RECLAMATION
Managing Water in the West

QUALITY OF WATER
COLORADO RIVER BASIN
Progress Report No. 23

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region **2009**

Mission Statements

The U.S. Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The mission of the Bureau of Reclamation is to management, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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SUMMARY

The Colorado River and its tributaries provide municipal and industrial water to about 33 million people and irrigation water to nearly 4 million acres of land in the United States. The river also serves about 3 million people and 500,000 acres in Mexico. The effect of salinity is a major concern in both the United States and Mexico. Salinity damages in the United States are presently about $383 million per year at 2008 salinity concentrations. This biennial report on the quality of water in the Colorado River Basin is required by Public Laws 84-485, 87-483, and the Colorado River Basin Salinity Control Act (Salinity Control Act) (Public Law 93-320, as amended by Public Laws 98-569, 104-20, 104-127, and 106-459).

Salinity damages to municipal water pipe.

The Salinity Control Act authorizes the Secretaries of the U.S. Department of the Interior (Interior) and U.S. Department of Agriculture (USDA) to enhance and protect the quality of water available in the Colorado River for use in the United States and the Republic of Mexico.

Title I of the Salinity Control Act authorized the construction and operation of a desalting plant, brine discharge canal, and other features to enable the United States to deliver water to Mexico having an average salinity no greater than 115 parts per million (ppm) plus or minus 30 ppm over the annual average salinity of the Colorado River at Imperial Dam. The Title I program (administered by the Bureau of Reclamation [Reclamation]) continues to meet the requirements of Minute No. 242 of the International Boundary and Water Commission, United States and Mexico.

Salinity damages to crop production.

Title II of the Salinity Control Act authorizes the Secretary of the Interior (Secretary) and the Secretary of Agriculture to implement a broad range of specific and general salinity control measures in an ongoing effort to prevent further degradation of water quality to meet the objectives and standards set by the Clean Water Act.

In 1995, Public Law 104-20 authorized an entirely new way of implementing salinity control. Reclamation's Basinwide Salinity Control Program opens the program to competition through a "Request for Proposal" process, which has greatly reduced the cost of salinity control. However, as the lowest cost projects are built, the price of salinity control is expected to continue to increase in the future.

The Colorado River Basin Salinity Control Forum (Forum) in accordance with the requirements of the Clean Water Act, prepared the 2008 *Review, Water Quality Standards for Salinity, Colorado River System* (Review). The Review reported that by 2030 a target of 1.86 million tons per year of salt will need to be diverted from entering the Colorado River in order to meet the water quality standards in the Lower Basin, below Lees Ferry, AZ. The combined Reclamation, USDA & BLM salinity reduction reported for 2008 shows that the Colorado River Basin Salinity Control Program (Program) has controlled over 1,158,700 tons of salt per year. In order to meet the 1.90 million tons of salt per year goal, it will be necessary to fund and implement potential new measures which ensure the removal of an additional 738,700 tons by 2030. The Forum stated that in order to achieve this level of salt reduction, the federal departments and agencies would require the following capital funding: Reclamation appropriation - $17.5 million per year (bringing the total Reclamation program with $7.5 million cost-sharing to $25 million per year); and USDA EQIP appropriation - $13.8 million per year (bringing the total on-farm program to $19.7 million per year with Basin states parallel program). Beginning in 2005, BLM began a comprehensive program to minimize the salt loading from BLM lands in the Colorado River basin. BLM salinity funding from Congress began in FY 2006.

With the reported existing salt controlled, and assuming no reduction of the existing salinity control projects, then nearly 35,000 tons of new or additional controls will need to be implemented each year to maintain the standards with increased future water development. This Program goal is the combined target for the participating agencies within Interior and USDA. The participating agencies reported to the Colorado River Basin Salinity Control Advisory Council, showing that the agencies efforts have been able to exceed the program's target over the past several years.

The Upper Colorado River Basin continues to experience a protracted multi-year drought. Since 1999, inflow to Lake Powell has been below average in every year except water years 2005 and 2008. The overall reservoir storage in the Colorado River Basin, as of September 1, 2009, is 34.8 million acre-feet or 58.5 % of capacity. Salinity concentration has increased during this time period (while salinity loading has decreased), but has not exceeded the numeric salinity criteria on the Colorado River below Hoover Dam, Parker Dam and at Imperial Dam; 723, 747 & 879 mg/L respectively. Reclamation's short term future salinity modeling scenarios indicate that the numeric salinity criteria should be maintained even with an additional 1-2 years of drought. However, the uncertainty of the prediction is within reach of the salinity criteria. The salinity criteria could have been exceeded in 2003 or 2004 without the salinity control program and other salt reductions. Nevertheless, salinity damages are still very high at the 2008 salinity levels. This is the first observation of this level of reservoir draw down. This drought is providing new data, which will eventually reduce the uncertainty in salinity forecasting.

CHAPTER 1 - INTRODUCTION

The Bureau of Reclamation (Reclamation) of the U.S. Department of the Interior prepared this report in cooperation with State water resource agencies and other Federal agencies involved in the Colorado River Basin Salinity Control Program (Salinity Control Program). This Progress Report is the latest in a series of biennial reports that commenced in 1963. This report, Progress Report 23, should have been out in 2007, but due to long review times for the last couple of reports (21 & 22) the time line has been delayed enough to skip a whole report in order to have the recent data included in this report.

AUTHORIZATION FOR REPORT

The directive for preparing this report is contained in four separate public laws.

Public Law 84-485 states:

> Section 15 –"The Secretary of the Interior is directed to continue studies and make a report to the Congress and to the States of the Colorado River Basin on the quality of water of the Colorado River,"
>
> Section 5c – "All revenues collected in connection with the operation of the Colorado storage project and participating projects shall be credited to the Basin Fund, and shall be available, without further appropriation, for (1) defraying the costs of operation, maintenance, & replacement of, and emergency expenditures for, all facilities". The ongoing water quality monitoring, studies, and report are considered part of the normal operation of the project and are funded by the Basin Fund."

Public Law 87-483 states:

> Section 15 - "The Secretary of the Interior is directed to continue his studies of the quality of water of the Colorado River System, to appraise its suitability for municipal, domestic, and industrial use and for irrigation in the various areas in the United States in which it is used or proposed to be used, to estimate the effect of additional developments involving its storage and use (whether heretofore authorized or contemplated for authorization) on the remaining water available for use in the United States, to study all possible means of improving the quality of such water and of alleviating the ill effects of water of poor quality, and to report the results of his studies and estimates to the 87th Congress and every 2 years thereafter."

Public Law 87-590 states that January 3 would be the submission date for the report.

Public Law 93-320 states:

> "Commencing on January 1, 1975, and every 2 years thereafter, the Secretary shall submit, simultaneously, to the President, the Congress, and the Advisory Council created in Section 204(a) of this title, a report on the Colorado River salinity control program authorized by this title covering the progress of

investigations, planning, and construction of salinity control units for the previous fiscal year; the effectiveness of such units; anticipated work needed to be accomplished in the future to meet the objectives of this title, with emphasis on the needs during the 5 years immediately following the date of each report; and any special problems that may be impeding progress in attaining an effective salinity control program. Said report may be included in the biennial report on the quality of water of the Colorado River Basin prepared by the Secretary pursuant to section 15 of the Colorado River Storage Project Act (70 Stat. 111; 43 U.S.C. 602n), section 15 of the Navajo Indian Irrigation Project and the initial stage of the San Juan-Chama Project Act (76 Stat. 102), and section 6 of the Fryingpan-Arkansas Project Act (76 Stat. 393)."

LEGAL ASPECTS

Water Quantity

Colorado River water was apportioned by the Colorado River Compact of 1922, the Boulder Canyon Project Act of 1928, the Water Treaty of 1944, the Upper Colorado River Basin Compact of 1948, and the United States Supreme Court (*Arizona* v. *California et al*., 1963).

The Colorado River Compact divided the Colorado River Basin between the Upper and Lower Basins at Lee Ferry (just below the confluence of the Paria River), apportioning to each use of 7.5 million acre-feet (maf) annually. In addition to this apportionment, the Lower Basin was given the right to increase its beneficial consumptive use by 1 maf per year. The compact also contains provisions governing exportation of Colorado River water. The Water Treaty of 1944 obligates the United States to deliver to Mexico 1.5 maf of Colorado River water annually, absent treaty surplus or shortage conditions.

Upper Colorado Use - The Upper Colorado River Basin Compact of 1948 divided and apportioned the water apportioned to the Upper Colorado River Basin by the Colorado River Compact, allocating to **Arizona** 50,000 acre-feet annually, with the remaining water allocated to Upper Colorado River Basin States as follows:

- **Colorado** 51.75 percent
- **New Mexico** 11.25 percent
- **Utah** 23 percent
- **Wyoming** 14 percent

Lower Colorado Use - States of the Lower Colorado River Basin did not agree to a compact for the apportionment of waters in the Lower Colorado River Basin; in the absence of such a compact Congress, through Secretarial contracts authorized by the Boulder Canyon Project Act, allocated water from the mainstem of the Colorado River below Lee Ferry among California, Nevada, and Arizona, and the Gila River between Arizona and New Mexico. This apportionment was upheld by the Supreme Court, in 1963, in the case of Arizona v. California.

As confirmed by the U.S. Supreme Court in 1963, from the mainstem of the Colorado River (i.e., The Lower Basin):

- **Nevada** was apportioned 300,000 acre-feet annually and 4 percent of surplus water available,
- **Arizona** was apportioned 2,800,000 acre-feet annually and 46 percent of surplus water available,
- **California** was apportioned 4,400,000 acre-feet annually and 50 percent of surplus water available.

Water Quality

Although a number of water-quality-related legislative actions have been taken on the State and Federal levels, several Federal acts are of special significance to the Colorado River Basin: the Water Quality Act of 1965 and related amendments, the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), commonly referred to as the Clean Water Act and related amendments, and the Colorado River Basin Salinity Control Act (Salinity Control Act) of 1974 as amended. Also, central to water quality issues are agreements with Mexico on Colorado River System waters entering that country.

The Water Quality Act of 1965 (Public Law 89-234) amended the Federal Water Pollution Control Act and established a Federal Water Pollution Control Administration (now Environmental Protection Agency [EPA]). Among other provisions, it required States to adopt water quality criteria for interstate waters inside their boundaries. The seven Basin States initially developed water quality standards that did not include numeric salinity criteria for the Colorado River primarily because of technical constraints. In 1972, the Basin States agreed to a policy that called for the maintenance of salinity concentrations in the Lower Colorado River System at or below existing levels, while the Upper Colorado River Basin States continued to develop their compact-apportioned waters. The Basin States suggested that Reclamation should have primary responsibility for investigating, planning, and implementing the proposed Salinity Control Program.

The enactment of the Federal Water Pollution Control Act Amendments of 1972 affected salinity control, in that it was interpreted by EPA to require numerical standards for salinity in the Colorado River. In response, the Basin States founded the Colorado River Basin Salinity Control Forum (Forum) to develop water quality standards, including numeric salinity criteria and a basinwide plan of implementation for salinity control. The Basin States held public meetings on the proposed standards as required by the enacting legislation. The Forum recommended that the individual Basin States adopt the report, *Water Quality Standards for Salinity, Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System*. The proposed water quality standards called for maintenance of flow-weighted annual averaged total dissolved solids concentrations of 723 milligrams per liter (mg/L) below Hoover Dam, 747 mg/L below Parker Dam, and 879 mg/L at Imperial Dam. Included in the plan of implementation were four salinity control units and possibly additional units, the application of effluent limitations, industrial use of saline water, and future studies. The standards are to be reviewed at 3-year intervals. All of the Basin States adopted the 1975 Forum-recommended standards. EPA approved the standards.

The Salinity Control Act of 1974 (Public Law 93-320) provided the means to comply with the United States' obligations to Mexico under Minute No. 242 of the International Boundary and Water Commission, United States and Mexico, which included, as a major feature, a desalting plant and brine discharge canal for treatment of WMID drainage water. These facilities enable the United States to deliver water to Mexico having an average salinity of 115 parts per million (ppm) plus or minus 30 ppm (United States' count) over the annual average salinity of the Colorado River at Imperial Dam. The act also authorized construction of 4 salinity control units and the expedited planning of 12 other salinity control projects above Imperial Dam as part of the basinwide salinity control plan.

In 1978, the Forum reviewed the salinity standards and recommended continuing construction of units identified in the 1974 act, placing of effluent limitations on industrial and municipal discharges, and reduction of the salt-loading effects of irrigation return flows. The review also called for the inclusion of water quality management plans to comply with section 208 of the Clean Water Act. It also contemplated the use of saline water for industrial purposes and future salinity control.

Public Law 98-569, signed October 30, 1984, amended Public Law 93-320. The amendments to the Salinity Control Act authorized the U.S. Department of Agriculture (USDA) Colorado River Salinity Control Program. The amendments also authorized two new units for construction under the Reclamation program.

In 1993, the Dept. of Interior Inspector General concluded that the lengthy congressional authorization process for Reclamation projects was impeding the implementation of cost-effective measures. Consequently, a public review of the program was conducted in 1994. In 1995, Public Law 104-20 authorized Reclamation to implement a basinwide approach to salinity control and to manage its implementation. Reclamation completed solicitations in 1996, 1997, 1998, 2001, and 2004 in which Reclamation requests proposals, ranks the proposals based on their cost and performance risk factors, and awards funds to the most highly ranked projects. The awards from the first three solicitations consumed the available appropriation ceiling of $75 million authorized by Congress to test the new program.

In 1996, Public Law 104-127 significantly changed the authorities provided to USDA. Rather than carry out a separate salinity control program, the Secretary of Agriculture was directed to carry out salinity control measures in the Colorado River Basin as part of the Environmental Quality Incentives Program established under the Food Security Act of 1985. Public Law 104-127 also authorized the Secretary of Agriculture to cost share salinity control activities from the basin funds in lieu of repayment. Cost sharing has been implemented for both USDA and Reclamation programs. Under this new authority, each dollar appropriated by the Congress is matched by $0.43 in cost sharing from the basin funds.

In 2000, Public Law 106-459 amended the Colorado River Basin Salinity Control Act to increase the appropriation ceiling for Reclamation's basinwide approach by $100 million ($175 million total). This appropriation authority will allow Reclamation to continue to request new proposals under its Basinwide Salinity Control Program. In 2002, Public Law 107-171, Title II, Subtitle D reauthorized the USDA's Environmental Quality

Incentives Program (under which the Secretary of Agriculture carries out salinity control measures). In 2008, Public Law 110-246, again authorized the USDA's Environmental Quality Incentives Program. PL110-246 also amended the Salinity Control Act to clarify the authority and implementation of the "Basin States Program".

Nothing in this report is intended to interpret the provisions of applicable federal law including, but not limited to, The Colorado River Compact (42 Stat. 171), The Upper Colorado River Basin Compact (63 Stat. 31), The Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, Treaty Between the United States of America and Mexico (Treaty Series 994, 59 Stat. 1219), the United States/Mexico agreement in Minute No. 242 of August 30, 1973, (Treaty Series 7708; 24 UST 1968), the 1964 Decree entered by the Supreme Court of the United States in Arizona v. California et al. (376 U.S. 340), as amended and supplemented, The Boulder Canyon Project Act (45 Stat. 1057), The Boulder Canyon Project Adjustment Act (54 Stat. 774; 43 U.S.C. 618a), The Colorado River Storage Project Act (70 Stat. 105; 43 U.S.C. 620), The Colorado River Basin Project Act (82 Stat. 885; 43 U.S.C. 1501), The Colorado River Basin Salinity Control Act (88 Stat. 266; 43 U.S.C. 1571), The Hoover Power Plant Act of 1984 (98 Stat. 1333), The Colorado River Floodway Protection Act (100 Stat. 1129; 43 U.S.C. 1600), or The Grand Canyon Protection Act of 1992 (Title XVIII of Public Law 102-575, 106 Stat. 4669).

