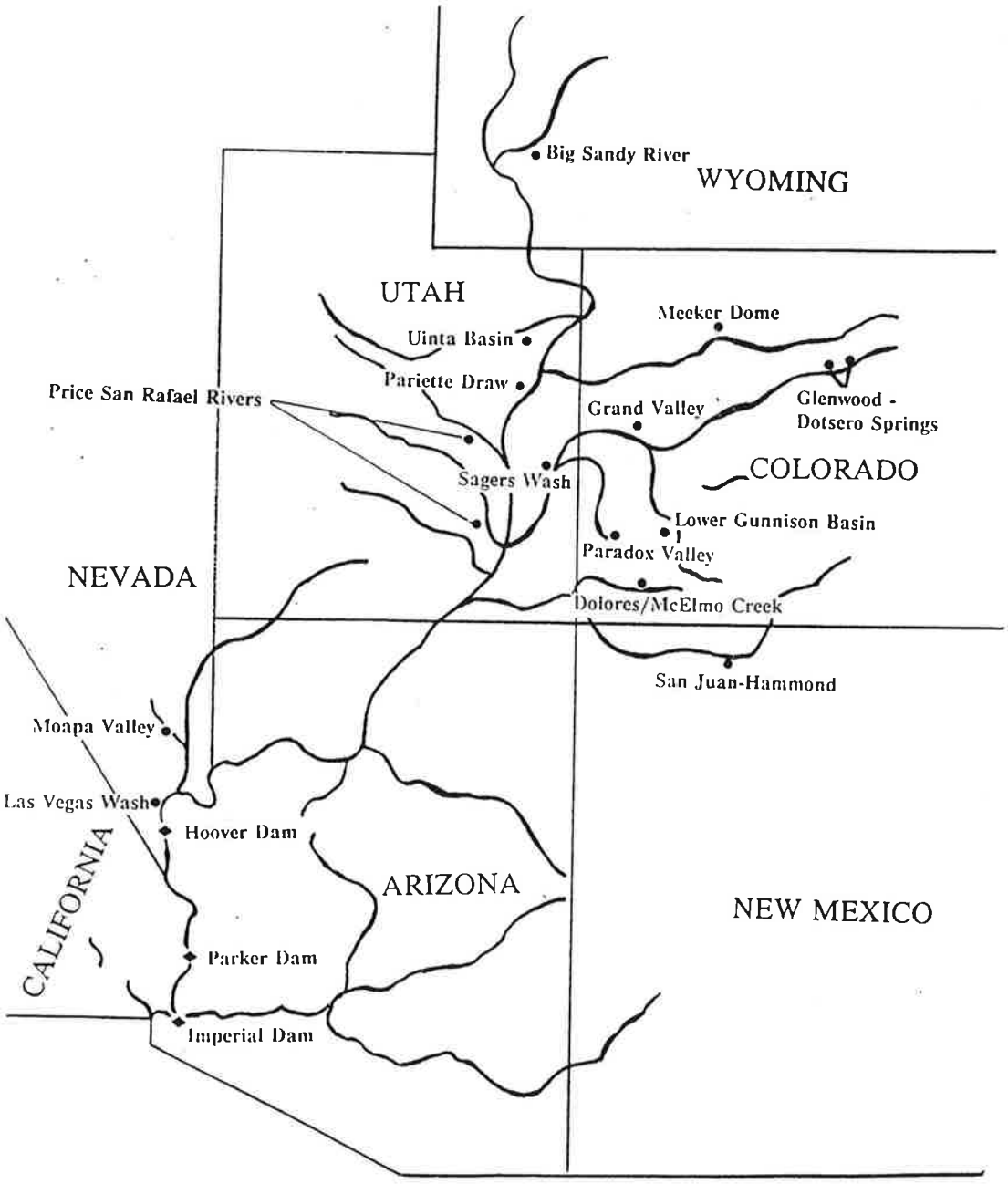
United States
Department of
Agriculture

USDA
Salinity
Control
Coordinating
Committee

1993 Report To Congress

Colorado River Basin Salinity Control Program



DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

5 AUG 1993

Honorable Albert Gore, Jr.
President of the Senate
Old Executive Office Building
Washington, D.C. 20501

Dear Mr. President:

Enclosed is the Department of Agriculture's (USDA) 1993 Report to Congress on the Colorado River Basin Salinity Control Program. This report is submitted in accordance with Section 202(c)(5) of the Colorado River Basin Salinity Control Act of 1974, as amended.

The report has been developed through the cooperative efforts of the following agricultural agencies serving on the USDA Salinity Control Coordinating Committee: Agricultural Research Service, Agricultural Stabilization and Conservation Service, Cooperative State Research Service, Extension Service, and Soil Conservation Service.

Any legislative proposals will be in the Administration's proposals for the 1995 Farm Bill.

Sincerely,

signed
MIKE ESPY
Secretary

Enclosure

EXECUTIVE SUMMARY

The Colorado River Basin Salinity Control (CRSC) Program is authorized by Section 202(c) of Title II of the Colorado River Basin Salinity Control Act of 1974, as amended (43 U.S.C. 1592).

The Colorado River serves as the primary source of water for over 18 million people in parts of seven Basin States (Basin) -- Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming --and the Republic of Mexico and is used and reused for crop irrigation and generating hydro-electric power as well as municipal and industrial purposes.

Program Mission

The purpose of the CRSC program is to identify salt source areas in the Basin; to assist landowners and operators in approved project areas in installing salinity reduction practices to reduce salinity levels in the Colorado River; to carry out research, education, and demonstration activities; and, to monitor and evaluate the activities being performed.

Program Scope

The salinity control program is underway in the following units; Grand Valley, Lower Gunnison Basin, and McElmo Creek, Colorado; Moapa Valley, Nevada; Uinta Basin, Utah; and the Big Sandy River, Wyoming. A joint plan with Bureau of Reclamation is nearly completed for the Price-San Rafael Utah, Unit. The plan and environmental documents for each unit identify the salt reduction and expected impacts on the environment and describe the voluntary wildlife replacement actions that will be initiated to replace the wildlife habitat values foregone during implementation.

Enrollment Activity and Impacts

More than 4,000 contracts have been approved with participants in the units under implementation since inception through fiscal year 1992. At the end of fiscal year 1992, salt loading into the Colorado River has been reduced by 153,317 tons. On a unit basis, this reflects a low of 3,561 tons in the McElmo Creek, Colorado, Unit where action was recently initiated, to a high of 56,653 tons in the Grand Valley, Colorado, Unit which has been underway the longest.

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BACKGROUND

In 1922, Mexico used 500,000 acre-feet of Colorado River waters annually. The possibility of a future Treaty with Mexico concerning Colorado River waters was recognized in the Colorado River Compact of 1922 (1922 Compact) which provided that any right to the use of such waters accorded Mexico by the United States shall be supplied first from surplus and, if insufficient, the deficiency shall be borne equally by the Upper and Lower Colorado River Basins.

In 1930, efforts to negotiate an agreement failed when Mexico claimed 4.5 million acre-feet (maf) and the United States offered 750,000 acre-feet. New negotiations in 1941 resulted in a 1944 Treaty with Mexico which linked the waters of the Rio Grande River with the Colorado River. By 1944, Mexico's use of the Colorado River waters rose to 1.5 maf annually.

The 1944 Treaty guaranteed Mexico a minimum quantity of 1.5 maf of Colorado River waters annually to be delivered according to schedules furnished in advance by Mexico. If there was a surplus, as determined by the United States, an additional 200,000 acre-feet was authorized, but Mexico acquired no rights to more than 1.5 maf. The 1944 Treaty also provided that in case of extraordinary drought, Mexican deliveries will be reduced in the same proportion as consumptive uses in the United States were reduced. After Senate ratification with reservations, President Truman proclaimed the 1944 Treaty in force effective November 8, 1945.

In October 1948, the Upper Colorado River Basin (Upper Basin) States entered into a Compact which was subject to the previously discussed 1922 Compact. The Colorado River Storage Act was passed in April 1956 to develop Upper Basin water resources. At that time, the Lower Colorado River Basin (Lower Basin) development had proceeded more rapidly than had the Upper Basin and included construction of Laguna Dam, Hoover Dam, Davis Dam, Parker Dam, Imperial Dam, Colorado River Aqueduct, and All-American Canal.

Salinity concentrations in water delivered to Mexico at Morelos Dam increased from 800 parts per million (PPM) in 1960 to over 1,300 ppm in 1961. In 1962, salinity concentrations increased to more than 1,500 ppm with salinity levels in some months exceeding 1,500 ppm. In November 1961, Mexico charged the United States with violating international law.

The International Boundary and Water Commission, United States and Mexico, entered into an August 1973 agreement (Minute No. 242) approving a permanent and definitive solution of the international problem of the salinity of the Colorado River in compliance with references contained in the June 1972 Joint Communique of Presidents Richard Nixon and Luis Echeverria.

BACKGROUND, *Continued*

The August 1973 agreement provided that the United States shall adopt measures to assure that the water delivered to Mexico upstream of Mexico's Morelos Dam has an average salinity of no more than 115 parts per million (ppm) plus or minus 30 ppm over the annual average salinity at Imperial Dam. This assurance to guarantee a certain salinity level would become effective upon appropriation by Congress to construct the necessary works.

