at best, quite limited. Soil moisture levels must be high enough for valid electro-magnetic readings, yet dry enough to avoid compaction and other damage resulting from equipment passage. Additionally, the crop must also be small enough to avoid destruction by

the salinity rig. Frozen soil conditions must also be avoided.

FARM TURNOUT LOW-COST GATE AUTOMATION

The NCWCD began promoting low-cost automation in 2000 under grant funding from the U.S. Bureau of Reclamation. Because on-farm efficiency is largely affected by the operation of local ditch companies, improved canal operations often promote increased irrigation efficiency by the farmer. This program seeks to maintain uniform deliveries and increase flexibility for irrigators. It provides demonstrations of low-cost gate automation on canal structures and/or farm head gates.

Gate automation generally necessitates accurate water level or flow measurement. Long-throated flumes, broad crested weirs, or ramp flumes (Replogle flume) can often provide low-cost flow measurement devices appropriate for many applications with minimum head loss. These are readily designed to meet many site constraints.

Local interest in gate automation has increased rapidly in recent years. Lower purchase costs for equipment, coupled with more flexible operations, are key factors. Additionally, increased urbanization of the NCWCD service area has increased the operational challenges and constraints facing local ditch companies. As productive agricultural lands are sold for development and the associated water rights transferred to cities, irrigation and ditch companies are faced with reduced flow rates, decreased exchange opportunities, and shorter delivery seasons. Improved flow measurement, remote monitoring, and gate automation are increasingly required for successful water delivery operations.

CONCLUSIONS

NCWCD has implemented a wide range of programs to promote improved on-farm water management and conservation. These efforts include a district-wide weather station network, field-by-field irrigation scheduling demonstrations, surge valve loan program, agricultural best management practices field demonstrations, cooperative salinity program, and farm turnout low-cost gate automation.

IMS does not focus on policies or politics. With a foundation based on information and technology, it has avoided the controversy and resistance often associated with political mandates and enforcement for regulatory compliance.

Water measurement is a key to improved irrigation management. Needed measurements include flow deliveries to the field, crop water use (calculated from weather station data), local rainfall, tail water runoff, etc. Such measurements allow calculation of on-farm irrigation efficiency. This is a major step beyond just

scheduling irrigations. It enables estimation of the volume of water used beneficially. This in turn supports effective decision making to increase water use effectiveness, reduce production costs, and/or improve the quantity and/or quality of crop yields.

Increased on-farm irrigation efficiency often requires improved flexibility in water deliveries from the canal to the farm turnout or field. However this improved delivery flexibility can result in increased spills or waste in canal operations. An appropriate balance must be achieved.

The IMS programs of NCWCD have experienced considerable success. Formally established in 1981, IMS currently employs nine full-time staff and six temporary field technicians each summer. In many years, area farmers/producers have routinely signed up on waiting lists to participate in several IMS programs. Initially skeptical and reserved, many irrigators quickly learn to accept and rely upon the information obtained through IMS programs. Irrigation effectiveness and efficiency subsequently increase, water resources are conserved, and water quality is preserved. Many cooperating farmers report production cost reductions, primarily in required labor for irrigation. NCWCD and its' IMS have become well recognized for their ongoing efforts to improve on-farm water management.

However, institutional and economic barriers continue to inhibit needed improvements in some areas. These barriers include water right administration, lack of flexibility in water deliveries to field turnouts, reduced canal /ditch flows resulting from water transfers to municipalities, etc. Consequently many area farmers/producers continue historical practices to use irrigation water whenever it is available, rather than just when it is needed, as its future availability is restricted and/or uncertain. In addition, many landowners are reluctant to fund irrigation system improvements needed by tenant farmers. Such investments can significantly reduce or even eliminate their net income from farm ownership. Often the farmer renting such ground cannot justify paying for capital improvements he cannot take with him if his lease is not renewed. Consequently many area irrigators are left to struggle using antiquated and inefficient irrigation methods. In average or wetter growing seasons, irrigation water continues to be a lower cost input to farm production and high irrigation efficiency is simply not required to insure profitability.