CHAPTER 2 – SALINITY CONDITIONS

CAUSES OF SALINITY

The Colorado River System is naturally very saline. At the USGS gauge below Hoover Dam, between 1940 and 1980 an average of approximately 9.4 million tons of salt were carried down the river every year. Since 1981, on average, approximately 8.8 million tons of salts have been measured in the river each year, including years of floods and drought, with the trend going down. The flow of the river dilutes this salt, and depending upon the quantity of flow, salinity can be relatively dilute or concentrated. Since climatic conditions directly affect the flow in the river, salinity in any one year may double (or halve) due to extremes in runoff. Because this natural variability is virtually uncontrollable, the seven Basin States adopted a non-degradation water quality standard.

Nearly half of the salinity in the Colorado River System is from natural sources. Saline springs, erosion of saline geologic formations, and runoff all contribute to this background salinity. Irrigation, reservoir evaporation, and municipal and industrial (M&I) sources make up the balance of the salinity problem in the Colorado River Basin. Figure 1 shows the relative amount each source contributes to the salinity problem. The Environmental Protection Agency (EPA, 1971) estimated that the natural salinity in the Lower Colorado River at Imperial Dam was 334 milligrams per liter (mg/L). For 2007 the average annual flow weighted salinity at Imperial Dam was 702 mg/L, a 368 mg/L increase over the estimated natural salinity. Table 1, on the following page, quantifies the salinity from several of these known sources.

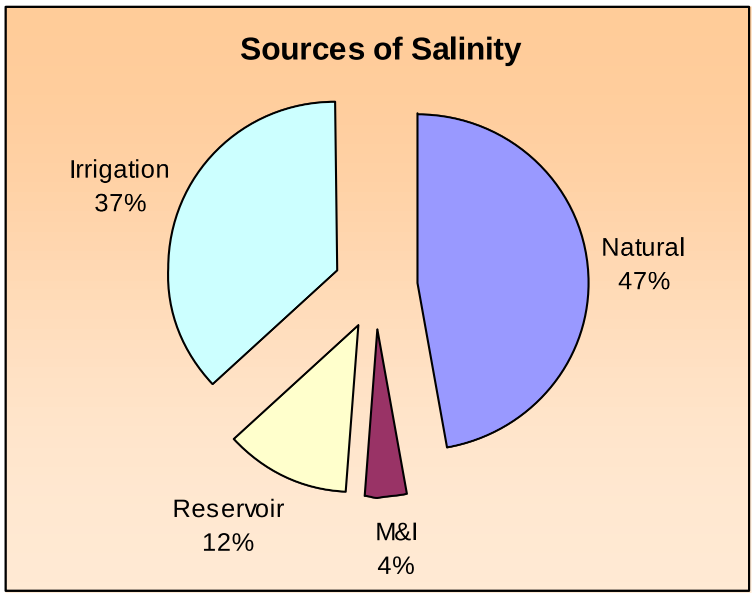

Figure 1 - Sources of Salinity

Salinity of the Colorado River has increased with the development of water resources in two major ways: (1) the addition of salts from water use and (2) the consumption (depletion) of water. The combined effects of water use and consumption have had a significant impact on salinity in the Colorado River Basin. The basin wide drought, since 1999, has also had an influence on the present salinity of the Colorado River.

Current information indicates that the present salt levels in the Colorado River system have few if any negative health effects and the EPA’s primary drinking water standards

Table 1 - Quantified Sources of Salt Loading

Source	Type of Source	Salt Loading (tons per year)
Paradox Springs	Springs / point	205,000 [1]
Dotsero Springs	Springs / point	182,600
Glenwood Springs	Springs / point	335,000
Steamboat Springs	Springs / point	8,500
Pagosa Springs	Springs / point	7,300
Sinbad Valley	Springs / point	6,500
Meeker Dome	Springs / point	57,000 [1]
Other minor springs in the Upper Basin	Springs / point	19,600
Blue Springs	Springs / point	550,000
La Verkin Springs	Springs / point	109,000
Grand Valley	Irrigation / non-point	580,000
Big Sandy	Irrigation / non-point	164,000
Uncompahgre Project	Irrigation / non-point	360,000 [1]
McElmo Creek	Irrigation / non-point	119,000
Price-San Rafael	Irrigation / non-point	258,000 [1]
Uinta Basin	mostly irrigation / non-point	240,000
Dirty Devil River Area	non-point	150,000
Price-San Rafael Area	non-point	172,000 [1]
Other, non regulated areas	Various	5,200,000
Total		8,724,000

Note: [1]- Values listed are pre salinity control project loading

are not exceeded (see Progress Report 21, Health section). However, the EPA secondary drinking water standards of 500 mg/L for TDS (salinity), and 250 mg/L for sulfate may be exceeded. A regression of sulfate versus TDS shows that sulfate exceeds 250 mg/L when the TDS exceeds 612 mg/L. During dry cycles the secondary drinking water standards for TDS and sulfate are exceeded at many places in the Colorado River in both the Upper and Lower Basins, including the three salinity criteria sites.

The primary negative impact of the Colorado River salinity presently is seen as economics. Economic damages have been shown to begin at salinity levels above 500 mg/L and a change of 1 mg/L TDS equates to 10,000 tons of salt per year. Present annual economic damage using the 2008 average annual salinity level at Imperial Dam (702 mg/l, latest data available) has been modeled at over $383 million dollars. This impact comes out at a cost of $173 per ton of salt or $1,733,000 per mg/L TDS per year, over the 500 mg/L base point. Even though the salinity level has dropped slightly from last year, the salinity impact cost has increased primarily due to increased agricultural damage costs (increase in acreage and crop prices) from last year.

Salinity related damages are primarily due to reduced agricultural crop yields, corrosion, and plugging of pipes and water fixtures. Figure 2 breaks down the percentage of total damages. The seven Basin States have agreed to limit this impact and adopted numeric criteria, which require that salinity concentrations not increase (from the 1972 levels) due to future water development. Salinity levels measured in the river may be low or high due to climatic conditions, but the goal of the Water Quality Criteria for the Colorado River Basin and the Colorado River Basin Salinity Control Program (Salinity Control Program) is to offset (eliminate) the salinity effects of additional water development.

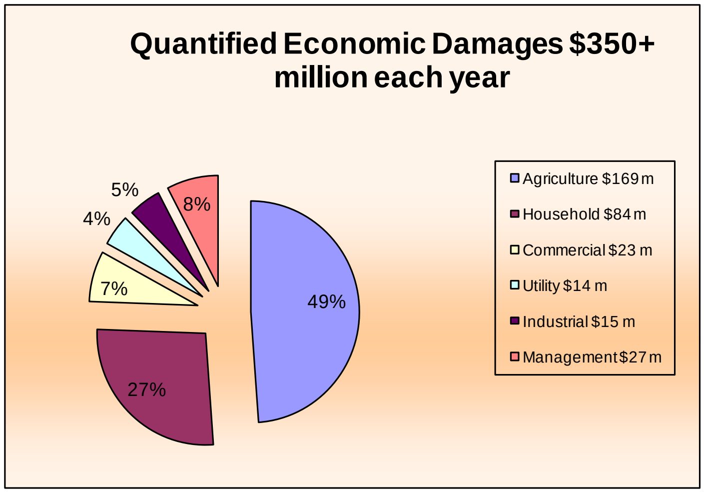

Figure 2 – Percentage of Salinity Damages

HISTORIC SALINITY CONDITIONS

Salinity in the Colorado River is monitored at 20 key stations throughout the Colorado River Basin. Salt loads and concentrations are calculated from daily conductivity and flow records using methods developed jointly between Reclamation and USGS (Liebermann et al., 1986). Historical annual streamflow, and salinity concentrations from 1940 through 2007 are included in graphical form in Appendix A. Monthly and annual data may be obtained by request from Reclamation, Salt Lake City, Utah or by going to Reclamation's Upper Colorado Regional Office Salinity Program web page; http://www.usbr.gov/uc/progact/salinity/index.html. The salinity of the 3 lower basin compact points since 1940 is shown in Figure 3. As Figure 3 shows, the last time the TDS exceeded or reached the salinity criteria at any of the compact points, was in 1972 – the year that the salinity standard was established for the Colorado River.

FACTORS INFLUENCING SALINITY

Stream flow, reservoir storage, water resource development, salinity control, climatic conditions, and natural runoff directly influence salinity in the Colorado River Basin. Before any water development, the salinity of spring runoff was often below 200 mg/L throughout the Colorado River Basin. However, salinity in the lower mainstem was often well above 1,000 mg/L during the low flow months (most of the year), since no reservoirs existed to catch and store the spring runoff.

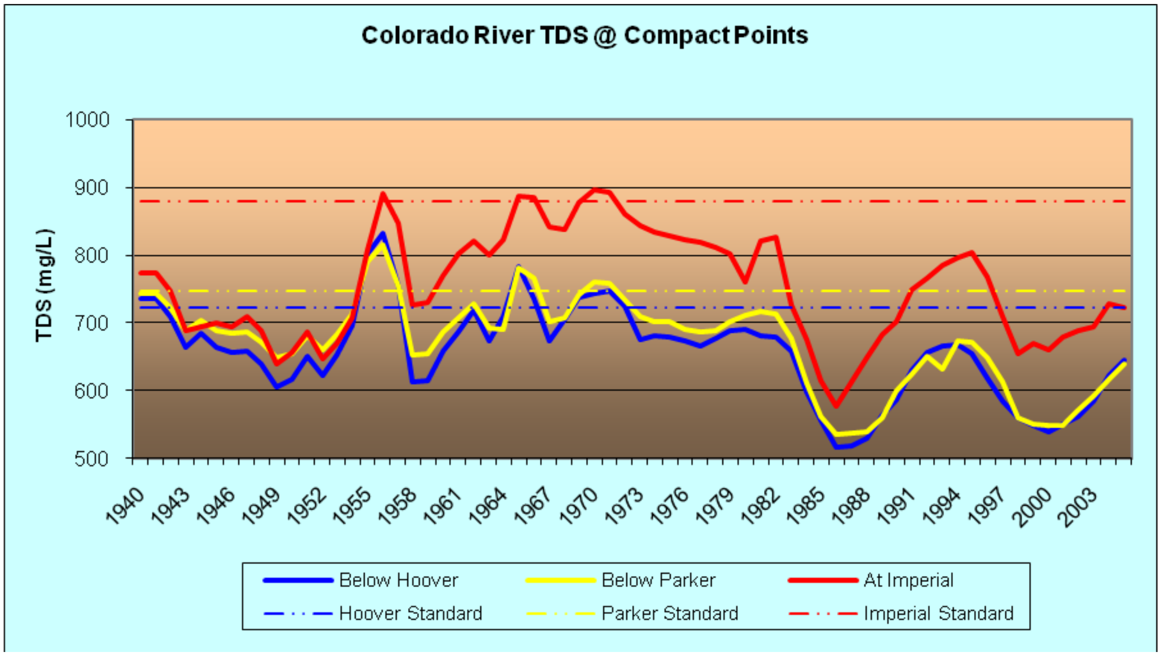

Figure 3 - Colorado River Salinity at Lower Basin Compact Points

Streamflow

Streamflow directly influences salinity. For the most part, higher flows (or reservoir releases) dilute salinity. The top graph in Figure 4 shows streamflow at two key points in the mainstem. In 1980, Lake Powell (Glen Canyon Dam) filled for the first time and spilled.

This spill went through Lake Mead (Hoover Dam) and on downstream through Imperial Dam. In 1983 and on through 1987, flows in the system were again extremely high and sustained, reducing salinity to historic lows. As shown in the bottom graph of Figure 4, more average flows in the system after 1987 returned the salinity in the reservoir system to more normal levels.

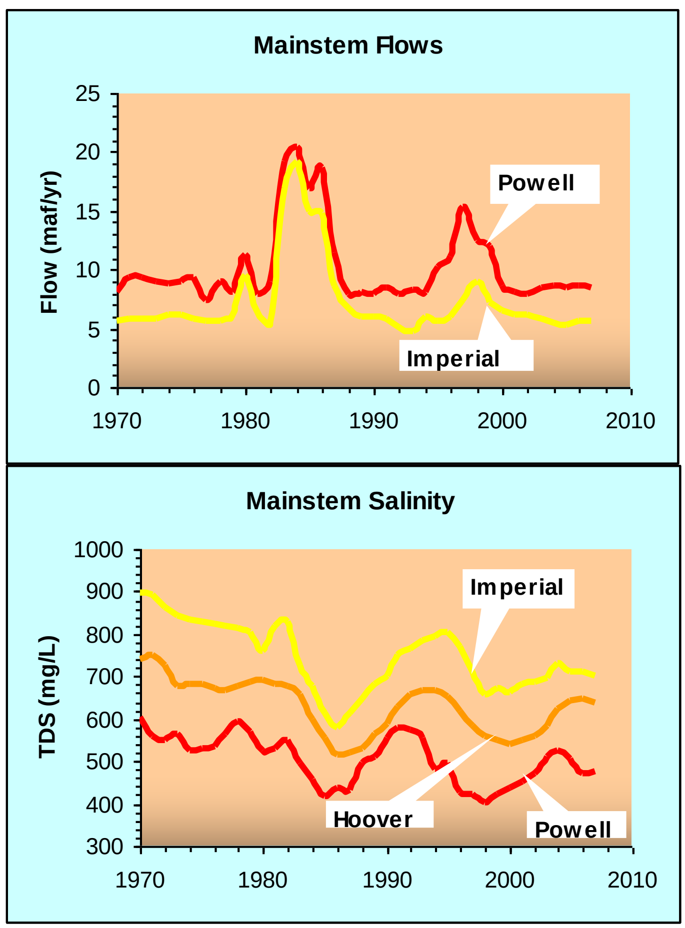

Figure 4 - Mainstem Flow and Salinity.

Reservoir Storage

The Colorado River Storage Project Reservoirs produce not only major hydrologic modifications downstream, but they also significantly alter the salinity variability of the downstream river. The overall long term salinity affects of the reservoirs are beneficial and have greatly reduced the salinity peaks and annual fluctuation (Figure 5). The high concentration low flow waters are mixed with low concentration spring runoff, reducing the month-to-month variation in salinity below dams (Mueller et al., 1988). At Glen Canyon Dam, the pre and post dam peak monthly salinity has been reduced by nearly 600 mg/L. Similar effects can be seen below Flaming Gorge, Navajo, and Hoover Dams, greatly improving the quality of water during the summer, fall and winter.

Large reservoirs like Lake Powell selectively route less saline water while holding more saline waters during low inflow periods. The poorer quality waters are then slowly released after the inflows have begun to increase, which helps to prevent exceeding the salinity criteria during drought years. The large reservoirs selectively retain higher salinity winter inflows in the bottom of the pool and route lower salinity overflow density currents from the spring runoff. The seasonal and long term affects of this selective retention and routing of salt has been shown below Glen Canyon Dam in Figure 5.