LEGISLATIVE HISTORY

Congress enacted the Colorado River Basin Salinity Act, Pub. L. 93-320 (the 1974 Act), on June 24, 1974. Title I of the 1974 Act concerned programs downstream of the Imperial Dam under the responsibility of the Secretary of the Interior. Title II of the 1974 Act concerned measures upstream of the Imperial Dam and Section 202(c) directed the Secretary of Agriculture to "cooperate in the planning and construction of on-farm system measures under programs available" within the United States Department of Agriculture (USDA).

In carrying out the provisions of the 1974 Act, USDA initiated a salinity control program through the use of existing authorities for planning and technical assistance. Cost-share funds were provided through the Agricultural Conservation Program (ACP). The established ACP payment limitation required program participants to borrow money for larger projects or install larger projects in a piece meal fashion over a number of years. This limitation created difficulties in implementing a cost effective salinity control program.

On October 30, 1984, Congress enacted Pub. L. 98-569 (1984 Amendments) which amended the 1974 Act and established a voluntary cooperative on-farm salinity control program to improve on-farm water management and reduce watershed erosion. The 1984 Amendments authorized the Secretary of Agriculture to: (1) identify salt source areas and determine the salt load resulting from irrigation and watershed management practices; (2) provide technical and financial assistance for voluntary implementation of salinity reduction practices; (3) perform information, education, and research programs; and (4) perform monitoring and evaluation of changes in salt contributions to the Colorado River to determine program effectiveness.

On May 5, 1987, the Agricultural Stabilization and Conservation Service (ASCS) published an interim rule at 7 CFR Part 702, Colorado River Basin Salinity Control Program. ASCS issued a final rule on March 1, 1993.

OBJECTIVES AND GOALS

The Colorado River Basin Salinity Control program's objective is to reduce salt loading within the Colorado River to comply with United States' obligations to Mexico and to achieve numeric water quality standards for improvement of water quality for all Colorado River water users. Reductions in salt loading are necessary to maintain the salinity concentrations at or below the numeric criteria discussed below while allowing States to continue development of water apportioned to them by various compacts and court decrees.

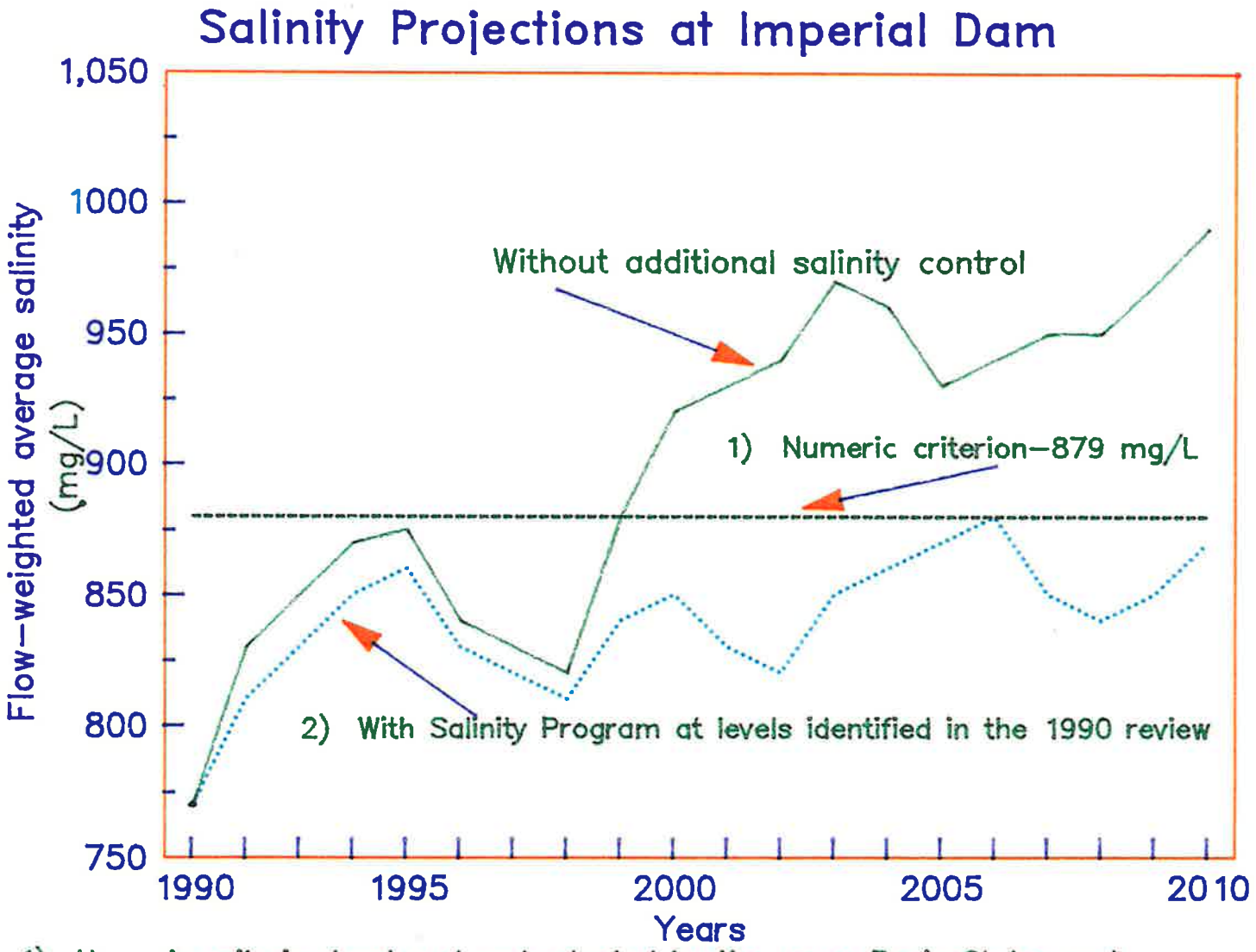
The Colorado River numeric criteria for salinity, measured as total dissolved solids (TDS), have been established by the Basin States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming, and approved by Environmental Protection Agency (EPA). The locations for measurement of the numeric criteria for salinity are: below Hoover Dam, 723 milligrams per liter (mg/L); below Parker Dam, 747 mg/L; and at Imperial Dam, 879 mg/L.

Historically, the Colorado River carries approximately 9 million tons of salt past Hoover Dam each year. EPA studies identified that agricultural irrigation return flow contributes approximately 37 percent of the total salt load to the Colorado River.

The projected salt load reduction needed to maintain salinity concentrations for TDS at or below the adopted numeric criteria is about 1.5 million tons per year. Of this total amount, the present salt load reduction goal for the Department of Agriculture (USDA) program is approximately 780,000 tons per year. This goal is based upon the estimated salt load reduction from the six salinity units under implementation and one salinity unit in planning status.

The plan of implementation for the entire Colorado River Basin was prepared and adopted by the Colorado River Basin Salinity Control Forum (Forum) in 1990 and is projected to meet the numeric criterion at Imperial Dam (Figure 1) by 2010. The Forum is an organization composed of water resource and water quality representatives appointed by the Governors of the seven Basin States. Analysis by the Forum indicates that salinity concentrations at Imperial Dam would exceed the numeric criteria if no additional salt reduction actions are implemented. These projections are based upon average long-term flows in the river, estimated future water development, and the combined removal of salt by USDA, Bureau of Reclamation (Reclamation), and Bureau of Land Management (BLM) of the Department of Interior (DOI), salinity control units.

Figure 1



1) Numeric criteria developed and adopted by the seven Basin States and approved by EPA.
2) Report on the 1990 Review, Water Quality Standards for Salinity Colorado River System, May 1990. Prepared by Colorado River Basin Salinity Control Forum.

OBJECTIVES AND GOALS, *Continued*

The projections were obtained from the Colorado River Simulation System (CRSS) computer model developed by Reclamation. The CRSS model is a package of computer programs and data bases developed by Reclamation as a tool for use by water resource managers dealing with water related issues and problems in the Colorado River Basin. The CRSS model is a computer program which simulates the flow of water and salt through the system and the operation of the reservoirs including hydroelectric power plants. The salt routing studies are conducted to provide estimates of future flow-weighted average annual salinity concentrations for each year of the 1990 through 2010 study period at selected points in the lower Basin using the future water depletion projections by the Basin States and the average annual long-term water supply of 15 maf. Salinity in the Basin is monitored by the United States Geological Survey (USGS) at 20 key stations. These data are used in the CRSS model. Historical salinity conditions are summarized in the, *Quality of Water, Colorado River Basin Progress Report No. 15, January 1991.*

As determined by a joint evaluation process by the Forum and appropriate Federal agencies, a cost-effective combination of USDA, Reclamation, and BLM projects is needed. In some cases, it is advantageous for USDA and Reclamation projects to coordinate joint implementation. For example, Reclamation's off-farm canal and lateral improvements may be needed before USDA's onfarm improvements can be initiated. Further, the off-farm improvements may allow individual irrigators to install more efficient and cost-effective gravity pressure sprinkler systems.