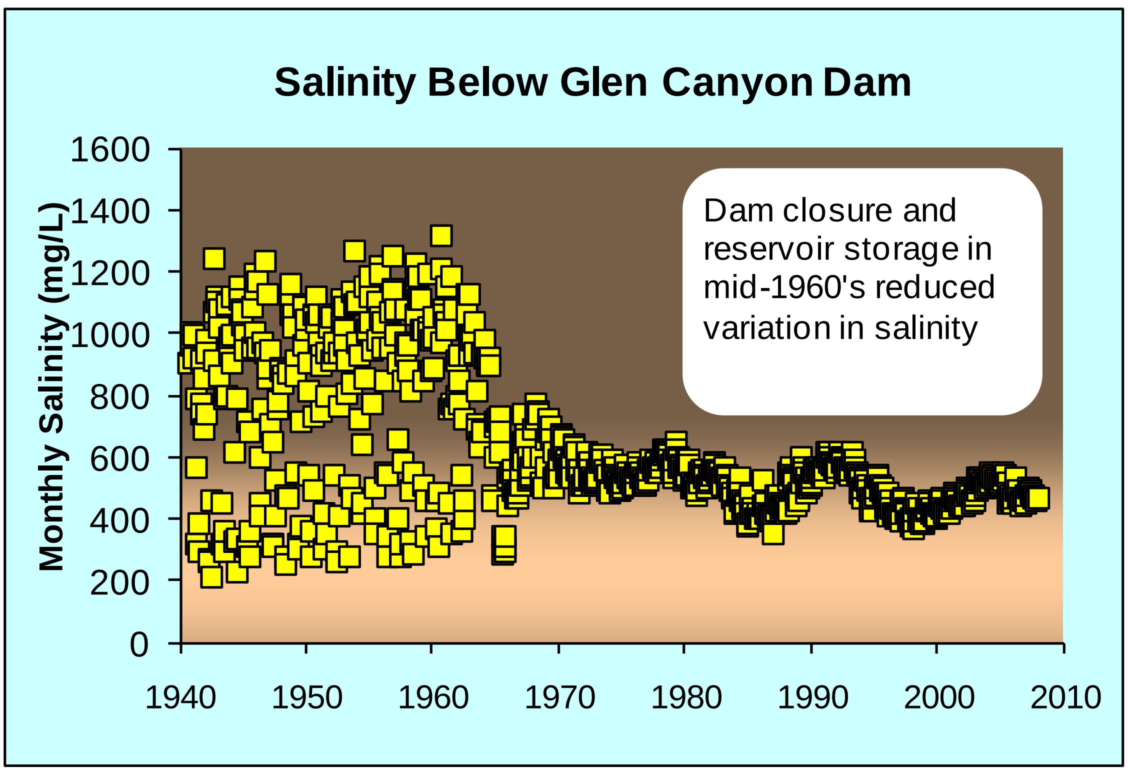

Figure 5 - Effects of Glen Canyon Dam on Colorado River Salinity at Lees Ferry.

Figure 6 further displays this retention. A long-term depth vs. time profile of salinity in the forebay of Glen Canyon Dam is a pictured history of salinity. The Y (vertical) axis is

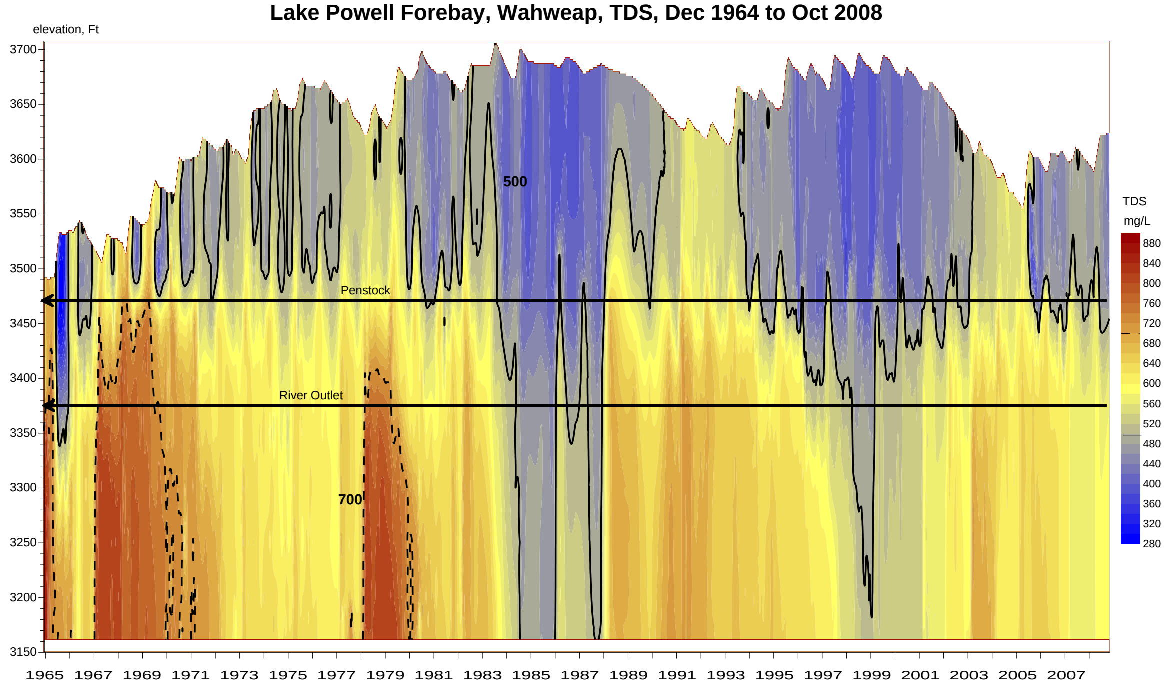

Figure 6 - Lake Powell Forebay, near Dam, Dec 1964 to March 2007 Salinity Concentration, mg/L

depth in the water column and the X axis is time in years. The color scale is the change in salinity.

Two things are demonstrated by this graphic: 1) Glen Canyon Dam selectively retains higher TDS water, especially during initial years of drought, and then routes those waters later, usually during wetter cycles. 2) Lake Powell has selectively retained higher salinity water during drier years, and then routed it with the increased mixing and shorter hydraulic retention times of wetter cycles as seen particularly in 1983 and 1999. During these wetter cycles these is a significant mixing and dilution of these previously stored salts.

The Colorado River salinity for the inflow and outflow into Lake Powell had 3 periods as Figure 7 shows (green and yellow trend lines). The inflow line in Figure 7 is the sum of TDS for the inflow stations to Lake Powell; Colorado River at Cisco, Green River at Green River, UT, San Rafael River near Green River and San Juan River near Bluff. The outflow line is the TDS at the USGS gauge at Lee's Ferry below Glen Canyon Dam. There was the pre dam period, 1940 – 1964, where the average salinity was increasing with some divergence between the average annual inflow and outflow salinity levels. The outflow TDS seems to have increased more than the inflow TDS. Then there was the dam filling period where Lake Powell and the upper basin reservoirs were completed and filling, 1965-1980. The average annual salinity concentration during this time decreased with a convergence occurring between the inflow and outflow concentrations. The outflow concentration decreased more than the inflow concentration, which could be due to the reservoir storing the higher TDS waters. Then there was the last period, after 1980, when the basin hydrology went through both wet and dry periods and the salinity control projects in the upper basin were coming online. The declining trend of the average annual salinity concentration over this time is seen to be constant between the inflow and outflow stations. Since 1980 there appears to be an equilibrium between the salt entering the reservoir and what is being released.

Lake Powell (and other reservoirs in the basin) went through an initial filling salt leach out which actually began with temporary water retention behind the coffer dam during construction in the mid 1950's. Long-term linear regression trend lines on the inflow and outflow salinity concentrations at Lake Powell indicate that internal salt leaching seems to have declined to a minimum by the mid-1990's suggesting a long-term salinity leach out which is approaching a dynamic equilibrium (Figure 7, red and blue trend line).

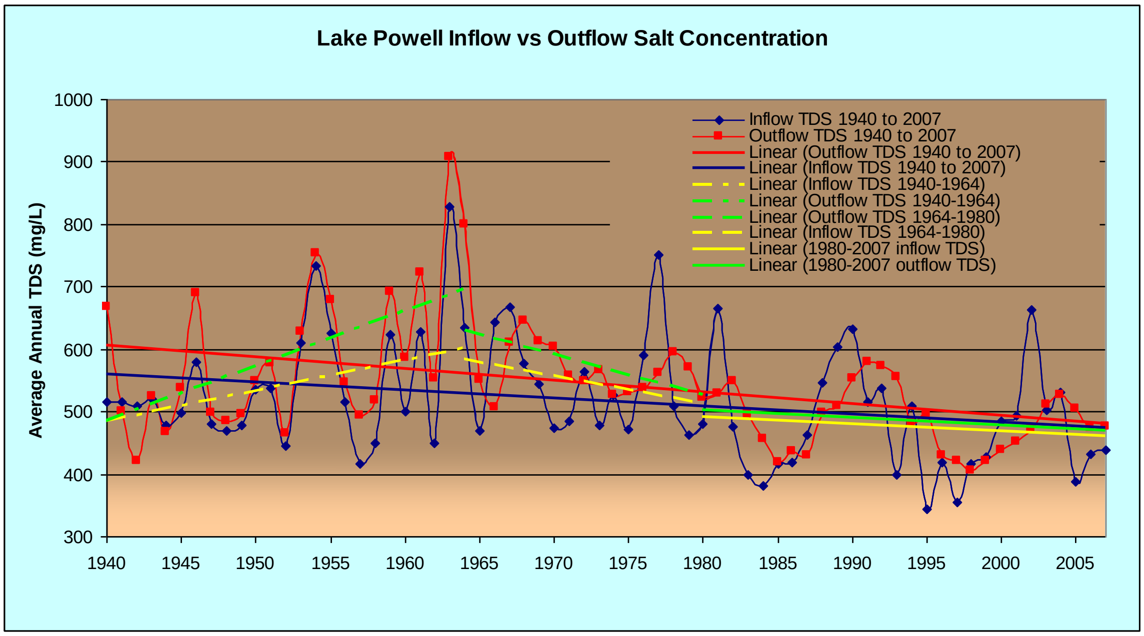

Figure 7 - Lake Powell Inflow and Outflow Salt Concentration, mg/L

NATURAL VARIATION IN SALINITY

Although seasonal swings in salinity have been greatly reduced, annual fluctuations in salinity are still observed. Natural climatic variations in rainfall and snowmelt runoff continue to cause large year-to-year differences in both flow and salinity and in some cases nearly doubling the salinity in the river.

The water quality standards require that the flow-weighted average annual salinity not to rise above the 1972 levels using a long-term mean water supply of 15 maf (2008 Review). This means that depending on the hydrology (drought conditions) that salinities may actually increase above the numeric criteria and it is not a violation of the standards, but is due to natural variations in the hydrologic conditions. Even with full compliance with the standards, the actual salinities at Imperial Dam (and elsewhere in the Colorado River Basin) will continue to fluctuate with hydrologic conditions in the future. The Salinity Control Program is designed to offset the effects of development, even as salinity varies from year to year in response to the climatic and hydrologic conditions. Assuming continued salinity control and full compliance with the standards, the potential range of annual salinities that might be observed in the future at Imperial Dam is quite wide. With Colorado River basin reservoir storage tempering the natural variability of the system, the range between the high and low salinity values at Imperial Dam has dropped to a monthly average of about 479 mg/L and an annual average around 266 mg/L since 1973.

AGRICULTURAL SOURCES OF SALINITY

Irrigated agriculture is the largest user of water in the Colorado River Basin and a major contributor to the salinity of the system. Iorns (Iorns et al., 1965) found that irrigated lands in the Upper Colorado River Basin contributed about 3.4 million tons of salt per year (37 percent of the salinity of the river). Irrigation increases the salt concentration of the source water by consuming water (evapotranspiration) and by dissolving salts found in the underlying saline soil and geologic formations, usually marine (Mancos) shale.

Irrigation mobilizes the salts found naturally on the soil surface as well as in the soil profile, especially if the lands are over irrigated. Many subbasins experienced significant changes in irrigation following development of available reservoir storage. For example, once late season irrigation supplies were assured, less water was applied to per unit of farmland during the snowmelt runoff, and overall irrigation efficiency increased.

Irrigation development in the Upper Colorado River Basin took place gradually from the beginning of settlement in about 1860, but was hastened by the purchase of tribal lands in the late 1800's and early 1900's. About 800,000 acres were being irrigated by 1905. Between 1905 and 1920, the development of irrigated land increased at a rapid rate, and by 1920, nearly 1.4 million acres were being irrigated. The *Upper Colorado Region Comprehensive Framework Study, June 1971*, reported that more than 1.6 million acres were in irrigation in 1965. Since that time, development of new agricultural lands has leveled off because of physical, environmental, and economic limitations. Reclamation's latest *Colorado River System Consumptive Uses and Losses Report 2006-2010* estimated that an average of 1.57 million acres were irrigated in the Upper Colorado River Basin in 2006 (latest data available).

Irrigation development in the Lower Colorado River Basin began at about the same time as in the Upper Colorado River Basin, but was slow due to the difficulty of diverting water from the Colorado River with its widely fluctuating flows. Development of the Gila area began in 1875 and the Palo Verde area in 1879. Construction of the Boulder Canyon Project in the 1930's, and other downstream projects, has provided for a continued expansion of the irrigated area. In 1970, an additional 21,800 acres were irrigated by private pumping either directly from the Colorado River or from wells in the flood plain. In 1980, nearly 400,000 acres were being irrigated along the Colorado River mainstem. Total irrigated lands for the entire Lower Colorado River Basin is around 1.4 million acres.

Reclamation and the U.S. Geological Survey (USGS) continuously monitor the flow and salinity of the river system through a network of 20 gauging stations (See Appendix A, Fig. A1). Reclamation evaluates the data collected to determine if sufficient salinity control is in place to offset the impact of water development. In 2008, the actual salinity in the Colorado River was below the numeric criteria at the established monitoring stations. However, as the impacts of recent and future basin developments work their way through the hydrologic system, or as drought conditions persist, salinity would increase without salinity control to prevent further degradation of the river system. Through salinity control practices, excess salt loading to the river system can be reduced significantly, helping maximize the future beneficial uses of the river.

Most of the irrigation projects that deplete water and increase salt loading to the river were in place before 1965. Moreover, like the newly inundated soils in reservoirs, newly irrigated lands are subject to a leach-out period. In cases where lands with poor drainage stored salt, these areas were taken out of production. In addition, irrigation practices changed significantly with the introduction of canal and lateral lining, sprinkling systems, gated pipe, trickle systems and tile drains (initial operation of tile drains increase salt loading, which decreases after time). These changes have resulted in reduced return flows and salt loading.

WATER USE BY MUNICIPAL & INDUSTRIAL USERS

Salinity levels are directly influenced by depletion (consumption) of water flowing in the river system and salt loading. Agriculture increases salinity by consuming water through evapotranspiration and leaching of salts from soils by irrigation. Municipal and industrial (M&I) use increases salinity by the consumption of the water, thus reducing the dilution of salts in the river or by disposal on land.

Another source of salinity from municipal & industrial use is from an increase in the housing developments within the basin. This brings with it an associated increase in water softening needs, due to the hard water found throughout the basin. One result of the increase of water softening is an increase in the sodium chloride salt discharged into the Colorado River. Another impact of the increased population in the basin is that more roads are paved and developed. During the winter this increase in road mileage impacts the salt discharged into the basin due to the addition of salt on the roads in order to help keep the snow and ice off of the roads. The amount of salt added to the basin from new municipal development has not yet been quantified.

Reclamation continues to monitor water use and adjusts their future salinity control needs as water development plans may be postponed, delayed, or canceled. The depletion schedules used to project salinity conditions have been updated so that the implementation needs for the Salinity Control Program can be planned to offset the impacts of additional water development (see Tables 2 & 3).

Energy Development

The large amounts of water use once forecasted for steam power generation, coal gasification, oil shale, and mineral development have not yet occurred. The few coal-fired power plants that have been constructed recently have obtained their water from existing agricultural rights rather than from developing additional water. This conversion of use reduces the salt loading to the Colorado River by eliminating the pickup of salt from canal seepage and on farm deep percolation.

Many of the geologic formations of the Colorado River Basin were deposited in marine (saline) or brackish water environments. Sulfates and sodium chloride are prevalent salts in most of these formations. Many of the formations were deposited in drier periods and are capable of transmitting water, but these aquifers are frequently sandwiched between hundreds or even thousands of feet of impermeable shale (aquicludes). These aquifers are, therefore, static and often saline. Many static and saline aquifers are present in the Colorado River Basin. When a path of flow is provided by drilling or mining, these aquifers are mobilized, and brackish or saline waters flow back to the surface.

The development of energy resources, specifically coal, oil, gas, oil shale, and coal bed methane, in the Colorado River Basin may contribute significant quantities of salt to the Colorado River. Salinity of surface waters can be increased by either mineral dissolution or uptake in surface runoff, mobilization of brackish groundwater, or consumption of good quality water. The location of fossil fuels is associated with marine-derived formations. Any disturbance of these saline materials will increase the contact surfaces, allowing for the dissolution of previously unavailable soluble minerals.

Salinity increases associated with mining coal can be attributed to leaching of coal spoil materials, discharge of saline groundwater, and increased erosion resulting from surface-disturbing activities. Spoil materials have a greater permeability than undisturbed overburden, allowing most of the rain falling on the spoils to infiltrate instead of running off. The water percolates through the spoils, dissolving soluble minerals.

Studies conducted on mining spoils in northwestern Colorado indicate that the resulting salinity of spoil-derived waters ranges from approximately 3,000 mg/L to 3,900 mg/L (Parker, et al., 1983; McWhorter, et al., 1979; and U.S. Department of the Interior, 1985). The variability in concentration depends on water residence time and the chemical and physical properties of the spoil.

Saline water is also a byproduct of oil and gas production in the Colorado River Basin. It is not uncommon to produce several times the amount of saline waters as oil. In one month the oil and gas operators in Colorado produced approximately 25 million barrels of saline water. The salinity of production waters varies greatly from location to location and depends upon the producing formation. Common disposal techniques include evaporation, injection, and discharge to local drainages.

The future development of the oil shale resources in Colorado, Utah, and Wyoming has the potential to increase salt loading to the Colorado River. Salt increases can be attributed to the consumptive use of good quality water, mine dewatering, and, if surface retorting is used, the leaching of spoil materials similar to those of surface coal mining.

Reclamation and others are attempting to identify abandoned exploration wells that are leaking and develop plans to control the leaks. The Meeker Dome Salinity Control Unit identified and plugged several abandoned wells along the White River to prevent a salt dome (a geologic formation) from discharging saline water into the river.

Coal Bed Methane - The increase of the price of natural gas has led to an increase in the interest of developing the methane gas, which is found with coal, in the plentiful coal formations of the Upper Colorado River Basin. This coal bed methane (CBM) development could result in an increase in the salt loading of the Colorado River if the water associated with this type of drilling is discharged on the ground surface and allowed to get into waterways.

In Utah, coal bed methane wells are located in Emery, Carbon, Duchesne, and Uinta counties. The State allows up to 4 wells per section. Most (99%) of existing product wastewater from the CBM wells is reinjected and 1 % is impounded for evaporation. No surface discharges have presently been permitted. It is projected that even with greater development of CBM wells, the handling of the produced wastewater will not change.

Figure 8 - Photo of Coal Bed Methane Well.

In Colorado, all the product water from CBM development in the San Juan Basin in southwest Colorado is presently, and in the foreseeable future will be, reinjected. New CBM wells are permitted in the northwest part of the State and in Moffat and Rio Blanco Counties, where new CBM developments are being considered. The State averages for product wastewater in the western part of the State are 90 % reinjected, 9.5 % impounded, and 0.5 % surface discharged. Any surface discharged water has to meet the water quality criteria of no more that 1 ton/day salt.

In Wyoming, new CBM well development is beginning in the Little Snake River drainage (Carbon County) with only a handful of wells permitted. This CBM development has the potential to spread into the whole southwest corner of the State (Sweetwater, Uinta, and Lincoln Counties) if the price of natural gas stays high. This part of the State could have over 10,000 new CBM wells if development takes off as it has in the Powder River Basin. Presently, the State will allow surface discharge of up to 1 ton/day per operator (not per well). CBM development in the southwest part of the State will most likely involve reinjection of most if not all of the waste water since the quality of the groundwater found in these coal beds is highly saline and of poor quality.

The recent push for increased development of coal bed methane and other energy sources in the Rocky Mountain area poses a potential for increased salinity due to the brine or saline ground water discharged from the wells into the Colorado River Basin.

FUTURE WATER DEVELOPMENT

Tables 2 and 3, summarize the projected depletions used by Reclamation to evaluate the effects of water use and depletions for this progress report. These water use estimates were compiled as the first step in the evaluation process. Table 2 summarizes the estimated depletion of water through full basin development for the mainstem Upper Colorado River Basin. The projections were made in consultation with individual States within the Colorado River Basin and the Upper Colorado River Commission; however, the States do not necessarily concur with the projections adopted by Reclamation for planning purposes.

The Upper Colorado River Basin Compact provides that the States of Arizona, Colorado, New Mexico, Utah, and Wyoming will share in the consumptive use of water available in the Upper Colorado River Basin in the following proportions: Arizona, 50,000 acre-feet; Colorado, 51.75 percent of the remainder; New Mexico, 11.25 percent of the remainder; Utah, 23.00 percent of the remainder; and Wyoming, 14.00 percent of the remainder.

Each Upper Colorado River Basin State is charged a proportionate share of the total evaporation. Figure 9 illustrates the historic Upper Basin States usage of the Colorado River (CUL) water and their projected (modeled) future river water use (CRSS). The depletions for the Lower Colorado River shown in Table 3 include only mainstem use of the Colorado River in the Lower Colorado River Basin. Reclamation's river simulation model does not model consumptive uses of the Lower Colorado River Basin tributaries. Fixed inflow values are used for the tributaries. Colorado River Basin use data (including tributary use) may be found in Reclamation's *Colorado River System Consumptive Uses and Losses Reports* or on the web at:
www.usbr.gov/uc/library/envdocs/reports/crs/crsul.html

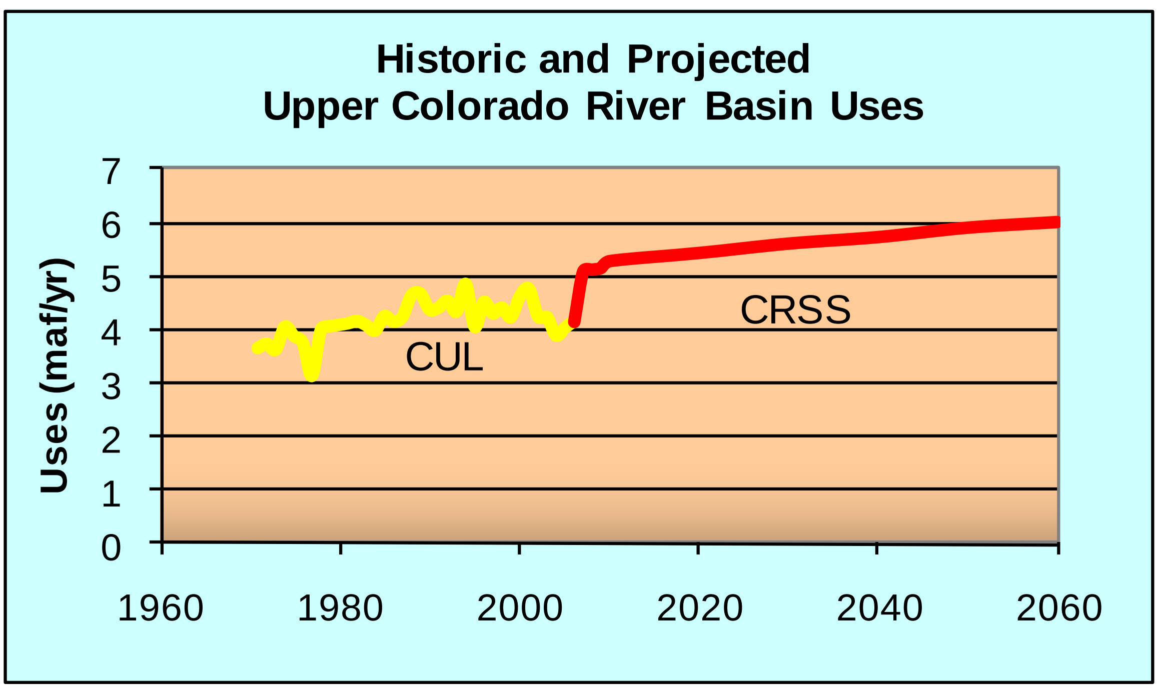

Figure 9 - Historic and Projected Water Uses.

Table 2 - Upper Basin Depletion Projections (1000 af/yr)

UPPER BASIN	2010	2020	2030	2040	2050	2060
Arizona						
Total scheduled depletion	50	50	50	50	50	50
State share of 6.0 maf	50	50	50	50	50	50
Remaining available	0	0	0	0	0	0
Percent of State share available	0	0	0	0	0	0
Colorado						
Total scheduled depletions	2,580	2,626	2,675	2,703	2,776	2,784
Evaporation storage units	295	295	295	295	295	295
Total	2,875	2,921	2,970	2,998	3,071	3,079
State share of 6.0 maf	3,079	3,079	3,079	3,079	3,079	3,079
Remaining available	204	158	109	81	8	0
Percent of State share available	7	5	4	3	0	0
New Mexico						
Total scheduled depletions	548	589	604	605	605	605
Navajo Reservoir evaporation	28	28	28	28	28	28
Evaporation storage units	58	58	58	58	58	58
Total	634	675	690	691	691	691
State share of 6.0 maf	669	669	669	669	669	669
Remaining available	35	-6	-21	-22	-22	-22
Percent of State share available	5	-1	-3	-3	-3	-3
Utah						
Total scheduled depletions	1009	1055	1129	1177	1207	1230
Evaporation storage units	120	120	120	120	120	120
Total	1129	1175	1249	1297	1327	1350
State share of 6.0 maf	1369	1369	1369	1369	1369	1369
Remaining available	240	194	120	72	42	19
Percent of State share available	18	14	9	5	3	1
Wyoming						
Total scheduled depletions	517	535	571	615	687	760
Evaporation storage units	73	73	73	73	73	73
Total	590	608	644	688	760	833
State share of 6.0 maf	833	833	833	833	833	833
Remaining available	244	225	189	145	74	0
Percent of State share available	29	27	23	17	9	0

Note: Evaporation from storage units - Estimates for evaporation from Lake Powell, Wayne N. Aspinall Unit, and Flaming Gorge Reservoirs are allocated as described in Article V of the Upper Colorado River Compact.

New Mexico will use more than their share of water if the future projected use is met.

Table 3 - Lower Basin Depletion Projections (1000 af/yr)

LOWER MAINSTEM	2010	2020	2030	2040	2050	2060
Nevada						
Robert B. Griffith Water Project	264	264	280	280	280	280
Other users above Hoover Dam	7	7	7	7	7	7
Southern California Edison	16	16	0	0	0	0
Ft. Mohave Indian Reservation	9	9	9	9	9	9
Laughlin and users below Hoover Dam	4	4	4	4	4	4
Total	300	300	300	300	300	300
Arizona						
Imperial Wildlife Refuge	10	9	10	10	10	10
Lake Havasu Wildlife Refuge	5	5	5	5	5	5
Fort Mohave Indian Reservation	73	73	73	73	73	73
City of Kingman	0	0	0	0	0	0
Mohave Valley I&D District	23	17	17	17	17	17
Bullhead City and other M&I	4	5	6	6	6	6
Cibola Valley I&DD, Parker and others	24	27	30	32	34	34
Lake Havasu I&D District	13	12	12	12	12	12
Central Arizona Project	1425	1419	1406	1398	1395	1395
Colorado River Indian Reservation	414	463	463	463	463	463
Cibola Wildlife Refuge	8	8	16	16	16	16
Gila Project	505	477	476	476	476	476
City of Yuma	27	30	35	41	41	41
Yuma Project - Valley Division	248	234	229	229	230	230
Cocopah Indian Reservation	12	12	12	12	12	12
Other users below Imperial Dam	9	9	10	10	10	10
Total	2800	2800	2800	2800	2800	2800
California						
City of Needles	1	1	1	1	1	1
Metropolitan Water District	855	852	852	852	802	802
Fort Mohave Indian Reservation	12	12	12	12	12	12
Chemehuevi Indian Reservation	5	8	8	8	8	8
Colorado River Indian Reservation	19	39	39	39	39	39
Palo Verde Irrigation District	373	366	366	366	366	366
Yuma Project Reservation Division	47	54	54	54	54	54
Imperial Irrigation District	2711	2641	2611	2611	2661	2661
Coachella Valley Water District	376	426	456	456	456	456
Other uses Davis to Parker Dam	1	1	1	1	1	1
Other uses below Imperial Dam	0	0	0	0	0	0
Total	4400	4400	4400	4400	4400	4400
Unassigned						
Fish, wildlife, and recreation	515	515	515	515	515	515
Yuma Desalting Plant	120	120	52	52	52	52
Total	635	635	567	567	567	567

Note: In the LC Basin, depletions are from mainstem diversions of the Colorado River only. Does not include depletions from diversions of Colorado River tributaries or evaporation from mainstem reservoirs. The Figures represent measured diversions less measured and estimated, unmeasured return flow that can be assigned to a specific project.

COMPLIANCE WITH THE SALINITY STANDARDS

Reclamation and the Basin States conducted salt-routing studies for the *2008 Triennial Review of the Water Quality Standards for Salinity, Colorado River Basin*. As part of the triennial review process, Reclamation used the Colorado River Simulation System (CRSS) river system model to evaluate whether sufficient salinity control measures are in place to offset the effects of development. The information provided in the next two sections of the report was used to evaluate compliance with the water quality standards.

In response to the Clean Water Act, the States have adopted water quality (salinity) criteria for the Colorado River Basin and the Environmental Protection Agency (EPA) has approved them at all three locations in the Lower Colorado River Basin. The standards call for maintenance of flow-weighted average annual salinity concentrations (numeric criteria) in the lower mainstem of the Colorado River and a plan of implementation for future controls.