COLORADO RIVER BASIN STATES

Colorado River Basin Salinity Control Advisory Council

The 1984 amendments to the Act authorized creation of the Colorado River Basin Salinity Control Advisory Council (Advisory Council) composed of representatives from the seven Basin States. The Advisory Council receives annual reports from the cooperating federal agencies on their salinity control activities and prepares an annual report which includes program recommendations to the Secretaries of Agriculture and Interior and the EPA Administrator.

Colorado River Basin Salinity Control Forum

The Colorado River Basin Salinity Control Forum (Forum) is an organization composed of water resource and water quality representatives appointed by the Governors of the seven Basin States. The Forum was established in 1972 as a result of amendments to the Clean Water Act and serves as an interstate water quality coordination mechanism. The Forum adopts implementation plans and schedules for controlling salt loading from a variety of sources and conducts a detailed review of the salinity control program every three years to determine if the numeric criteria will be met as future development occurs in the Basin.

Section 303 of the Clean Water Act requires that water quality standards be reviewed at least once every three years beginning in 1972. The most recent report on the findings, "1990 Review, Water Quality Standards for Salinity, Colorado River System," was published by the Forum in May 1990. The report identified that the salinity concentrations in 1989 were below the adopted numeric criteria at Hoover, Parker, and Imperial Dams. It was concluded that there was no reason to believe that the numeric criteria would be exceeded in the next three-year review period. It was further concluded that because of the long lead time required to conduct salinity studies, complete feasibility reports, and authorize, implement, and achieve full impact at lower main stem stations, it is necessary to continue efforts to appropriate funding for the recommended plan of implementation for salinity control as set forth in the Review.

Basin States Cost-share

The Basin States reimburse the Federal government for 30 percent of the CRSC Program construction costs. Reimbursement is made annually based upon an annual report from ASCS which identifies the Federal assistance paid to participants upon installation of salinity reduction practices.

Reports and Meeting Participation

USDA provides annual reports to the Advisory Council and Forum. ASCS, Extension Service ES), and Soil Conservation Service (SCS) representatives participate in meetings and committee actions of the Advisory Council, Forum, and Forum Work Group. The Forum Work Group is the technical arm of the Forum and functions as a technical review team for the Advisory Council.

PROGRAM COORDINATION

Interdepartmental

Coordination between USDA and DOI relative to Pub. L. 93-320, the Colorado River Basin Salinity Control Act, was established by a November 1974 Departmental Memorandum of Understanding (MOU). This MOU was revised in August 1986 following the 1984 amendments to Pub. L. 93-320, (the Act).

A Memorandum of Agreement (MOA) between ASCS and SCS of USDA and Reclamation was initiated in 1974 and revised in August 1986 to be consistent with the CRSC program authorities for USDA. The MOA established a cooperative program for implementation of salinity control measures specified in the Act and provides for memorandum of agreements or interagency agreements with respect to performance of the Act. Specific functions and actions by ASCS, Reclamation, and SCS are listed in the MOA as well as designation of DOI and USDA liaison officers.

Departmental

CRSC program coordination is conducted by agency administrators of the ASCS, SCS, Agricultural Research Service, Cooperative State Research Service, and ES. USDA established a National Salinity Control Coordinating Committee (NSCCC) which has responsibility for performing the day-to-day coordination functions of the CRSC program and to perform responsibilities identified in the MOU with DOI. The NSCCC provides the mechanism for determining the administration and program management functions for the respective USDA agencies, makes recommendations on policy matters, funding levels, implementation priorities, and prepares salinity reports. Reclamation, EPA, and BLM are ex-officio members of the NSCCC. The Director of Land Treatment Program Division, SCS, is chairperson of the NSCCC. Local salinity coordinating committees coordinate agency and local entity functions at the field level in each of the salinity units.

To enhance coordination efforts between USDA agencies, Reclamation, and BLM, SCS established a CRSC coordinator position which is located with the Reclamation Salinity Coordinator in the Denver, Colorado, Reclamation office. The CRSC Coordinator also provides technical guidance and assistance to the USDA agencies in the Basin while coordinating basin-wide activities with the States. The CRSC Coordinator has been successful in resolving day-to-day technical and program coordination issues with Reclamation and BLM.

AGENCY RESPONSIBILITIES

Agricultural Stabilization and Conservation Service (ASCS)

ASCS provides overall administration of the CRSC program within USDA through ASCS county offices in each unit. ASCS is responsible for annually recommending and preparing agency estimates of proposed funding levels for each unit and provides cost-share funds through the State Agricultural Stabilization and Conservation (ASC) committees. The county ASC committees review and approve all requests for cost-share assistance. Additionally, ASCS is responsible for controlling funds, issuing cost-share payments, maintaining farm records, developing statistical reports, and ensuring that the program is coordinated with the other ASCS conservation and farm programs.

Soil Conservation Service (SCS)

The SCS, in cooperation with local Conservation Districts, is responsible for the USDA CRSC program planning and technical assistance functions. In this role, SCS conducts investigations of salt contributing agricultural areas and prepares plans and environmental reports for the areas selected for implementation. SCS assists applicants in the approved salinity control units to prepare salinity control plans which become a part of the salinity control contract. Technical assistance is provided to each participant for the design, installation, and operation and maintenance of the salinity reduction practices and systems with emphasis on irrigation water management. This includes assistance in planning, application, and maintenance of wildlife habitat practices. In addition, SCS is responsible for monitoring and evaluating the technical aspects of the USDA salinity control program.

Extension Service (ES)

Extension Service, in cooperation with the State Universities and local Counties, develops and coordinates information and educational programs for the Colorado River Salinity Control Program. In this role field demonstration projects are set up and special conferences, public field days and meetings are held. Assistance is provided with monitoring and evaluation activities and special studies are made. Local information programs are carried out to provide participants with information on program participation procedures and implementation methods and techniques.

Agency Responsibilities, *Continued*

Bureau of Reclamation (Reclamation)

Reclamation, acting for the Secretary of the Interior, provides leadership for interagency coordination, salinity investigations, and analysis of needs and accomplishments. In this role, Reclamation enters into formal and informal agreements with other agencies and works closely with the Colorado River Basin Salinity Control Forum. Reclamation also provides a lead role in activities of the Federal Interagency Salinity Control Coordinating Committees.

Reclamation conducts studies, prepares salinity control plans and implements the salinity control units authorized for construction. Presently, Reclamation has a number of salinity control units under construction which range from lining irrigation canals and laterals, to deep well injection for disposal of natural brines which enter the river system. Reclamation's salinity control program does not include onfarm construction activities. Both Reclamation and USDA have authority to improve lateral systems. The salinity control plan for each unit identifies the specific agency responsibility for lateral improvements.

Other Agencies

Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (FWS), U.S. Geological Survey (USGS), and State wildlife agencies are other CRSC program cooperating agencies. EPA analyzes water quality standards, numeric criteria, and environmental effects. EPA reviews environmental documents and the impacts of implementation of the USDA salinity control program on the environment.

FWS provides support during planning on technical issues such as relative impacts on fisheries, wetlands, and other wildlife habitat, and reviews the impacts of implementation on wetlands and habitat values.

State wildlife agencies coordinate implementation of wildlife habitat practices which involve State lands or State regulations and assist with implementation.

USGS monitors Colorado River salinity concentrations and provides information in published reports and conducts special investigations to identify sources of salt loading.

MONITORING AND EVALUATION

Background

The Act requires the Secretary of Agriculture to "provide continuing technical assistance for irrigation water management as well as monitoring and evaluation (M&E) of changes in salt contribution to the Colorado River to determine program effectiveness." Responsibilities for monitoring and evaluating USDA salinity control program activities are assigned to SCS.

M&E is an integral part of the technical assistance provided to salinity program participants. During implementation of the CRSC program, SCS monitors and evaluates the practices and management systems that participants have applied to determine whether the planned objectives are being achieved. These M&E actions also identify if participants need additional technical assistance to achieve the desired salinity program effects.

Further, SCS is responsible for verifying salt load reduction, determining whether farmers and landowners receive sufficient onfarm benefits to offset the onfarm costs and whether the program is achieving the planned level of voluntary replacement of wildlife habitat.

In addition to SCS responsibilities, various Federal, State, and local agencies are involved in on-going M&E in the Colorado River Basin and provide data and interpretations on salinity conditions. The major thrust of their monitoring actions is to determine in-stream water quality, including salinity concentrations. Data are evaluated to determine the causes of salt loading, future salinity level projections, and areas needing control.

The major objectives of the M&E actions are to evaluate the effectiveness of salinity reduction practices and quantify salt load reduction; evaluate and quantify the environmental effects on fish and wildlife values; and, measure the onfarm economic aspects of implementing irrigation water management and systems.

M&E actions in each salinity control unit are set forth in an M&E plan developed for that unit and a Salinity Control framework plan provides guidance for all USDA M&E activities.

USDA M&E Strategy for Estimating Salt Load Reduction

Salt load reductions result from improved efficiency of irrigation water delivery systems and irrigation water management on individual fields by the application of salinity reduction practices. The USDA strategy in monitoring the changes in salt load reduction involves the monitoring and evaluation of specific irrigation parameters. The information obtained is then translated into estimated salt load reduction.