The water quality standards are based on the *Water Quality Standards for Salinity, Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System,* prepared by the Colorado River Basin Salinity Control Forum, June 1975. The document was adopted by each of the Basin States and approved by EPA. A summary of the report follows:

> The numeric criteria for the Colorado River System are to be established at levels corresponding to the flow-weighted average annual concentrations in the lower mainstem during calendar year 1972. The flow-weighted average annual salinity for the year 1972 was used. Reclamation determined these values from daily flow and salinity data collected by the USGS and the Bureau of Reclamation. Based on this analysis, the numeric criteria are 723 mg/L below Hoover Dam, 747 mg/L below Parker Dam, and 879 mg/L at Imperial Dam.
>
> It should be recognized that the river system is subject to highly variable annual flow. The frequency, duration, and availability of carryover storage greatly affect the salinity of the lower mainstem; and, therefore, it is probable that salinity levels will exceed the numeric criteria in some years and be well below the criteria in others. However, under the above assumptions, the average salinity will be maintained at or below 1972 levels.
>
> Periodic increases above the criteria as a result of reservoir conditions or periods of below normal long-time average annual flow also will be in conformance with the standards. With satisfactory reservoir conditions and when river flows return to the long-time average annual flow or above, concentrations are expected to be at or below the criteria level.
>
> The standards provide for temporary increases above the 1972 levels if control measures are included in the plan. Should water development projects be completed before control measures, temporary increases above the criteria could result and these will be in conformance with the standard. With completion of control projects, those now in the plan or those to be added subsequently, salinity would return to or below the criteria level.
>
> The goal of the Salinity Control Program is to maintain the flow-weighted average annual salinity at or below the numeric criteria of the salinity standards. The program is not, however, intended to counteract the salinity fluctuations that

are a result of the highly variable flows caused by climatic conditions, precipitation, snowmelt, and other natural factors.

SALINITY CONTROL

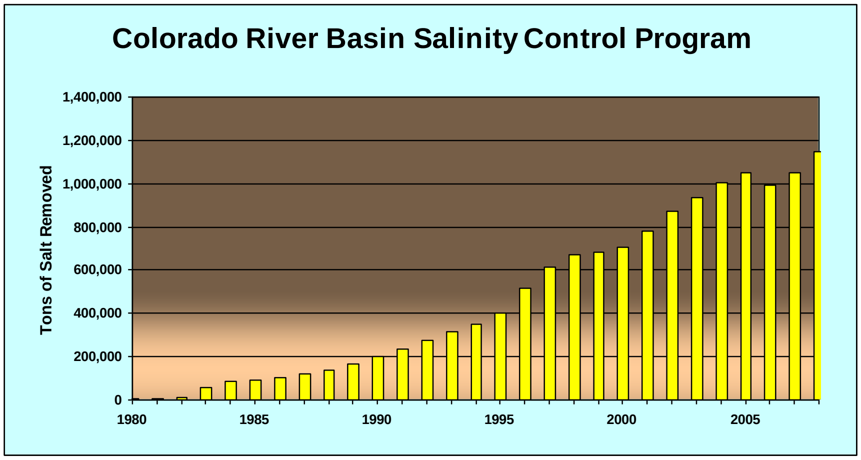

Figure 10 – 2008 Est. Salinity Control Progress; BOR, NRCS & BLM

Existing salinity control measures will prevent over a million tons of salt per year from reaching the river. By 2008 the salinity control program for Reclamation has controlled an estimated 598,300 tons of salt, while the USDA NRCS (NRCS) program has reduced an estimated 463,900 tons of salt, and the BLM has controlled an estimated 96,500 tons of salt per year from entering the Colorado River (Figure 10). Discussions within the Colorado River Salinity Control Forum have estimated that salinity control units will need to prevent nearly 1.9 million tons of salt per year from entering the Colorado River by 2030, in order to meet the standard and keep the economic damages minimized. To reach this objective, as shown in Table 4, the program needs to implement 741,000 tons of new controls beyond the existing 1,159,000 tons of salinity control presently in place (2008) as reported by Reclamation, USDA & BLM. About 35,000 tons per year of new salinity control measures must be added each year if the program is to meet the cumulative target of 1,900,000 tons per year by 2030.

To achieve this goal, a variety of salinity control methods are being investigated and constructed. Saline springs and seeps may be collected for disposal by evaporation, industrial use, or deep-well injection. Other methods include both on-farm and off-farm delivery system and irrigation improvements, which reduce the loss of water and reduce salt pickup by improving irrigation practices and by lining canals, laterals, and ditches. See Progress Report #21 for a more detailed description of each salinity control project and the salinity controlled by Reclamation, NRCS and BLM.

Table 4 - Salinity Control Requirements and Needs Through 2030

Estimated Salinity control needs (2030)	1,900,000 tons
Measures in place (2008)	- 1,159,000 tons
Plan of Implementation Target	741,000 tons

CHAPTER 3 – TITLE I SALINITY CONTROL PROGRAM

The Colorado River Basin Salinity Control Act (Salinity Control Act), Public Law 93-320, as amended, authorized the Secretary of the Interior (Secretary) to proceed with a program of works of improvement for the enhancement and protection of the quality of water available in the Colorado River for use in the United States and the Republic of Mexico. Title I enables the United States to comply with its obligation under the agreement with Mexico of August 30, 1973 (Minute No. 242 of the International Boundary and Water Commission, United States and Mexico [Minute No. 242]), which was concluded pursuant to the Treaty of February 3, 1944 (TS 994).

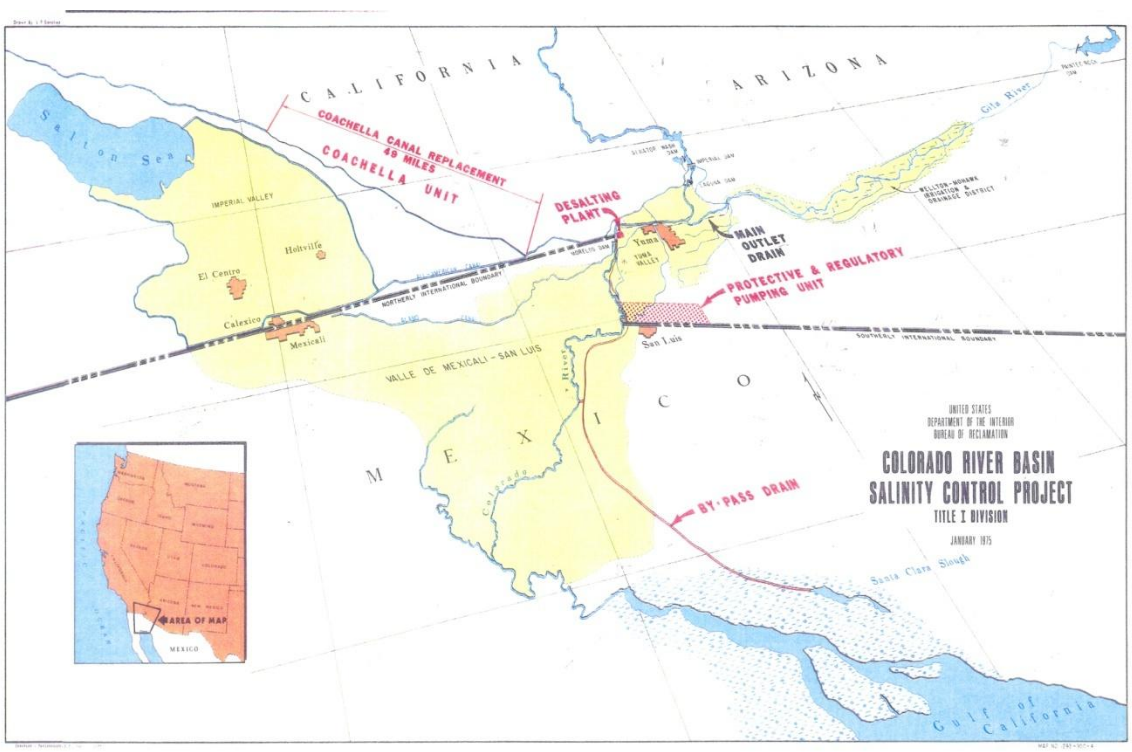

Figure 11 - Map of Title I Projects.

These facilities enable the United States to deliver water to Mexico with an average annual salinity concentration no greater than 115 parts per million (ppm) plus or minus 30 ppm (United States count) over the average annual salinity concentration of the Colorado River water at Imperial Dam.

The background and history of the Title I projects (Coachella Canal Lining, Protective and Regulatory pumping, Yuma Desalting Plant, Wellton-Mohawk Irrigation & Drainage District) can be found in Progress Report 22, chapter 4 at; http://www.usbr.gov/uc/progact/salinity/pdfs/PR22.pdf

Updates for the Title I projects since Progress Report 22 are as follows:

Coachella Canal Lining

No new activity or change since last progress report.

Protective and Regulatory Pumping

No new activity or change since last progress report.

Yuma Desalting Plant

The Yuma Desalting Plant (YDP) was constructed under the authority of the Colorado River Basin Salinity Control Act of 1974 to recover through desalination, the majority of the Wellton-Mohawk Irrigation and Drainage District agricultural return flows which bypass the Colorado River, thereby allowing the treated water to be delivered to Mexico as part of the 1.5 million acre-feet of Colorado River water that the U.S. must deliver to Mexico under the 1944 Water Treaty. Due to the high cost of operating the plant and general agency budget constraints, as well as surplus and normal conditions in the lower Colorado River Basin prior to the current drought, the YDP has not been operated; however, the facility has been maintained.

The U.S. has met the Treaty's salinity requirements by bypassing an average of 107,000 acre-feet of saline agricultural flows and then releasing additional water from Lake Mead. Since the diverted agricultural flows bypass the Colorado River, they are not counted as part of the 1.5 million acre-feet of Treaty water delivered annually to Mexico.

Metropolitan Water District of Southern California, Southern Nevada Water Authority, and Central Arizona Water Conservation District, collectively referred to as the Municipal Utilities, have jointly requested that Reclamation conduct a Pilot Run of the YDP to consider long term, sustained operation as a means to extend water supplies on the lower Colorado River during an unprecedented drought. Such consideration requires: 1) collecting performance and cost data; 2) identifying any remaining equipment improvements that are needed; and 3) testing changes that have already been made to the plant. Reclamation has developed a plan for a Pilot Run, in which the plant will operate for 365 days within an 18 month period at 1/3 capacity.

The Pilot Run is targeted to commence in May, 2010 and will add approximately 29,000 acre-feet of water to Colorado River system storage for an estimated cost of $23 million, of which about $14 million is being contributed by the Municipal Utilities. Based on the Intentionally Created Surplus (ICS) provisions of the Colorado River Interim Shortage Guidelines of December 2007, the entities will receive ICS credits in proportion to their capital contributions to the Pilot Run. The Pilot Run will be conducted in full compliance with all United States (U.S.) statutes. Reclamation has finalized an Environmental Assessment and the Finding of No Significant Impact. Reclamation received a discharge permit from the Arizona Department of Environmental Quality in accordance with the Clean Water Act.

Plant operation reduces the volume and increases the salinity of the flow to the Ciénega de Santa Clara (Ciénega) wetland in Mexico. Reclamation consulted with Mexico through the International Boundary and Water Commission which resulted in an agreement of joint cooperative actions including providing 30,000 acre-feet of water to the Ciénega. This water will be provided in equal one-third increments by the U.S., Mexico, and a bi-national coalition of non-governmental organizations. In addition, the Municipal Utilities are collaborating with the bi-national coalition to develop a monitoring program for the Ciénega.

Through a Cooperative Research and Development Agreement (CRADA) with the Municipal Utilities alternative configurations of the YDP will be tested in 2010 including alternative methods of pretreatment, low energy reverse osmosis membranes, and different feed water for the plant. The results of the Pilot Run and this CRADA will provide information necessary to evaluate the YDP's potential as a means to augment water supplies on the lower Colorado River.

Wellton-Mohawk Irrigation and Drainage District (WMIDD)

All permanent measures implemented by WMIDD are still in use, although the Federal program has been discontinued. Total crop acres have remained relatively stable since the early 1970's because more acreage is double-cropped than when the program was initiated. In particular, more vegetable crops are being grown in the district than in the past. Irrigation efficiency levels and return flow levels for 1990-2008 are shown on the following page, in Table 5.

Reclamation believes that the impacts of Gila River flows in 1992, 1993, and 1995 make irrigation efficiency and return flow data from the district questionable for 1992, 1993, 1994, 1995, and 1996. In 1993, the Gila River flood destroyed much of the WMIDD Main Conveyance Channel**;** so most of the drainage pumping went into the Gila River during 1993 and 1994 until these facilities could be repaired.

With the use of monthly groundwater table monitoring using observation well measurements as well as input from land users, WMIDD is able to maintain a drainage-pumping program that sufficiently maintains the agriculture root zone. Land users continue to maintain water efficient farming techniques with the use of dead level, high heads, and short runs.

Table 5 - WMIDD Irrigation Efficiency

Year	Pumped Drainage Return Flow (acre-feet)	Irrigation Efficiency, % (note: data provided by WMIDD)
1990	138,200	-
1991	144,900	68.8
1992	116,200	70.4
1993	8,970	68.8
1994	49,820	65.4
1995	121,500	64.3
1996	119,600	60.4
1997	91,695	62.2
1998	98,972	61.9
1999	94,869	63.0
2000	110,287	59.7
2001	107,908	60.9
2002	119,410	61.2
2003	116,477	57.8
2004	106,002	63.3
2005	110,770	64.6
2006	103,810	62.3
2007	112,910	62.6
2008	120,190	63.0
2009	105,482	na

CHAPTER 4 - TITLE II SALINITY CONTROL PROGRAM

Title II of the Salinity Control Act authorizes the Secretary of the Interior (Secretary) and the Secretary of Agriculture to implement a broad range of specific and general salinity control measures in an ongoing effort to prevent further degradation of water quality in the United States. These efforts are shown on the map below. The Act also calls for periodic reports on this effort. The report is to include the effectiveness of the units, anticipated work to be accomplished to meet the objectives of Title II with emphasis on the needs during the 5 years immediately following the date of each report, and any special problems that may be impeding an effective salinity control program. Title II also provides that this report may be included in the biennial Quality of Water Colorado River Basin, Progress Report. The history and background of the Title II projects can be found in Progress Report 21 at: http://www.usbr.gov/uc/progact/salinity/pdfs/PR21.pdf . Ongoing and active projects are listed in this report.

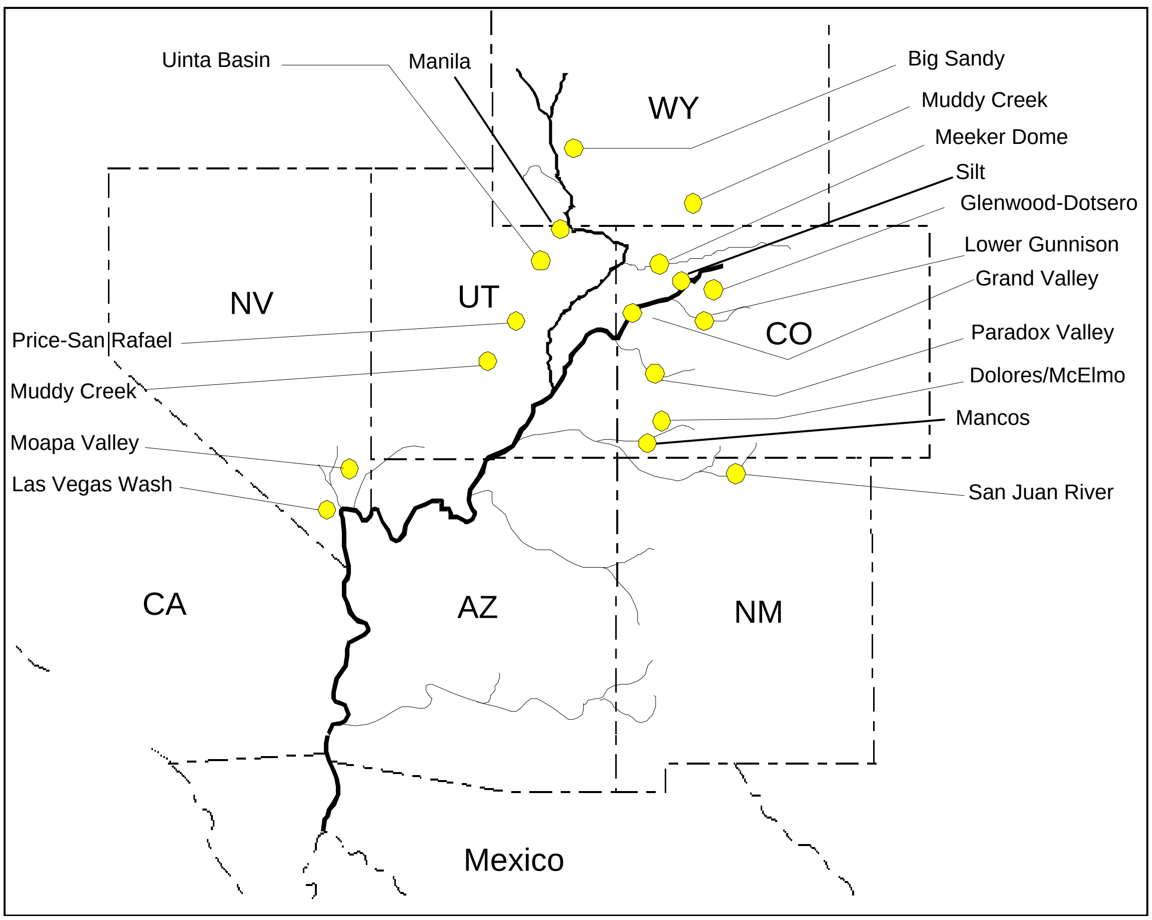

Figure 12 - Map of Title II Salinity Control Project Areas.

U.S. Bureau of Land Management

Public Law 98-569 directed the Secretary to develop a comprehensive program for minimizing salt contributions from lands administered by the Bureau of Land Management (BLM) and to provide a report on this program to the Congress and the Advisory Council. A report entitled *Salinity Control on BLM-Administered Public Lands in the Colorado River Basin* was completed for the Congress and the Advisory Council in 1987. The report discussed this ongoing program; outlined BLM's implementation actions; and quantified, classified, and mapped the saline soils on lands administered by BLM. The BLM's strategy is to provide the best management of the basic resource base. Successes with the resource base will translate to improved vegetation cover, better use of onsite precipitation, and stronger plant root systems. In turn, a more stable runoff regime and reduced soil loss should result; thus, benefiting water quality of the Colorado River.

The BLM administers 48 million acres in the Colorado River Basin above Imperial Dam, or 40 percent of the Colorado River Basin's area. Of the 48 million, approximately 7.2 million acres, or about 15 percent, contain saline soils (slightly, moderate, and strongly saline soils). Soil salinity is usually greatest where surface geology reflects saline marine shale and annual precipitation averages less than 12 inches. In depositional settings, soil salinity may also be high, even where the underlying geology is relatively non-saline.

The BLM is committed to its role in reducing the mobilization of salt on public lands. The BLM undertakes this responsibility through the multitude of individual management decisions that are made within each BLM jurisdiction. Progress in preventing salt from moving off BLM land is achieved through efforts to minimize the impacts of grazing, protect riparian areas, reduce off-road vehicle impacts, conduct prescribed burns, and generally manage vegetative cover and reduce erosion. As such, in the past, it has been difficult to single out salinity-control efforts for many of the projects that did have salt savings. In a step to strengthen our reporting effort, a restructuring of the allocation of salinity funding was done and new tracking and accounting systems were put in place in FY 2006. Thus, FY 2009 is the 4th year of reporting under the re-structured system.

For FY 2009 $800,000 (same as FY 2008) was allocated for BLM's salinity-control program. Funding goes to 4 major areas: Program administration (ADMIN); Planning (PLAN); Science (SCI); and On-the-ground implementation projects (OTG) (see Figure 13 for FY 2006 - 2009).

Tons of salt retained can not be calculated for program administration, planning, and science projects. However, one of the goals for the re-structured program in FY 2006 was to develop an accounting system to begin calculating more reliable 'tons of salt retained' for on-the-ground implementation projects.

Program Administration

During FY 2003, BLM created a new full-time, salinity coordinator position. The salinity coordinator began work in FY 2004. FY 2006 was the first full year of the newly re-structured program. The re-structured plan consists of 3 main parts: 1) Allocation of

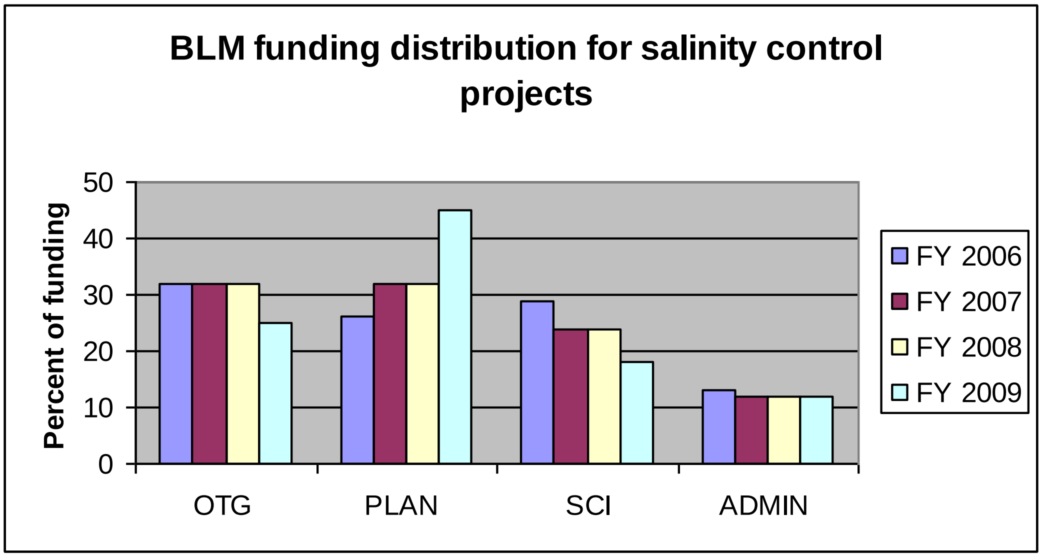

Figure 13 – BLM Salinity Control Program Funding Distribution

funds to the Upper Basin States (AZ, CO, NM, UT, and WY) based on submittal of project proposals; 2) A tracking system for projects that fit into BLM's Rangeland Improvement Project System (on-the-ground implementation projects); 3) Annual reporting consisting of narratives for on-going and current year, and a worksheet to determine 'tons of salt retained' for on-the-ground implementation projects. FY 2007 & 2008 program administration was a continuation of the framework put into place during FY 2006, however, there was an increased emphasis on capturing salt loading for more implementation projects (OTG). Projects that have been science or planning may become implementation projects in future years.

Planning

Planning is an important part of natural resource management. Resource management plans become the 'blueprints' for BLM's near future. As such, this is an opportunity to plan for salinity control, especially for some of our most important activities on public land such as energy development, grazing, and recreation. Planning projects that successfully captured salinity funding for FY 2009 include:

Colorado

- North Desert Salinity, Restoration near Fruita for off-highway vehicle designation - ongoing - $15,000
- Piceance Basin baseline water-quality monitoring - ongoing - $140,000

Utah

- Nine Mile Canyon near Price for soil erosion model - ongoing - $30,000
- Factory Butte OHV impact and soil study (Planning/Science) – Hybrid planning/science, ongoing - $25,000
- Pariette water-quality monitoring - ongoing - $90,000

Wyoming

- Progressive soil surveys managed from the State Office - ongoing - $54,000
- Erosion sediment modeling - ongoing - $31,000

Science

Salt loading from public lands is often episodic and can be dependent on factors such as: precipitation amount and intensity; topography; content and texture of soils; and the types, amount, and architecture of vegetative ground cover. The transit mode of salt loading can be surface-water runoff, or it can be ground-water recharge to streams and rivers. In a watershed, understanding which factors are most important and what is the main transit mode of salt loading can necessitate an investigation prior to determining the proper on-the-ground implementation project for good salinity control. The following science projects to investigate salt loading factors were funded from salinity monies during FY 2009:

Colorado

- Vegetation and soil stability project with USGS Biological Resources Discipline (BRD) in Badger Wash (central-western Colorado) to investigate grazing impacts on vegetation and sediments - ongoing - $35,000
- San Luis Valley wetlands salinity study $10,000

Utah

- Factory Butte OHV impact and soil erosion study - ongoing - $25,000

Wyoming

- Transport dynamics of salinity/sediment - ongoing - $25,000

Upper Colorado River Basin Regional project

- Forecasting phenological plant stage in the Upper Colorado River Basin - ongoing - $50,000

On-the-ground Implementation

When mechanisms of how salt loading occurs are understood and once planning is done, on-the-ground implementation projects follow. The success of an on-the-ground project is very much tied to understanding system mechanics and proper planning. The success is also tied to sufficient funding and trained natural resource personnel to go out in the field and construct or carry out the plan.

On-the-ground projects funded by salinity program allocations during FY 2009 include:

Arizona

- Rock Crossing dike system in Ft. Pierce Wash that is tributary to the Virgin River southeast of St. George, Utah - $50,000

Colorado

- Maintenance activities for Gunnison and Dolores River watersheds - $20,000

New Mexico

- San Juan River stabilization - ongoing - $35,000
- La Manga Canyon watershed restoration - ongoing - $50,000

- San Juan River salt/sediment retention structures - ongoing - $15,000

Utah

- Reducing OHV impacts on saline soils near Moab, Utah - $30,000

Table 6 - BLM Salt Retention Estimates for Fiscal Years 2006 – 2008

PROJECT CATEGORY	SALT RETAINED IN TONS / YEAR [1]		
	FY 2006	FY 2007	FY 2008
POINT SOURCE[2]	14,600	14,600	14,600
NONPOINT SOURCE[3]	3,300	26,000	81,900
ALL PROJECTS	17,900	40,600	96,500

1 Rounded to the nearest 100 tons.

2 BLM's Salinity Report to Congress through the year 2002, plus the plugging of 2 wells in Utah during FY 2004 (approximately 5,000 tons/yr).

3 Amount that could be calculated, i.e., this is a minimum.

U.S. Department of Agriculture (USDA)

The Natural Resource Conservation Service (NRCS) of the United States Department of Agriculture (USDA) conducts Colorado River Basin Salinity Control activities under the authorities of the Environmental Quality Incentives Program (EQIP). EQIP was enacted with passage of PL104-127, Federal Agricultural Improvement Act of 1996, a.k.a. "1996 Farm Bill" and reauthorized by PL 107-171, The Farm Security and Rural Investment Act of 2002, the "2002 Farm Bill" and by PL 110-246, The Food, Conservation, and Energy Act of 2008, the "2008 Farm Bill." The 2008 Farm Bill expires September 30, 2012.

Through EQIP, NRCS offers voluntary technical and financial assistance to agricultural producers, including Native American tribes, to reduce salt mobilization and transport to the Colorado River and its tributaries. Within the ten approved salinity project areas, producers may be offered additional financial incentives to implement salinity control measures with the primary goal of reducing offsite and downstream damages and to replace wildlife habit impacted as a result of the salinity measures.

In fiscal year 2008, $19.5 million of appropriated EQIP funding was allocated for financial and technical assistance to agricultural producers in eight project areas in Colorado, Utah, and Wyoming to share the cost with landowners and operators to install conservation systems that provide salinity control and wildlife habitat replacement.

New Salinity Projects and Investigations

Manila-Washam, Utah/Wyoming

Astride the Utah-Wyoming border, and adjacent to the shores of Flaming Gorge Reservoir, the Manila-Washam Project is the newest, authorized project area. This area of 11,000 acres of irrigated pasture and hayland contributes about 53,000 tons of salt annually to the Green River. Nearly 2000 acres have been treated or contracted since the first plans were developed in 2007. All new irrigation systems have been some form of sprinkler system, such as side roll, pods, or center pivots.

West Black's Fork, Wyoming

An area of some 28,000 acres of irrigated pasture and hayland near Lyman, Wyoming, contributes salt to the Blacks Fork River, tributary to the Green River. While a large portion of the area contributes little salt by geology, about 10,000 acres may contribute significant amounts of salt from canal and ditch seepage and deep percolation from water applied to fields. Further verification of stream data is needed to determine if cost effective salinity control measures are practical. Reclamation, NRCS, and the U.S Geological Survey are reviewing historical data to better characterize the salt "pick-up" values from the areas with treatment potential.

Plateau Creek, Colorado

Fifteen miles upstream from Grand Junction, Colorado, is the mouth of Plateau Creek that drains an intermountain basin north and adjacent to Grand Mesa. The community of Collbran serves this agricultural region of about 30,000 acres of irrigated hay and pastureland. A significant portion of the irrigation water supply is stored in Vega Reservoir and other small reservoirs and is transported by open, earthen canals and ditches. Reclamation constructed the Collbran Project to provide supplemental water to about 19,000 acres and full water supplies to another 2,500 acres. Investigations are being conducted to determine the salt loading from this area to the mainstem of the Colorado River. NRCS and the Colorado State Conservation Board plan to implement a pilot program that would provide financial incentives proportional to salt control.

White-Yampa Basin, Colorado

Narrow bands of irrigated pasture and hay land are found along the Yampa River near Craig, Colorado, and along the White River, near Meeker, Colorado. Extensive areas of dry cropland that is often summer fallowed also drain into these tributaries of the Green River. Recent salinity concentrations have trended upward. A hydrosalinity analysis is planned to determine if salt loading from agricultural lands is significant and cost effective to control.

McKinnon – Burnt Fork, Wyoming

The headwaters of the Henry's Fork (of the Green River) have provided rich resources, first for Native Americans, and then for immigrants who settled and introduced ranching and agriculture. About 20,000 irrigated acres (15,000 acres in Wyoming and 5,000 acres in Utah) contribute a significant salt load to the Henry's Fork River. Farmers and ranchers in this area have seen the improvements occurring in the adjacent irrigated areas around Manila, Utah, and have expressed their desire to implement a project. Initial water quality sampling during the 2008 irrigation season suggest that further investigation and planning is warranted.

San Juan Basin, New Mexico

In the 1990s, a salinity study indicated significant salt loading to the San Juan River from agricultural areas served from Navajo Reservoir. Interest has been expressed by local water districts there, particularly the San Juan Dineh Water Users Association, to update this earlier study to determine if cost effective salinity control is feasible.