Research by Agricultural Research Service and other entities has proven that deep percolation and seepage of irrigation water through soils overlying salt laden geologic formations results in salt loading to the Colorado River system. Research has also proven that surface irrigation return flows do not contribute significant amounts of salt. Because of these findings, the USDA M&E strategy is to estimate deep percolation and seepage reductions from irrigation improvements and translate these into salt load reductions. The amount of salt loading per acre foot of water is determined from site specific studies of the irrigation drains, soils and geologic formations in each of the salinity units.

Seepage losses from ditches can be measured and correlated with the predominate soils in the area. Because of this, estimating the amount of seepage and salt load reductions that are achieved by lining and piping earthen ditches is relatively straight forward. However, the amount of deep percolation that takes place from irrigating crops cannot be directly measured under field conditions. Therefore, the M&E strategy is to estimate the reduction in deep percolation and salt loading by using a water and salt budget prepared by accurately measuring all of the parameters that are physically possible to record. These parameters are: amount of irrigation water applied to a defined field, the amount of surface runoff from the field, local weather data to compute the moisture used by the crop, and soil moisture. The amount of deep percolation and salt loading is computed from an analysis of these known parameters. By comparing the results from fields with applied salinity reduction practices to those without treatment, reasonable estimates can be derived.

SALINITY UNIT SUMMARIES

Implementation is underway in six USDA salinity units, these are: Grand Valley, Lower Gunnison Basin, McElmo Creek, Uinta Basin, Big Sandy River and Moapa Valley. A brief report on each unit is provided in this section.

Grand Valley Unit, Colorado

The Grand Valley salinity unit lies along the Colorado River in western Colorado in Mesa County. The program is administered from the USDA service center in Grand Junction.

The USDA plan was published in December 1977 and amended in 1980.

This unit encompasses 65,000 acres of irrigated land of which approximately 53,000 acres are scheduled for treatment. The focus of the salinity program in this area is to assist farmers to improve surface irrigation systems by lining and placing earthen irrigation ditches in pipelines, installing surge systems and leveling the land. Also drip and other specialized systems are being installed on orchards and vineyards. The major emphasis in this unit is on irrigation water management. The proper timing and application of irrigation water in accordance with the crop needs greatly reduces deep percolation and salt loading.

Implementation was initiated in 1979 under existing USDA authorities. Since 1987, implementation has been under the authorities of the CRSC program. The goal is to reduce salt loading by 163,000 tons. Through September 30, 1992, 3,264 ACP/long term agreements and CRSC contracts have been approved and 180 applications are pending approval. A salt load reduction of 56,653 tons has been accomplished.

It is estimated in the plan that the average cost per ton of salt reduction would be approximately $27 per ton. Studies to date indicate that costs in this range are being achieved.

The voluntary wildlife habitat replacement program is based upon a goal to develop or improve 1,200 acres of wildlife habitat. Progress toward achieving this goal had been limited, with approximately 150 acres accomplished through September 30, 1992. The rate of planning and application has improved considerably since the CRSC program has been authorized.

Close cooperation is underway with the Bureau of Reclamation off-farm salinity control program in this same unit. Because many of the major laterals are being improved by Reclamation, a close interagency working relationship is being maintained to assure that the off-farm and onfarm programs are constructed in the most cost-effective manner. A successful cooperative onfarm surge irrigation

demonstration program is underway with Reclamation. The benefits of this effort are being closely monitored.

A comprehensive monitoring program has been underway in this unit since 1984 to determine the effects of the salinity control program. This effort is providing valuable information that is being used to guide the onfarm program.

Publication of the USDA Colorado salinity newsletter, *The Waterline,* is coordinated by Cooperative Extension staff in this unit. A strong information and education and demonstration program is underway to support farmers as they convert to surge, drip and other specialized irrigation systems.

This was the first unit for USDA to initiate implementation of onfarm activities to reduce salt loading to the Colorado River. There are many small farms in this area and the treatment needs are very complex. This unit has been in the fore-front in applying research developments to field applications, especially in the use of the most recent technology for surface irrigation systems. Steady progress is being made in this unit in achieving salinity reduction goals.

Lower Gunnison Basin Unit, Colorado

The Lower Gunnison Basin salinity unit is located in western Colorado in Delta and Montrose counties. The land to be treated is located in the Uncompahgre and Gunnison River Valleys. The salinity control program is administered from the USDA service centers which are located in the towns of Delta and Montrose, Colorado.

The USDA salinity control plan was prepared in 1981 and environmental statement was published in 1982. This is the largest of the USDA salinity units encompassing 171,000 acres of irrigated land.

Salinity control measures in this unit focus on improving surface irrigation systems by land leveling, lining or placing earthen laterals and onfarm ditches in pipelines and installing surge irrigation systems. Micro-jet and other specially designed irrigation systems are being installed on orchards, vineyards and vegetable crops.

This unit was divided into 4 sub-areas for management purposes with implementation initiated in 1988 in the Lower Gunnison #1 sub-area (Tongue Creek) which is the highest priority area. Implementation has been phased into the other sub-areas with the program now underway in all of the Lower Gunnison Basin. The salt load reduction goal for this unit is 280,500 tons per year. Through September 30, 1992, the program has achieved a salt reduction of 25,061 tons.

Through September 30, 1992, 149 salinity control contracts have been approved and 457 applications are pending approval.

The estimated average cost per ton of salt reduction in this unit is approximately $70 per ton. Currently, only those contracts with a salt reduction cost of less than $60 per ton are being approved.

The Bureau of Reclamation is assisting with a surge irrigation demonstration program to accelerate the adoption and use of surge irrigation systems. Under this program, the salinity control benefits of these systems are being closely monitored. The Colorado Division of Wildlife is cooperating with wildlife habitat replacement efforts. Voluntary replacement of habitat values foregone in the unit is ahead of schedule.

Under the information and education program, many field demonstrations are underway and special inserts on the USDA salinity control program have been released in the local newspapers. A monthly newsletter called, *The Waterline,* is published jointly by the Colorado Cooperative Extension offices and is distributed to the public in each of the salinity units.

Cooperative efforts in this large unit by the local entities and Federal agencies through the Local Salinity Coordinating Committee are satisfactory.

McElmo Creek Unit, Colorado

The McElmo Creek Unit is located in southwest corner of Colorado in Montezuma County. This salinity unit lies within the McElmo Creek watershed which drains into the San Juan River. The salinity control program is administered from the USDA service center in Cortez, Colorado.

The USDA salinity plan and the environmental impact statement were published in August 1989. This unit encompasses 29,100 acres of irrigated land, of which 21,500 acres are scheduled to be treated. The focus of the salinity control program in this unit is to assist farmers with converting inefficient surface irrigation to side-roll sprinkler systems. A small acreage of surface irrigation systems will also be improved.

Implementation of the CRSC program was initiated in 1990. The goal is to reduce salt loading from the area by 38,000 tons of salt. Through September 30, 1992 there were 91 contracts approved and 336 applications pending approval. A reduction of 3,561 tons of salt has been accomplished.

It was estimated that the cost of salt reduction would be about $83 per ton. Early estimates indicate that costs range from $26 to $70 per ton.

The goal is to replace wildlife habitat values foregone during implementation. Through September 30, 1992, 57 percent of the contracts contain wildlife habitat practices with installation progressing at a steady pace.

The USDA salinity control program is being closely coordinated with the Bureau of Reclamation off-farm salinity control program in this unit. Pipeline laterals are presently being installed which will provide gravity pressure for over 50 percent of the irrigated land that will be treated.

In this unit most of the water users are limited resource farmers, and there are a number of minority farmers. The program is having a positive impact on these individuals by assisting them with installation of salinity reduction practices and irrigation water management.

The information, education and demonstration program is providing strong support to farmers as they convert to sprinkler systems. Special needs for flow/pressure meters and automatic shut-off valves are being addressed.

Although the salinity control program has been underway in this area for only a short time, the support of the local farmers and cooperation by the various agencies has been very good resulting in excellent progress.

Uinta Basin Unit, Utah

The Uinta Basin unit is located in northeastern Utah in Duchesne and Uintah Counties. The area to be treated lies within the Ashley Creek, Brush Creek and Duchesne River watersheds which flow into the Green River. The salinity control program is administered from the USDA service centers in the towns of Roosevelt and Vernal, Utah.

The USDA salinity control plan was prepared in 1979, and amended in 1987. The EIS was published in 1982. The Uinta Basin Unit Expansion Plan/EIS was published in 1991.

This unit encompasses 221,300 acres of irrigated land of which 137,00 acres are scheduled to be treated. In this area, the salinity control program focuses on assisting farmers convert inefficient flood irrigation systems to sprinklers and replacing earthen laterals and onfarm ditches with pipelines. A high priority is given to working with groups of farmers to replace inefficient earthen laterals with pipelines to develop gravity pressure for onfarm sprinkler systems. Improvements are also being made on a limited number of surface irrigation systems.

Implementation began in 1980 under existing USDA authorities. Since 1987, implementation has been under the authorities of the CRSC program. The goal is to reduce salt loading by 106,800 tons. Through September 30, 1992, a salt reduction of 55, 485 tons has been achieved. Approximately 1,370 annual ACP/long-term agreements and CRSC salinity control contracts have been approved and 138 applications are pending approval.

It was estimated in the Uinta Basin salinity plan that the cost per ton of salt reduction would be approximately $80 per ton. The average cost of salt reduction to date is about $61 per ton.

Voluntary replacement of wildlife habitat values by participants has been good, with over 300 acres of wildlife habitat and wetlands developed. Also 10,500 acres are being managed for wildlife.

Close cooperation among agencies, through the Local Salinity Control Coordinating Committee, has been instrumental to successful implementation. This has been necesary in working with groups, emphasizing wildlife habitat and implementation on Ute Tribal lands. Approximately 30,000 acres of irrigated land within the Uinta Basin unit are controlled by the Ute Tribe.

A demonstration area is being established on Ute Tribal land to be used as a training facility. The emphasis is on irrigation water management, improved farming techniques, selection of crop varieties and addressing fertility needs.

Excellent progress is being made towards achieving the salinity reduction goals. Farmers are rapidly adopting the salinity reduction practices and irrigation water management techniques.

Big Sandy River Unit, Wyoming

The Big Sandy River salinity unit is located north of Rock Springs, Wyoming in Sweetwater County. This salinity unit lies along the Big Sandy River which flows into the Green River. The salinity control program is administered from the USDA service center which is located in Farson, Wyoming.

The USDA EIS was published in September 1987 and the final salinity control plan, which incorporated considerations in the EIS was released in February 1988.

This unit encompasses 18,700 acres of irrigated land of which 15,700 acres are scheduled to be treated. The salinity control program focuses on assisting farmers to convert inefficient surface irrigation systems to low pressure sprinklers. Surface irrigation improvements will be applied to a small portion of the area.

Implementation of the CRSC program was initiated in 1988. The goal is to reduce salt loading by 52,900 tons per year. Forty seven salinity control contracts have been approved and 19 applications are pending approval. Participants have installed 35 sprinkler systems and made improvements on 3 surface systems. Through September 30, 1992, a salt load reduction of 12,557 tons has been achieved.

It was estimated that the cost of salt reduction would be $27 per ton. The average cost per ton of salt reduction for the practices installed is in this range.

The voluntary replacement of wildlife habitat values is being determined by the Habitat Evaluation Procedure (HEP). A full time wildlife biologist is located in the service center to assist with implementation and tracking of the wildlife habitat replacement program.

FWS is assisting with wildlife habitat improvements. Various State agencies are supporting efforts to upgrade the electrical power distribution system in order to provide critically needed three phase power for sprinkler system pumps.

Implementation in this unit is progressing at a rapid rate. Farmers are rapidly applying the needed salinity reduction practices and achieving significant improvements in irrigation efficiencies and salt load reductions.

Moapa Valley Unit, Nevada

The Moapa Valley salinity unit is located about 60 miles northeast of Las Vegas Nevada in Clark County. This salinity unit lies along the Muddy River which flows into Lake Mead.

The final salinity control plan/EIS was issued in January 1993 and the Record of Decision was published February 26, 1993.

This unit encompasses 19,500 acres of irrigated land in the Moapa Valley. The salinity control plan includes installation of salinity reduction practices on individual farms and replacement of the main irrigation water distribution system.

The first phase of implementation will be initiated in 1993 with construction of the beginning segments of the irrigation water distribution system. The goal is to reduce salt loading by 18,700 tons per year.

It is estimated that the cost of salt reduction will be about $38 per ton.

Replacement of the wildlife habitat values will be accomplished by voluntary actions by farmers. It is also anticipated that wildlife habitat improvements will be installed on the Overton Wildlife Management Area which is located within the boundaries of the salinity unit.

Implementation is expected to proceed in this unit as rapidly as cost-share funds will allow.

Colorado River Salinity Control Program Accomplishments
Cumulative from Inception through FY 1992

Activity	Uinta Basin Unit, Utah	Grand Valley Unit, Colorado	McElmo Creek Unit, Colorado	Lower Gunnison Unit, Colorado	Big Sandy River Unit, Wyoming	Grand Total
Contract Status						
Approved (no.)	1,370	3,264	91	149	47	4,921
Completed (no.)	912	1,836	0	8	34	2,790
Terminated (no.)	156	966	3	15	2	1,142
Pending Approvals						
Applications Pending Approval (no.)	138	180	336	457	19	1,130
Land Treatment						
Onfarm Pipeline (feet)	2,719,710	1,870,204 *	105,925	257,051 *	74,310	5,027,200
Off-farm Pipeline (feet)	479,091	379,180 *	46,993	52,327 *	0	957,591
Sprinkler Systems (systems, acres	1,040 67,399	38 619	49 949	6 172	35 3,207	1,168 72,346
Surface Systems (systems, acres)	221 13,050	1,308 19,087	18 189	43 403	3 56	1,593 32,785
Land Leveling (acres)	2,239	4,505	0	706	0	7,450
Irrigation Water Management (acres)	59,032	10,555	1,385	11,805	3,196	85,973
Land Treatment Results						
Deep Percolation Reduction (ac./ft./yr.)	44,449	14,788	838	1,291	8,302	69,668
Salt Load Reduction (tons/yr)	55,485	56,653	3,561	25,061	12,557	153,317

* Includes concrete ditch lining.

APPENDIX OF TECHNICAL DATA AND FINDINGS

Grand Valley Unit, Colorado

Lower Gunnison Basin Unit, Colorado

McElmo Creek Unit, Colorado

Uinta Basin Unit, Utah

Big Sandy River Unit, Wyoming

GRAND VALLEY UNIT, COLORADO

The Grand Valley M&E activities began in 1984. Efforts are focused on monitoring and evaluating the effects of furrow irrigation systems, although several sprinkler and drip systems are also being monitored. An average of 19 irrigation sites have been monitored each year representing eight different irrigation systems, seven different soil types, and six different crops. Crops monitored include corn, alfalfa, small grains, beans, grapes and orchards.

All irrigation events, including pre-season irrigation, are monitored at each site to collect accurate data. In 1991, this required the monitoring of 166 irrigation events during the irrigation season. In the Grand Valley over 1,050 irrigation events have been monitored which provides an excellent data base for analysis.

Monitoring indicates that where salinity reduction practices have been installed, deep percolation has been reduced substantially and an average seasonal irrigation application efficiency of over 43 percent is being achieved. On some fields the use of surge valves has increased efficiencies up to 65 percent. This monitoring confirms that the CRSC program is accomplishing salt load reduction.

Findings indicate that surge irrigation systems contribute 20 to 50 percent less deep percolation than conventionally operated gated pipe surface irrigation systems. This is because about 50 percent of the deep percolation occurs during the first two irrigations and the proper use of surge systems reduces this deep percolation substantially. By applying liquid fertilizer through surge valves there is less deep percolation of nitrate nitrogen. Under the Grand Valley Surge irrigation demonstration project funded by Reclamation, 77 surge systems were installed by farmers in the first two years with assistance from the Cooperative Extension Service and SCS.

As of December 1991, approximately 858 acres of wildlife habitat replacement has been planned and 143 acres applied. The most common practices applied were ponds, shallow water wetlands, grass and legume plantings, and fencing for livestock control. The goal set forth in the environmental impact statement for the Grand Valley Unit is to develop or improve the value of existing habitat on 1,200 acres.

The results of an analysis of various fields with different irrigation systems are shown in Table 1. These fields were selected because they represent the major types of irrigation systems in use in the Grand Valley Unit.

The information recorded on Figure 2 and in Table 1 indicates the salt reduction capabilities of the various systems as compared to an earthen ditch with feeder ditches. These data are the average of five end of the year irrigation event summaries.

Gross water application is reduced as the systems become more sophisticated, reducing seepage and outflow. The application of Salinity Reduction Practices (SRP's) on the field, including irrigation water management, reduces deep percolation. Estimates indicate up to 50 percent reduction under graded furrow systems and virtual elimination under sprinkler and drip systems.

Information required to do a cost-effectiveness comparison is shown in Table 1. A 10-acre field size was judgmentally selected. Larger fields should reduce the cost per acre of the installations and smaller fields should increase the installation per-acre cost because the fixed installation cost would be allocated accordingly. An inlet/outlet structure sized to flow 1.5 cubic feet per second (cfs) which includes a standpipe, turnout, divide box, trash screen, weir, and gauge was used in each instance.