Monitoring and Evaluation

Project offices continue to monitor and evaluate the effectiveness and quantity of salinity control, wildlife habitat, and economic performance replacement in order to improve overall performance and management of the program. Generally, the program continues to function effectively and economically, though the overall cost per ton of salt control rose sharply in some areas in 2008. It is also noted that additional efforts are needed to identify and implement valuable, low-maintenance, sustainable wildlife habitat replacement. The individual Monitoring and Evaluation reports for each project can be found on the world-wide-web at http://www.usbr.gov/uc/progact/salinity/index.html

Active Salinity Control Projects

Table 7 – Active Salinity Control Projects

Project Area

State	Project	Potential Irrigated Acres	USDA Servicing Office
Colorado	Grand Valley	60,000	Grand Junction
	Lower Gunnison River	171,000	Delta and Montrose
	McElmo Creek	29,000	Cortez
	Mancos Valley	11,700	Cortez
	Silt	7,400	Glenwood Springs
Utah	Uinta Basin	226,000	Roosevelt, Vernal, Ft. Duchesne
	Price/San Rafael Rivers	66,000	Price, Castle Dale
	Muddy Creek	6,000	Castle Dale
	Manila-Washam	8,000	Vernal
Wyoming	Big Sandy River	18,000	Farson

Grand Valley, Colorado

Implementation has been underway in this unit since 1979. Application of salinity control and wildlife habitat replacement practices continues. Farmers are installing underground pipelines, gated pipe, concrete lined ditches, land leveling, and a variety of other practices. Nearly all the orchards and vineyards in the Palisades and Orchard Mesa area are being irrigated with high-efficiency drip or micro-sprinkler irrigation. Field trials of buried drip irrigation for high value crops such as onions have shown promise.

The installation of surge irrigation systems is promoted by NRCS staff and other consultants. The surge units provide the participants with the capability of performing fertigation, which involves applying liquid nitrogen fertilizer during the soak stage of irrigation. Well-managed surge systems can approach or equal the application efficiency of some sprinkler systems. As of 2008 41,610 of the 60,000 acres planned to be treated have been and 92,658 tons, 69% of the salt control goal, has been achieved.

The valley is experiencing rapid urbanization. To understand the impacts of agricultural land conversion, the Basin States provided a grant to NRCS, the U.S. Geological Survey and the Mesa Conservation District partnership to conduct "Estimating Effects of the Conversion of Agricultural Land Use to Urban-Suburban Land Use on Water Budgets and Deep Percolation in the Uncompaghre Valley and Grand Valley, Western Colorado." The report can be obtained from the U.S. Geological Survey.

Lower Gunnison Basin, Colorado

This project encompasses the irrigated farmland in the Gunnison and Uncompaghre River valleys and is located in Delta and Montrose counties. Implementation of salinity projects was initiated in 1988 in this unit. Approximately 50 percent of the salt control goal has been achieved to date. As of 2008, of the 135,000 acres to be treated 56,491 acres have been with a total cumulative salt reduction of around 93,100 tons.

Application of salinity reduction and wildlife habitat replacement practices continue to be an integral part of the salinity control activities of Lower Gunnison unit. The major practices are underground pipelines, ditch lining, land leveling, irrigation water control structures, gated pipe, sprinkler, and surge irrigation system. Field-scale drip irrigation trials have proven successful. Premium prices for the aggressively marketed Olathe sweet corn are encouraging more intensive water management efforts. NRCS and the Basin States piloted the installation of one of the first center pivot irrigation systems in the project in 2004. The success of the pilot, among other factors, has resulted in acceptance and adoption of sprinkler irrigation systems in the project area. A significant portion of new contracts in 2007 and 2008 were sprinkler systems.

Mancos River, Colorado

This project, near the town of Mancos, Colorado, was initiated and approved for funding and implementation by USDA-NRCS in April 2004. The first EQIP contracts were signed in 2005 and implementation of improved irrigation systems is proceeding on schedule. Currently, 39 contracts have been developed with EQIP and Basin States Parallel funds. One large wildlife habitat replacement project has been installed. It is anticipated that approximately 5,400 acres of improved irrigation systems with salt control benefits will be installed over the project life and presently 914 acres have been treated. Presently 2,438 tons of salt per year have been controlled out of the estimated total of 11,940 tons of salt entering the Colorado River system per year.

McElmo Creek, Colorado

Implementation was initiated in this unit in 1990. Application of salinity reduction and wildlife habitat replacement practices continue to be implemented in this area with sprinkler systems, underground pipelines, and gated pipe being installed.

Development and use of automatic shutoff valves for sprinkler systems continue to be widely implemented in the project to achieve better water management. This project was planned to install predominantly sprinkler systems with a small number of improved irrigation systems. The goal for treated acres has been achieved. The salt reduction, however, has only reached about 46 percent of the goal or about 23,300 tons of salt. This is likely due to a lower percentage of sprinkler irrigation being installed. This area is also experiencing the conversion of agricultural lands to residential properties.

Uinta Basin, Utah

Implementation began in this unit in 1980. The rate of applying salinity reduction and wildlife habitat replacement practices continues to increase. Producer participation is exceeding the original projections. The major practices installed are sprinkler irrigation systems, improved surface systems, underground pipelines, and gated pipe. In this area, a large number of groups are replacing earthen laterals with pipelines to provide gravity pressure for on-farm sprinkler systems. More high-efficiency center pivot irrigation systems are being installed than originally projected.

The Utah Association of Conservation Districts (UACD) conducted a study, "Irrigation System Evaluation and Replacement Study" in 2007 of 59 side roll (wheel line) sprinkler irrigation systems in the project and interviewed 33 operators. Most systems continued to be operated at high efficiency, but as these systems near the end of their designed life, producers are concerned about the cost of rehabilitation. The backlog of applications to replace systems is growing. The cost per ton to rehabilitate or replace an existing system may approach $300. A combination of EQIP and Basin States funds has resulted in the implementation of approximately 137,500 tons of annual salt control.

Price-San Rafael, Utah

The Bureau of Reclamation (Reclamation) and USDA continued implementation of salinity control practices in the project area in fiscal year 2008. Underground pipelines are being installed by Reclamation to deliver water to the participating farms. The major practices being done on-farm by USDA are sprinkler irrigation systems. Participation is exceeding expectations; approaching 100 percent on many laterals. The project has reached more than 30 percent of its salt control goal and is controlling about 53,900 tons of salt.

A particularly large integrated project was approved for the Huntington-Cleveland area which may ultimately treat 16,000 acres of irrigated cropland. By using a Reclamation award to construct the off-farm components along with financial support from a majority industrial share-holder and USDA's EQIP, a large portion of the entire Price-San Rafael Project will be accomplished. Currently, about $4M of active EQIP contracts are in the Huntington-Cleveland group.

Muddy Creek, Utah

NRCS continues to receive applications for on-farm salinity control projects in this area, with potential obligations of $10 - $12 million. No funds have yet been obligated due to higher priority applications in the older salinity control areas, as well as the need to construct a large settling basin/control structure. The local irrigation district is actively pursuing options to locate funding to construct the needed silt-settling structure and it appears likely that the U.S. Army Corps of Engineers will provide assistance. This structure would be the first critical step to improving the delivery infrastructure that would enable on-farm salinity control measures.

Big Sandy River, Wyoming

Implementation has been underway in this unit since 1988. Application of salinity reduction and wildlife habitat replacement practices continue to be implemented. In this area, farmers are converting from surface flood irrigation to low-pressure center pivot irrigation systems for salinity control. Approximately 13,000 acres of the planned 15,700 acres have been treated (86 percent) reducing salt by approximately 56,000 tons. Producers also report that the water savings from improvements in irrigation systems now allows a full irrigation season of water for the entire irrigation district.

A field review by NRCS, U.S Fish and Wildlife Service and the Wyoming Game and Fish Department indicated that wildlife habitat replacement is “current and proportional” with salt control. Good opportunities exist, however, for further habitat enhancement.

Alkali Creek Tributary to Montezuma Creek, Utah

A project to investigate and demonstrate salinity control on grazing land is being implemented in southeastern Utah on Navaho Nation tribal lands. A partnership of NRCS from Utah and Arizona, Bureau of Land Management, Bureau of Indian Affairs and the Navajo Nation is contributing experimental design, data collection, and analysis and implementation of grazing land treatment practices in an effort to identify cost effective treatment in arid, grazed landscapes. The Basin States provided a grant of $92,000 to implement this project during 2006 and 2007.

Table 8 - USDA Salinity Control Unit Summary Through 2008

Unit	Controls (tons)	Potential[2] (tons)	Percent of Goal	Costs	* Annualized Costs	Projected Total Cost	Cost/ton
Uinta Basin, UT	137,426[1]	140,500	98	$88,874,177	$7,367,669	$90,862,150	$54
McElmo Creek, CO	23,326	46,000	46	$16,645,459	$1,379,909	$32,825,649	$59
Silt, CO	2,908	3,990	31	$2,174,278	$180,248	$2,983,277	$62[3]
Muddy Creek, UT	0	11,677	0	0	0	$11,655,523	$75[3]
Lower Gunnison, CO	93,113	186,000	47	$57,686,525	$4,782,213	$115,233,036	$51
Manila, UT	2,183	17,430	6	$1,971,052	$163,400	$15,737,725	$75

Grand Valley, CO	92,658	132,000	69	$48,759,426	$4,042,156	$69,462,369	$44
Price/San Rafael, UT	53,930	146,900	29	$20,142,084	$1,669,779	$54,865,050	$31
Mancos, CO	2,438	11,940	14	$4,334,171	$359,303	$21,226,416	$147
Big Sandy, WY	55,957	83,700	67	$13,347,780	$1,107,866	$19,965,495	$20
TOTALS	**463,939**	**780,137**	**60**	**$253,934,952**	**$21,052,543**	**$434,816,690**	**$45**

[1]Includes off-farm control

[2]Goal may not include off-farm control

[3]Projected

*Cost per ton based on amortization over 25 years at 6.625% interest (0.083)

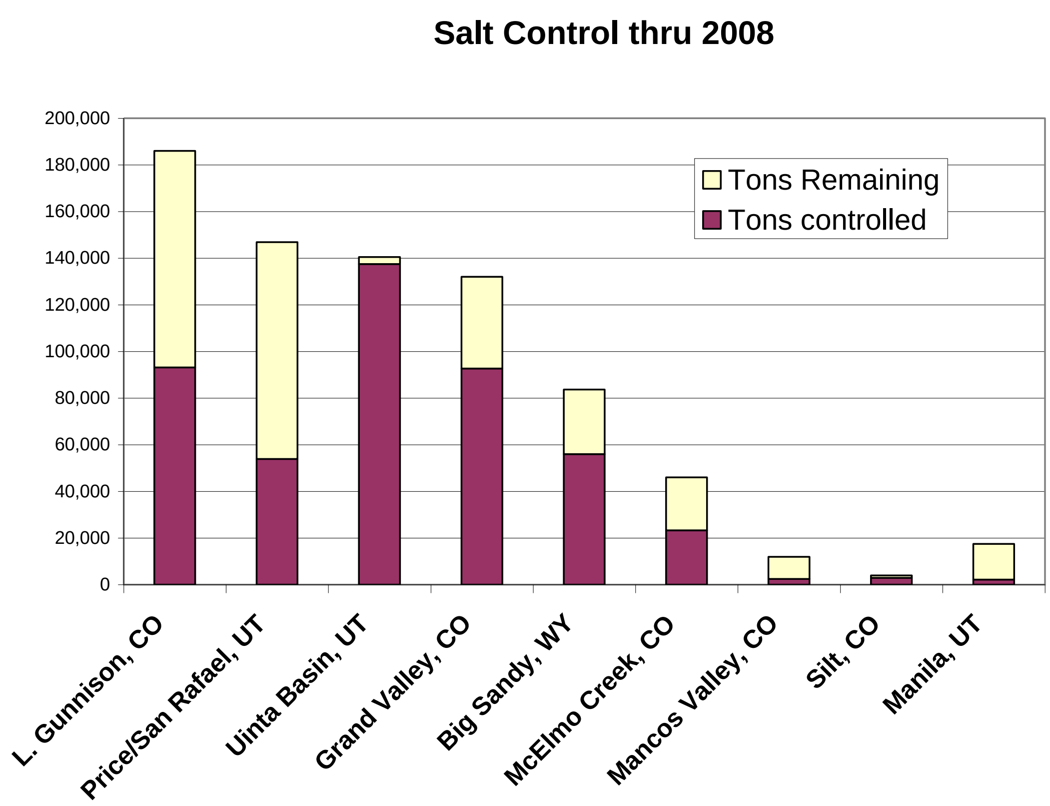

Figure 14 – NRCS On-Farm Salt Control Through 2008

U.S. Bureau of Reclamation

Program Summary

Background -- The Bureau of Reclamation involvement in the Colorado River Basin Salinity Control Program dates back to the early 1960's when salinity levels in the river started to rise. In 1968, Reclamation initiated a cooperative reconnaissance study in the Upper Colorado Basin. Study objectives were to identify feasible control measures and estimate their costs. This investigation evolved into several salinity control units. In 1974, Public Law 93-320 authorized the construction of the Grand Valley, Paradox, Crystal Geyser, Las Vegas Wash Units. In 1984, Public Law 98-569 authorized the construction of the Lower Gunnison and McElmo Creek Units.

By 1993, Reclamation had gained 20 years of experience with the program and identified new and innovative opportunities to control salinity, including cooperative efforts with USDA, BLM, and private interests, which would be very cost effective. However, these opportunities could not be implemented because the Congress did not specifically authorize them. The Inspector General's audit report (1993) noted the Salinity Control Act directed that "the Secretary shall give preference to implementing practices which reduce salinity at the least cost per unit of salinity reduction." The Inspector General concluded that the congressional authorization process for Reclamation projects impedes the implementation of cost-effective measures by restricting the program to specific, authorized units (specific areas).

The Inspector General recommended that Reclamation seek changes in the Salinity Control Act to simplify the process for obtaining congressional approval of new, cost-effective salinity control projects. Specifically, the Inspector General recommended Reclamation seek authorities similar to those provided to USDA in the 1984 amendments to the act, wherein USDA was empowered with programmatic planning and construction authority. At the time, USDA had only to submit a report to Congress and wait 60 days before it could proceed if Congress did not object. In contrast, Reclamation was required to seek approval of its projects through legislation. This had proved to be a cumbersome way to manage the program. With broader authorities, Reclamation would be able to take advantage of opportunities as they presented themselves, thus reducing costs.

Reclamation agreed with the Inspector General and wanted to explore any other innovative ideas, which would help improve the effectiveness of its program and take advantage of opportunities that were not envisioned 20 years ago. With most of the cost-effective portions of the authorized program nearing completion, this was a pivotal moment for the program. It would either be reauthorized or end in 1998 due to appropriation ceiling limits. From Reclamation's point of view, it seemed a very appropriate time to reassess the direction of the program.

In 1994, Reclamation and the Basin States developed legislation to broaden Reclamation's authorities so that it could manage the implementation of the program without further congressional approval. This legislation was introduced in Congress late in 1994 and was approved and signed into law (Public Law 104-20) in 1995. Congress will retain its fiscal oversight, but will leave the program's management to Reclamation. The 1995 amendments to the Salinity Control Act authorized Reclamation to pursue salinity control throughout the Colorado River Basin and required Reclamation to develop guidelines on how it would implement this new, basinwide approach to the program.

Guidelines -- Reclamation has prepared guidelines for its new Basinwide Salinity Control Program, which implements the recommendations made in the review of the program. As an alternative to adopting new, specific regulations, Reclamation administers the program through existing procurement techniques and established Federal regulations. Since February 1996, the program has been made available to the general public through this competitive process.