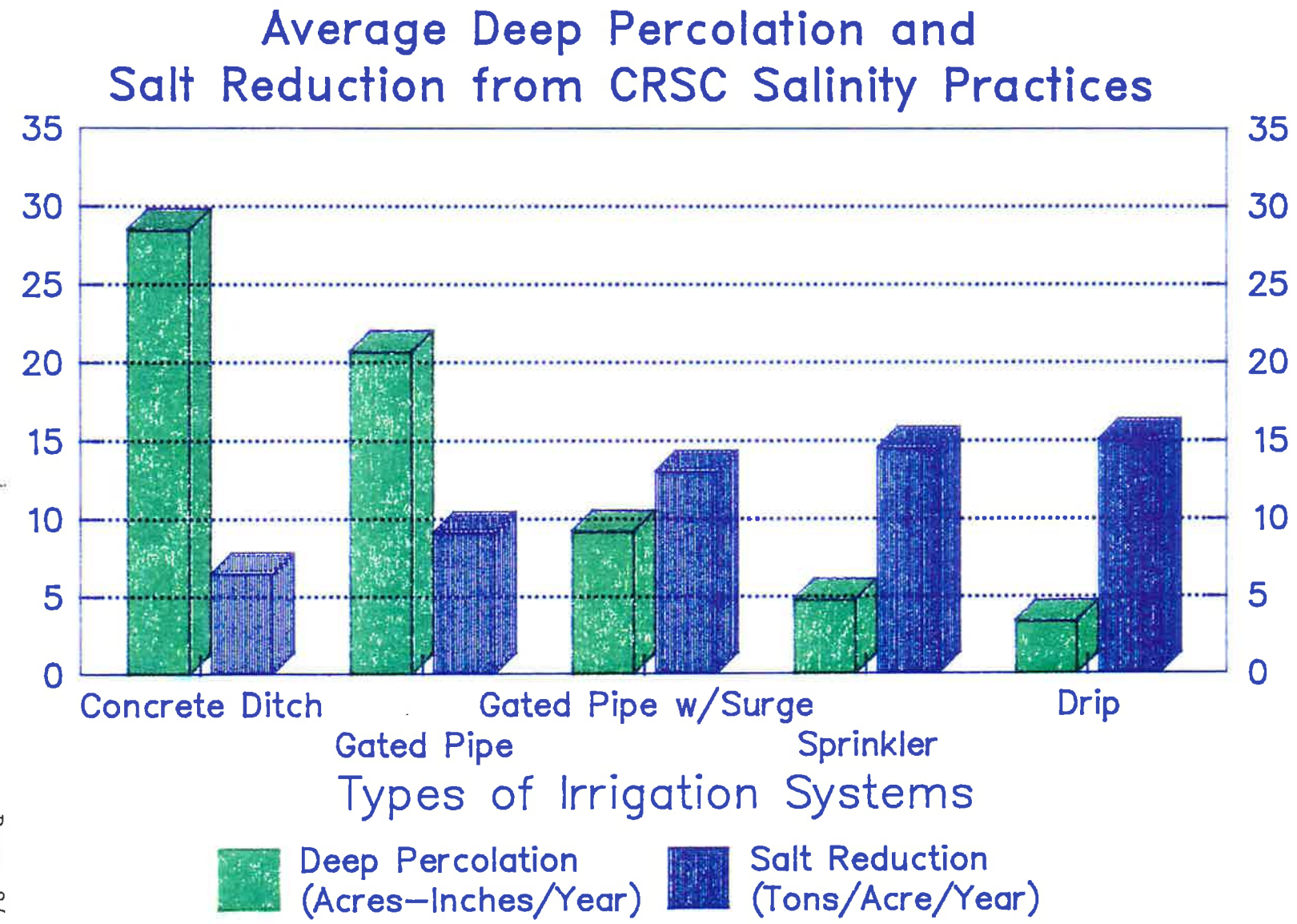
All equipment costs were taken from the current cost docket and reflect all but minor incidental costs associated with the installation of the systems. The exception is land leveling costs which may or may not be associated with the graded furrow systems and gate socks which are necessary for erosion reduction on some soils.

The 1.5 cfs delivered to the fields provides about 10 gallons per minute per furrow to the surface systems. Side roll sprinklers used in the Grand Valley at the lower end of the Government Highline Canal pipe laterals do not require an inlet structure and pumping plant because the closed laterals deliver water under adequate pressure.

Side roll sprinklers would be more widely used except that some of the soils in the valley crust when irrigation water is applied by sprinkler which inhibits emergence of small seeded crops and side roll sprinklers are not high enough to clear tall corn crops in mid and late season. As each system is compared to the earthen ditch with feeder ditch system the amount of salt loading decreases with the increasing cost of the system until the approximate 14 tons per acre range is reached.

Figure 2 reflects the salt savings as a function of systems improvements. While the drip system is the most expensive in terms of cost per ton of salt saved, the farmers' cost of installation is also more than other systems. In general, the use of this system is limited to vineyards and areas of soils with high intake rates that may be on sloping topography.

Figure 2


Average Deep Percolation and
Salt Reduction from CRSC Salinity Practices
35
30
25
20
15
10
5
0
Concrete Ditch
Gated Pipe
Gated Pipe w/Surge
Sprinkler
Drip
Types of Irrigation Systems
Deep Percolation
(Acres–Inches/Year)
Salt Reduction
(Tons/Acre/Year)

Another benefit of the drip or micro-jet system that has not been quantified is the the reduced soil erosion that accompanies these systems. Cost effectiveness of salt reduction by the use of improved irrigation systems is calcultated as indicated in table 1.

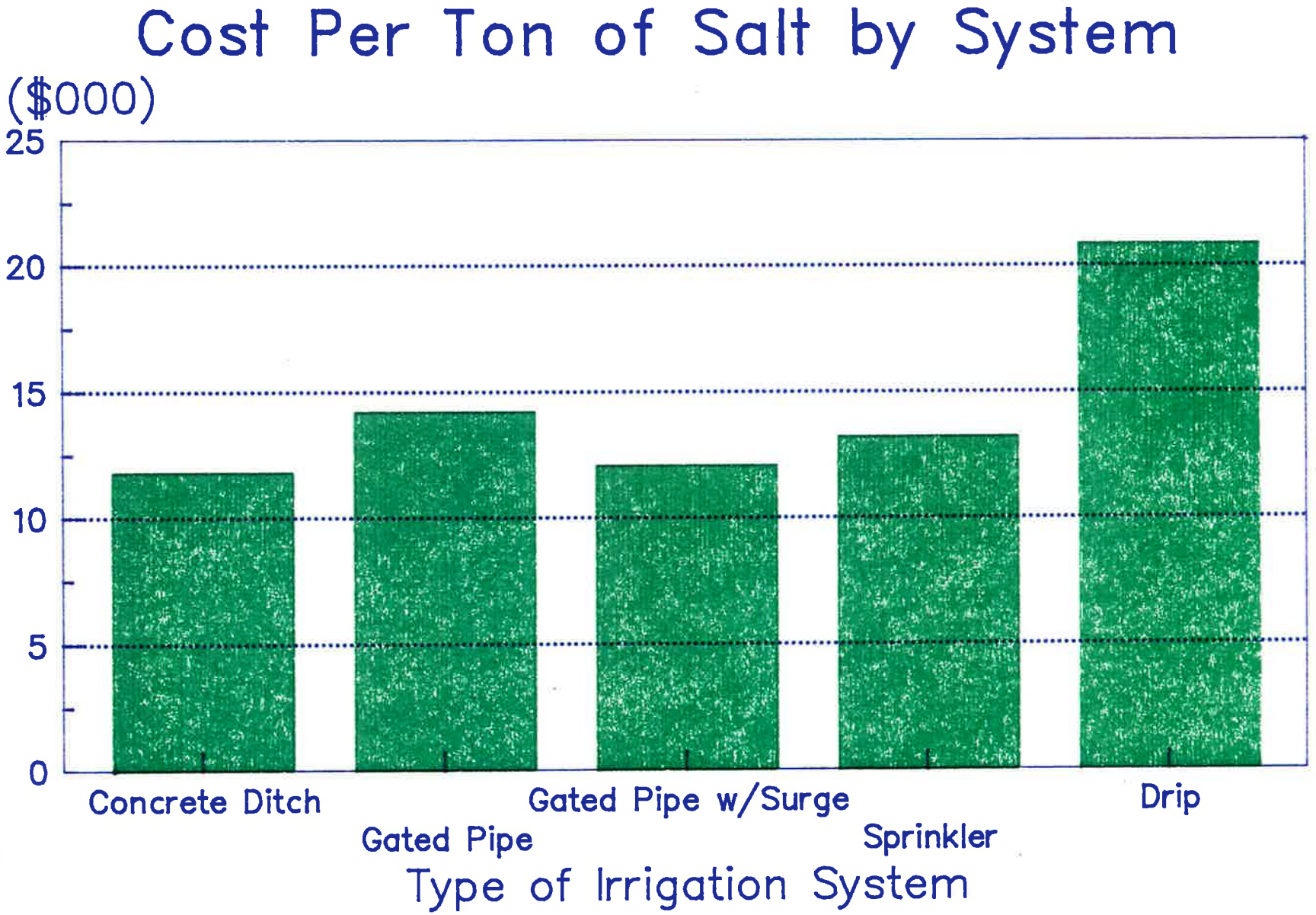
Table 1. Cost Effectiveness of Improved Irrigation Systems

System	Concrete Ditch	Gated Pipe	Gated Pipe w/ Surge	Sprinkler	Drip
Total Cost to Install	$7,554.00	$11,095.00	$13,454.00	$11,270.00	$20,335.00
Useful Life, years	20	15	15	15	10
Annual Equivalent 8 percent	$ 769.00	$ 1,296.00	$ 1,572.00	$ 1,317.00	$ 3,131.00
Annual O & M	$ 76.00	$ 111.00	$ 135.00	$ 113.00	$ 203.00
Total Annual	$ 845.00	$ 1,407.00	$ 1,707.00	$ 1,430.00	$ 3,334.00
Salt Reduction = tons per 10 acres	65	91	130	145	150
Annual cost per ton	$ 11.83	$ 14.24	$ 12.09	$ 13.23	$ 20.87

Operating and maintenance costs above are based on 1 percent of new cost. No power costs are used for sprinkler or drip systems. The system cost per ton of salt is illustrated in Figure 3.

The cost of $11.83 per ton for the concrete ditch system indicates a greater return on the investment than the other types of improved irrigation system. Part of the reason for this cost is the 20 year life expectancy of the concrete ditch and comparatively low installation cost. However, compared to the other identified improved irrigation systems, concrete ditches are subject to solar heating during the winter months when the ground is frozen. Ditches with north-south orientation heat relatively uniformly during the day but those with east-west orientation are subject to differential heating as the north wall is in the sun and the south wall is shaded. This differential expansion causes cracks which require annual maintenance to prevent leaking.

Figure 3


Cost Per Ton of Salt by System
($000)
25
20
15
10
5
0
Concrete Ditch
Gated Pipe
Gated Pipe w/Surge
Sprinkler
Drip
Type of Irrigation System

Grand Valley Unit, Colorado, *Continued*

The underground portion of the gated pipe and gated pipe with surge systems is approximately 25 percent of the system cost. This underground part of the system is budgeted with a 15-year life span although the life expectancy of PVC pipe is expected to be considerably longer than 15 years.

The addition of the surge unit to gated pipe enhances the farmer's ability to manage the irrigation water; this reduces deep percolation and improves the cost-effectiveness. Another benefit is that less nitrogen fertilizer will be lost to deep percolation if applied during one of the cutback cycles of surge irrigation.

Drip and micro-jet irrigation appears to be less cost effective than graded furrow systems. This is dependent on the amount of earth work necessary to prepare the land for effective irrigation water management. Some fields that are shallow to shale or gravel cannot be effectively leveled for graded furrow irrigation, yet are productive when water is applied by drip and micro-jet systems.

Leveling is required on some fields to achieve optimum irrigation water management. If land leveling is required at a cost of $1,000 per acre on a concrete ditch system, the cost becomes $27.81 per ton instead of $11.83 per ton.

Irrigation Water Management (IWM) is a requirement in all contracts. For effective IWM to occur, it is necessary, on many fields, to do land leveling as part of the contract. Land leveling increases the cost of the contract but makes possible the maximum salt savings.

Deep percolation may be eliminated by using a sprinkler or micro-jet system, while a 50-percent reduction may be all that is possible with a graded furrow system under practical salinity management practices.

While most farmers are willing to prevent deep percolation to minimize salt loading downstream, they may not be willing to provide extra time or cash outlay for this. For instance, if the set time for a siphon tube system requires that a manual water change on a 20 hour interval and that interval occurs in early morning then the change may actually occur somewhat later diminishing the efficiency. If this change can be automated with a sprinkler or drip system, then increased water management will be accomplished.

An additional local benefit would be the multiplier effect of Federal cost-share assistance on the local economy. These are, multiplier effects of 2.72 for irrigated agriculture, 2.65 for trades, and 2.45 for services, as business multipliers for the Colorado economy. All of the business multipliers are involved with the irrigation system improvements made possible by the CRSCP.

The summary, shown in the table below, lists criteria used to evaluate the systems.

Table 2. Criteria Used to Evaluate Irrigation Systems

System	Concrete Ditch	Gated Pipe	Gated Pipe with Surge	Sprinkler	Drip
Cost[a]	$7554[1]	11095[1]	13454[1]	11270	20335
Salt[b] Reduction	6.5	9.1	13.0	14.5	15.0
Deep[c] Percolation	28.5	20.7	9.2	4.8	3.4
Deep Perc.[c] w/SRP	14[2]	10[2]	2.5[2]	0[2]	0[2]
Annual cost[d] per ton	$11.83	$14.24	$12.09	$13.23	$20.87
Limitations	3,4,5	3,4,5	3,4	6	7

a. Cost per 10 acre unit.
b. Tons of salt per acre.
c. Acre inches per acre.
d. Dollars per ton of salt.

1. Additional site specific land leveling costs may be necessary.
2. Leaching requirements may be up to 10% of inflow.
3. High intake rate soils.
4. Topography.
5. Deep percolation.
6. Tall crops.
7. Cost of system.

Efficient systems will enable the farmer to substantially reduce deep percolation which cuts down on the salt loading. The largest contribution to salt loading is deep percolation which occurs as a result of inefficient irrigation management. The effectiveness of salinity reduction will be reduced if the appropriate irrigation systems are not applied and if the tools and training to accomplish irrigation water management are not provided.

The Lower Gunnison Basin Unit is divided into 4 subareas for management purposes. Monitoring and evaluation data are being collected from 4 weather stations and 5 irrigated fields. Wildlife habitat is also monitored to determine the impacts of implementation and to track habitat values being replaced under the CRSC program. Wildlife cover is typed and analyzed through the Habitat Evaluation Procedure (HEP) process on each farm unit. HEP is a species-habitat approach developed by FWS to access impacts on wildlife habitat and determine habitat replacement needs.

The cost per ton of salt saved per year is the criterion used to determine which contracts are funded rather than the convenience of the system. Currently, contracts are being approved which fall below the line of $60 per ton of salt saved. Farmers have to compete on the basis of dollar per ton of salt saved, and those with the systems at lower cost per ton of salt saved receive primary consideration. If the farmer wants to install a system which exceeds the current value used, then he is liable for the additional cost of the system provided the system is technically feasible and jointly approved by SCS and the farmer.

The farmer is offered alternatives which provide estimated total cost, cost-share dollars, and dollar per ton of salt saved per year. If the alternative chosen is over $60 per ton of salt saved per year, then the farmer is informed that the salinity control plan will be written and submitted for consideration; however, the likelihood of approval will be diminished based on the excessive cost.

The system to be adopted and built on a farm depends on physical location of the farm; crops to be grown such as hay pasture, row crops, or orchard; and operating cost and farmer's personal financial ability to assume costs of operation. All these factors will lend to the variability of cost per system or practice.

Lower Gunnison Unit, Colorado, *Continued*

The findings in this section were obtained from an analysis of information collected in the Lower Gunnison #2 Unit in Montrose County. Listed below are the major practices used in Lower Gunnison #2 area to reduce salinity along with the cost-effectiveness comparisons.

A. PIPELINE: Irrigation Water Conveyance System

Example 1

OnFarm Salinity Practice	Feet	Acres Served	Cost Per Ton of Salt
8" Gated Pipe	2,760	34.0	$2.95
8" Underground Pipeline	1,360	75.0	$8.28

A. DITCH LINING: Irrigation Water Conveyance System

Example 2

OnFarm Salinity Practice	Feet	Acres Served	Cost Per Ton of Salt
20" Concrete Lined Ditch	16,973	417.2	$12.76

Irrigation Water Management (IWM) and land preparation for irrigation are critical components that have a major influence on the potential salinity reduction opportunities. These components are not recognized in the above data or calculations.

With proper IWM and the use of a surge irrigation system, farmers have been able to reduce deep percolation substantially. Therefore, salinity reduction can be accomplished through proper IWM under surge systems and proper water management on conventional irrigation settings via corrugates and furrows so as to reduce deep percolation.

Surge irrigation water management demonstrations implemented in the Grand Valley in 1990 and 1991 document that deep percolation was reduced substantially on most trials. Similar results can be expected in the Lower Gunnison Basin.

The average cost for salinity reduction has been approximately

Lower Gunnison Basin, Colorado, *Continued*

$60.00 per ton. This estimate is subject to many variables, such as types of soils, depth to salt laden shale, IWM practices, and the integrity of the overall irrigation delivery system.

Agriculture producers can best understand their irrigation systems when IWM is monitored on their farms. Such monitoring provides them with actual facts for each irrigation and the guidelines on how to control deep percolation losses and irrigation water runoff.

McELMO CREEK UNIT, COLORADO

The M&E program was initiated in 1990. During the 1991 irrigation season, monitoring equipment was established on five irrigated fields and two weather stations were installed.

The goal for the McElmo Creek Unit is to reduce the annual salt load to the Colorado River by 38,000 tons. The goal will be accomplished by converting 235 miles of open delivery ditches to off-farm pipelines, by removing and/or replacing onfarm ditches with pipe on 21,550 acres, by converting 19,700 acres of surface irrigation to sprinklers and by improving 1,850 acres of surface irrigation. The expected salt reduction from off-farm pipelines, onfarm pipelines, and improved irrigation methods is 9,000 tons, 13,000 tons, and 16,000 tons, respectively.

Irrigation water management for sprinkler systems is being enhanced by crop water use reports from an automated weather station and by portable flow/pressure meters, automatic shut-off valves, and information from sprinkler-can tests.

Planning and application of habitat replacement practices is underway. Each plan includes cover type mapping, habitat data collection, and Habitat Suitability Unit evaluations as required by the Habitat Evaluation Procedure. About 8 percent of the funds used for implementation are being used for wildlife practices. Presently, replacement and enhancement are keeping pace with upland and wetland losses.

The trend in McElmo Creek unit is toward side-roll sprinkler systems which is different from other salinity units which focus on surface irrigation or center-pivot sprinklers. The reasons for this trend relate to the physical features of the Montezuma Valley where McElmo Creek is located. The Montezuma Valley has steep slopes and undulating terrain. Field size is small and irregular because of stony mesa tops and cross-cutting ravines and canyons. The soils have slow water intake rates (0.3 to 0.5 inches per hour) and are erodible. Traditional surface irrigation systems consist of earthen head ditches and lead ditches that direct water into shallow furrows. Head ditches often run along ridge tops and cannot be located square with the edge of a field. The shallow furrows that run in many directions within a field are of varying lengths and slopes and are relatively short at 600 feet to 900 feet. This type of topography limits surface irrigation improvements.

Conversely, side-roll sprinklers can operate over this varied terrain and often small fields can be combined and squared into one larger field. Center-pivots can operate over undulating terrain; however, it is difficult to make a large circular field in the Montezuma Valley. Also, center-pivots have high application rates which create runoff on sloping fields with low intake rate soils. Runoff causes insufficient water to be stored in the soil, erodes the soil, and mires pivots in low areas. Side-roll sprinklers have application rates that match the soil intake rates.

Therefore, irrigators generally opt for side-roll sprinklers. To a lesser extent, gated pipe is used on small fields and on fields where the water supply pipeline will not produce enough gravity pressure to operate sprinklers.

Side-roll sprinkler irrigation, however, is more efficient regarding the effective use of water than gated pipe and salt-load reduction is expected to be greater with side-roll systems. The estimated irrigation system efficiencies are: 40 percent for existing corrugate systems, 55 percent for gated pipe systems, and 70 percent for side-roll sprinklers. Side-rolls save twice as much water as gated pipe in relationship to existing irrigation practices.

There are three situations that are fairly representative of the McElmo Creek Unit: 1) side-roll sprinkler on medium acreage, 2) side-roll sprinkler on small acreage, and 3) gated pipe on small acreage. The associated costs are shown in Table 3. These costs are from actual contracts and two contracts were selected for each of the three situations. The costs in Table 3 represent only the 65 percent cost share rate.

Table 3. McElmo Creek Unit - Salt Load Reduction and Cost of Irrigation Improvements

Farm ID	Description	Salt Load Reduction	Cost per Ton	Cost
Farm #1	Side-roll - 94.7 acres, Onfarm pipe - 4,980 feet, Off farm pipe - 0	130.7 tons	$28.18	$36,492
Farm #2	Side-roll - 115.1 acres, Onfarm pipe - 5,880 feet, Off farm pipe - 1,520 feet, Inlet structure	169.9 tons	$26.92	$45,388
Farm #3	Side-roll - 19.7 acres, Onfarm pipe - 1,080 feet, Off farm pipe - 800 feet	33.0 tons	$27.06	$8,860
Farm #4	Side-roll - 8.1 acres, Onfarm pipe - 920 feet, Off farm pipe - 0	11.2 tons	$69.96	$7,775
Farm #5	Gated pipe - 14.1 acres, Onfarm pipe - 2,190 feet, Off farm pipe - 3,100 feet	22.6 tons	$39.55	$14,364
Farm #6	Gated pipe - 7.1 acres, Onfarm pipe - 370 feet, Off farm pipe - 0	7.0 tons	$35.04	$2,434

UINTA BASIN UNIT, UTAH

The goal of the Uinta Basin Unit is to reduce salt loading from the Uinta Basin by 106,800 tons. This will be accomplished primarily by treating approximately 137,000 acres of irrigated land. A large portion of the irrigation systems will be converted from inefficient flood irrigation to sprinkler systems.

The M&E activities were initiated in 1983. Monitoring efforts are focused on evaluating the effects of sprinkler irrigation on salt load reduction. Seven remote sensing weather stations have been installed. An average of 14 irrigation sites have been monitored each year for the last six years. Monitoring sites have been established for two surface irrigated systems, six center-pivots and six wheel line sprinklers. Sites average about 100 acres in size.

Wildlife habitat is being monitored at selected sites throughout the basin to measure changes in quantity and quality. Biology data was first collected in 1984 from 30 sites. An additional 30 sites were installed by 1986, and 30 more sites were established in 1989. Data is be collected on a three year rotation. Eighteen transects have been established within different cover types to represent both onfarm and offsite effects.

A biologist is planning and assisting in installing wildlife practices on each farm unit. Replacement of wildlife habitat values continues to receive high priority and 105 acres of wetland habitat have been developed by constructing shallow ponds and potholes. Grass, trees, and shrubs have been planted for wildlife habitat.

The Colorado River and its tributaries naturally transport salts because of the geologic formations they traverse. Included in these saline and gypsiferous formations are the Uinta, Green River, Mesa Verde, and Mancos formations found in the Uinta Basin. The Uinta Basin is part of the Upper Colorado River Drainage System. Beginning in the early 1900's the development of irrigated agriculture in the Uinta Basin added to the salt loading of the Colorado by increasing the amount of water that moves through the salt bearing formations. As water development increased so did salt loading in the Upper Colorado River Basin resulting in increased salt induced problems in the lower basin.

Uinta Basin Unit, Utah, *Continued*

Irrigated farmlands in the Uinta Basin have been grouped into 11 salt monitoring areas by potential for salt loading and other physiographic characteristics. These areas are Arcadia, Fruitland-Strawberry, Tabiona-Hanna, Upper Duchesne, and Upper Lake Fork in Duchesne County. The Ashley Valley, Brush Creek, Pelican Lake, and White Rocks areas are in Uinta County. The Dry Gulch and Lower Duchesne areas have sections in both counties.

There are 201,200 acres of irrigated farmland in the Uinta Basin Unit which are contributing salt to the Colorado River. The percent of contracted acres ranges from a high of 15.8 percent in the Ashley Valley Area to a low of 1.9 percent in the Fruitland-Strawberry Area for an average of 8.9 percent of irrigated acres in the Uinta Basin under contract. Irrigated farmland along the Green River was also added to the Brush Creek Area. In addition to the current CRSC program contracts, there are 33,387 acres in the Basin under ACP Salinity long-term agreements and another 10,333 acres under non-cost-shared annual management practices.

The physiography of the Uinta Basin generally results in irregularly shaped fields. This requires more relatively short side roll sprinkler systems and handlines than would be the case if fields were larger and in a more uniform shape. Because of the physiography and ownership patterns, a few center pivots have been installed. Cropping patterns may also affect the irrigation technology adopted in an area. Alfalfa is the major crop in the Uinta Basin, followed by irrigated pasture, and small grains. Center pivots or surface irrigation are required to irrigate the less than 5,000 acres of corn grown in the Basin.

Artificially created wetlands and their related plant communities are being adversely impacted under the salinity program. These effects occur both onfarm and off-farm. Four years of the past five years have received below normal precipitation. Information collected indicates a decrease in the Habitat Suitability Index values for muskrats, yellow-headed blackbirds, pheasants, and mallard ducks due to these adverse effects on artificial wetlands. Generally, upland wildlife species such as pheasants, mule deer, and ferruginous hawks indicated increased HSI values.

The structural improvements and improved water management practices are estimated to reduce the amount of deep percolation by 10,358 acre feet. CRSC contracts provide an average reduction in deep percolation of 61.1 percent for the Basin. The amount of reduction in deep percolation varies from 83.8 percent in Arcadia to 26.6 percent in Dry Gulch.

Deep percolation before irrigation improvements was 16,948 acre-feet while after irrigation improvements, deep percolation was 6,590 acre-feet reflecting a 10,358 acre-feet change in deep percolation.

BIG SANDY RIVER UNIT, WYOMING

To predict effects on salinity reduction, the Farm Irrigation Rating Index (FIRI) computer program is used to determine water conservation and reduction in deep percolation for each irrigation unit. Calculations are made of the amount of water conserved and salinity reduction based on changes in field and conveyance efficiency as a result of irrigation improvements.

Periods of drought frequently occur in the area. The fifth consecutive year of below normal precipitation has been experienced. The improved irrigation technology and methods result in net water savings of 30-50 percent over border dike flood irrigation systems which the program is replacing.

Six deep wells and seven shallow wells are being monitored to track ground water tables and drain flow influenced by irrigation improvements.

The Fish and Wildlife Service (FWS) is assisting with installation of wildlife habitat. A biologist is assisting with planning, applying, and monitoring habitat replacement practices. Each plan includes cover type mapping, habitat mapping, and an evaluation by HEP. Wetlands are being tracked by type and by acres onfarm and off-farm. The Wyoming Game and Fish Department has been contracted to collect information on fisheries habitat quality in the Big Sandy River and Bone Draw.

The Big Sandy River Unit is removing salt at a cost of approximately $27 per ton and the range of costs is from $14 per ton to $121 per ton. Large farm units are normal in the Big Sandy River Unit. This tends to eliminate many design options for irrigation systems when based on dollars per ton of salt analyses. On these large acreages, center pivot systems are usually the preferred option for reducing a ton of salt at the cheapest cost.

On small acreages, the side-roll, surge valve/gated pipe or stationary sprinkler systems often are selected. Two stationary sprinkler systems, one surge valve/gated pipe, two side-rolls, and thirty-seven center pivot systems have been installed.

Big Sandy River Unit, Wyoming, *Continued*

Onfarm yields have increased in the area. This can be attributed to: (1) better irrigation water management afforded by modern irrigation technology and methods installed under CRSC, (2) use of improved alfalfa varieties, (3) improving harvest management strategies, (4) addressing soil fertility problems, and (5) addressing weed and pest problems. Another significant benefit of the project is heightened awareness of the value of wildlife habitat.