In 1984, Public Law 98-569 directed the Secretary to give preference to those projects which reduce salinity at the least cost per ton of salinity control. Since that time, cost effectiveness (cost per ton of salt removed) has been used to prioritize the implementation of salinity controls. However, cost effectiveness is only an estimate (prediction) of the project's cost and effectiveness at controlling salinity. Depending upon the project, there can be a degree of uncertainty in either of these values. Given the diversity of proposals that Reclamation may receive, an evaluation of the proposal's risks has been included in the current selection process.

All proposals (including those studied by Reclamation) are first ranked on their cost per ton of salt removed. This ranking is then adjusted for risk factors that might affect the project's performance. The performance risk evaluation considers both financial and effectiveness risks. For example, the Government is interested in limiting its risk of cost overruns. One way that performance risk could be reduced would be for the proponent to accept some risk through contractual limits on the Government's payments. Another method of limiting the costs would be to have the work bonded through a private bonding agency. The other major area of performance risk is in the amount of salinity control realized versus projected. Some types of salinity control are inherently more predictable or consistent than others. For example, industrial processes might have very little salinity control performance risk if the payments were based on a measurable product. On the other hand, the effectiveness of water management is often highly variable from farmer to farmer. Automation would be one way a farmer might propose to reduce this type of risk.

Ultimately, there is a tradeoff between risk and cost. In the end, eliminating risk may cost more than accepting some risk. A ranking committee is assembled to evaluate the tradeoffs between cost effectiveness and performance risks. The ranking committee is made up of representatives from the two cost-sharing partners, the Basin States and Reclamation. After the committee ranks the proposals, Reclamation attempts to negotiate the final terms of an agreement with the most highly ranked proponents. The first awards under this new process began in FY97.

Performance Review -- Past projects (Grand Valley, Paradox, Lower Gunnison, Dolores) have averaged slightly over $70 per ton. For a number of reasons, the new projects are much more cost effective, ranging between $20 and $35 per ton (see Tables 7 and 8).

One of the greatest advantages of the new program comes from the integration of Reclamation's program with USDA's program. Water conservation within irrigation projects on saline soils is the single most effective salinity control measure found in the past 30 years of investigations. By integrating USDA's onfarm irrigation improvements with Reclamation's off-farm improvements, significantly higher efficiencies can be obtained. If landscape permits, pressure from piped delivery systems (laterals) may be used to drive sprinkler irrigation systems at efficiency rates far better than those normally obtained by flood systems. The new authorities allow Reclamation much greater flexibility (in both timing and funding) to work with USDA to develop these types of projects.

The new authorities also allow Reclamation to respond to opportunities that are time-sensitive. Cost-sharing partners (State and Federal agencies) often have funds available at very specific times.

Another significant advantage of the program is that projects are "owned" by the proponent, not Reclamation. The proponent is responsible to perform on its proposal. Costs paid by Reclamation are controlled and limited by an agreement. Yet, unforeseen cost overruns can occur. The proponent has several options: the project may be terminated or the proponent may choose to cover the overruns with their own funds or borrow funds from State programs. The proponent may also choose to reformulate the project costs and recompete the project through the entire award process. For example, pipeline bedding and materials costs for the Ferron Project were underestimated in the proposal and subsequent construction cooperative agreement. The proponent was denied permission to award materials contracts for the pipeline, since the costs were beyond those contained in the agreement. After months of negotiations and analysis, the proponents elected to terminate the project, reformulate it, and recompete against other proposals the following year. Their project was found to be competitive at the reformulated cost and was allowed to proceed. Since this project ran into difficulties, none of the other projects have shown any problems.

Due to several issues that had arisen in the recent years from managing the Salinity Program, the Upper Colorado Regional Director, Reclamation, requested that an evaluation and review (Review) be completed of the Colorado River Basin Salinity Control Program (Salinity Program) administered by the Upper Colorado Region. A Project Management Plan for the Review was prepared and approved in May 2007, by the Regional Director and the Chairman of the Colorado River Basin Salinity Control Forum Work Group. Initial and Draft Review Documents were prepared during calendar year 2007 by Project Team, comprised mostly of Reclamation's Salinity Coordinators and provided to the Review Team, comprised of Reclamation staff outside of the Salinity Control Program and members of the Work Group, to review and provide comments. The Final Review Document was prepared during the spring of 2008 and sent to the Review Team and all members of the Work Group, June 27, 2008.

The Review served the following purposes:

1. Documented all existing procedures and policies
2. Sought recommendations to improve the Program, particularly in the areas where issues have arisen recently:
    a. Reimbursement requirement for operation and maintenance (O&M) for salinity control improvements
    b. Procedures for determining the tons of salt claimed
    c. The Request for Proposals (RFP) and agreement processes
    d. Differing standards and requirements for habitat replacement
    e. Salinity control improvements on Federal facilities versus non-Federal facilities
    f. The use of funds from Basin Funds

3. Identified areas where new procedures and policies need to be developed
4. Created a Standard Operation Procedure manual that can serve as guide for the future management and execution of the Program

The Review Document is a living document and will be subject to updating and revisions as the program progresses.

Basinwide S*alinity Control Program (Basinwide Program) (P.L. 04-20*)

In July 1995, Public Law 104-20 was signed into law. It authorizes the Secretary of the Interior to implement a basinwide salinity control program, directs the Secretary of the Interior to prepare a planning report on the new program, and authorized $75,000,000 to be appropriated. Additional authority was provided in November 2000 which increased the appropriation ceiling to $175,000,000. With cost sharing from the Upper and Lower Colorado River Basin Funds, the program has authority to expend up to $250 million within the Basin. In FY-07 Reclamation obligated and/or expended approximately $8.9 million in appropriations and approximately $3.8 million in up-front cost-sharing from the Basin Funds for a total Basinwide Program of $12.7 million and $11.39 million in 2008. Since the authorization of the Basinwide Program in 1996, approximately $105.6 million in appropriations and approximately $45.3 million in up-front cost sharing from the Basin Funds have been expended for a total program of $150.9 million. Through the last Request for Proposals (RFP) process in FY-06, five new project proposals were selected for funding totaling about $22 million and the cost effectiveness ranged from $27 to $33 per ton of salt. Construction on four of the projects and a project from the previous RFP were completed in FY-08. The fifth proposal selected in 2006 has encountered problems with increases in pipe prices and was advised to reformulate their proposal and submit it again in the future.

In 2007, it was determined that instead of soliciting proposals through the RFP process, they would be solicited through a process for financial assistance agreements called Funding Opportunity Announcements (FOA). Instead of evaluating the proposals in the TPEC process, they would be evaluated in a process common to negotiated procurement procedures where an evaluation committee would be organized that would be chaired by the Program Manager and have representatives from the Work Group and Reclamation area offices. This process would not follow the construction contract procedures and should allow more flexibility in the evaluation and agreement process.

In order to have projects ready to utilize the Basinwide Program funding in 2008 and beyond, an FOA was released in February 2008 soliciting applications to be submitted by May 2008. Twenty-five applications totaling over $167 million in salinity control projects were received. An Application Evaluation Committee (ARC) was organized that was chaired by the Program Manager and had representatives from the Work Group and Reclamation area offices. The applications were reviewed, evaluated, and ranked by the ARC under the criteria set forth in the FOA. Applications receiving highest rankings within the competitive range of less than $57 per ton of salt were selected and proposers were notified of the selection and negotiations were begun to execute an agreement. The proposers of the unsuccessful applications were also notified. If agreements are executed for all of the successful applications, $27 million worth of salinity control projects could be installed over the next 3-4 years.

In April, 2009, in response to funding available under the American Recovery and Reinvestment Act, another FOA was released. 23 applications totaling over $100 million in salinity control projects were received. The most competitive five projects totaling nearly $17 million were selected and awarded with cooperative agreements. These projects are expected to be completed by the end of FY 2010 and will result in reducing nearly 12,000 tons of salt per year.

New Reclamation Salinity Projects

Price- San Rafael Rivers Unit, Utah

The Huntington Cleveland Salinity Reduction Project is located in northern Emery County, in and around the towns of Huntington, Lawrence, Cleveland, and Elmo. Approximately 350 miles of open earthen canals and laterals are being replaced with a pressurized pipeline system to accommodate sprinkler irrigation on about 16,000 acres. Funding for this project is being shared between Reclamation's Basinwide Program, Huntington Cleveland Irrigation Company, NRCS's EQIP, the Parallel Program, and Rocky Mountain Power, formally known as Utah Power and Light. The last of Reclamation's share of $17,116,336 for the off-farm delivery system was obligated in 2008. The project, expected to be completed in 2012, will result in the annual reduction of 57,808 tons of salt in the Colorado River at an anticipated cost of $46/ton.

The $1,991,000 Butcher Lateral Salinity Control Project is located in Carbon and Emery Counties, Southeast of Price, Utah. It was selected from the applications received in the 2008 FOA. A Cooperative Agreement was executed in September of 2008. This project will replace approximately 73,300 feet of earthen laterals with 45,000 feet of pressurized irrigation pipe resulting in the annual reduction of 1,354 tons of salt in the Colorado River. It is expected that the pressurized pipeline will induce on-farm improvements resulting in the annual reduction of an additional 2,058 tons of salt. It is anticipated that the project will result in the total annual reduction of 3,412 tons of salt in the Colorado River at an anticipated cost of $49 per ton of salt.

Uinta Basin Unit, Utah

The Bureau of Indian Affairs (BIA) Salinity Reduction Project has been transferred to Central Utah Completion Act Office (CUPCA) sponsorship. There has been no activity on this project.

The Duchesne County II Salinity Reduction Project is located in Duchesne County, in and around Roosevelt, Utah. A total of 51.94 canal miles serving 13,350 acres is being replaced to accommodate pressurized pipeline systems, in order to facilitate sprinkler irrigation. The K2 and Pleasant Valley phases of the project are completed, but land easements from the Business Committee of the Ute Tribe of the Uintah and Ouray Agency need to be obtained in order to complete the last and final phase (TN Dodd) of the project. It is anticipated that the off-farm portion of this project will result in the annual reduction of 42,800 tons of salt in the Colorado River at $25 per ton of salt.

The Moffat-Ouray Pipeline Salinity Project near Gusher, Utah was completed in 2008. This project replaces approximately 30.2 miles of canals with pipelines and 15,900 tons of salt will be reduced annually to the Colorado River at a cost of $28 per ton. The abandoned canals have been replaced by pipelines which provide a pressurized irrigation system.

Tropic Project, Utah

The Habitat Replacement Plan was completed and approved on October 11, 2007. The Construction Contract was awarded August 30, 2007, and the construction replacing the 5-mile long open earthen East Valley Canal with a pipeline system was essentially completed in June 2008. The project resulted in the annual reduction of 1,829 reportable tons of salt in the Colorado River at an anticipated cost of $28 per ton of salt.

Grand Valley Unit, Colorado

As a result of selection under the 2008 Basinwide Program FOA, the Grand Valley Irrigation Company was awarded a $3 million cooperative agreement to line about 3 miles of their main canal within the city of Grand Junction. A salt loading reduction of approximately 4,500 tons annually is expected. The canal lining will consist of a PVC membrane with a shotcrete cover. Construction started in November 2008 and will be completed in 2011.

Lower Gunnison Basin Unit, Colorado

In FY07, the Uncompaghre Valley Water Users Association continued with Phase 2 of the East Side Laterals piping project in the Cedar Creek area, southeast of Montrose. The current effort, which began in FY05, is piping a total of 20.5 miles of laterals under the South Canal system using $2.1 million of Basinwide Salinity Program funding supplemented by $2.2 million of Departmental Irrigation Drainage Program (DIDP) funding for selenium remediation. Phase 2 was completed in 2009.

Phase 3 involves the piping of another 11 miles of laterals. This phase has salinity-control funding as well as funding from DIDP and also from an EPA Section 319 grant. Construction of Phase 3 began in November 2007 and is scheduled for completion by the end of 2011.

Ongoing Reclamation Salinity Control Projects

Big Sandy River Unit

The Big Sandy River Unit is located near Farson and Eden in Sweetwater County in southwestern Wyoming. The purpose of the Big Sandy River Unit investigation was to determine the feasibility of lowering the salt inflow to the Big Sandy River. The study was specifically directed toward reducing salt pickup from seeps and springs along a 26-mile reach of the Big Sandy River west of Eden, Wyoming. Feasibility planning was authorized by the Colorado River Basin Salinity Control Act (Public Law 93-320) of

1974 and the Water Resource Development Feasibility Investigations Act (Public Law 96-375) of October 1980.

Investigations indicate that seeps, which surface in the Bone Draw and Big Bend areas, produce saline water at a rate of about 27 cubic feet per second (ft^3/s). The salinity here varies from 1,000 to 6,000 milligrams per liter (mg/L) along the Big Sandy River, with a total annual contribution of more than 164,000 tons of salt. Indications are that salt is picked up by water contacting the shale of the Green River Formation beneath the surface and eventually seeping into the river. Irrigation was identified as a significant contributor to the water source recharging the springs.

Reclamation has studied alternatives to intercept the springs and seeps and then transport, treat and use, or dispose of the saline water. In the irrigated area, off-farm solutions such as selective lining of canals and laterals were studied.

Studies conducted in cooperation with USDA indicated that control of onfarm irrigation is the most cost-effective alternative for controlling salinity from the Big Sandy River Unit. Because of past selective lining programs, the canals and laterals showed relatively low seepage rates, offering little room for improvement.

In 2006 the local water district applied for funding for a new salinity control project. This funding was to be supplemented by the state of WY. In 2006 & 2007 new seepage tests were conducted by Reclamation to determine if the linings on various canals and laterals were still functioning. It appears that at some locations as the canals were cleaned the clay lining was removed and deposited along the bank. In 2007 a review of the salt loading at the USGS gages on the Big Sandy was performed to determine if seepage from the agricultural area has changed from what was originally calculated.

Lower Gunnison Basin Unit

The Lower Gunnison Basin Unit is located in west-central Colorado in Delta and Montrose Counties. The unit was authorized for investigation by the Colorado River Basin Salinity Control Act (Public Law 93-320) of 1974. An amendment to the act, Public Law 98-569, later authorized portions of the unit for construction in 1984.

An estimated 360,000 tons of salt is added to the Colorado River annually from the Uncompaghre Project, a Reclamation irrigation project built in the early 1900’s. Studies indicate that salt loading occurs when irrigation conveyance system seepage and irrigation return flows pass through highly saline soils and the underlying Mancos Shale Formation. By reducing the amount of groundwater percolating through these saline soils, salt loading to the Colorado River is being reduced.

With Reclamation funding, the water districts have completed the winter water facilities. Reclamation has completed plans for local improvements to the irrigation delivery systems. USDA is implementing onfarm improvements, including upgrading irrigation systems and improving irrigation management.

The Uncompaghre Project is a Federal development constructed in the early 1900’s for irrigation of approximately 86,000 acres. Approximately 34 percent of the total 86,000 irrigated acres are on Mancos-Shale-derived soils. These soils are naturally high in both salt and selenium. Reclamation and USDA have implemented various salinity control measures in the area.

The Salinity Control Act authorizes the construction of winter water replacement facilities in the Uncompaghre River Valley and irrigation delivery system improvements on the more saline, east side of the valley. The plan of development includes the winter water replacement and lateral lining programs. Although authorized for construction, the canal lining has not been competitive with other, lower cost alternatives within the Salinity Control Program. The canal lining construction program remains in a deferred status.

The objective of the winter water replacement program is to eliminate winter livestock watering from the unlined canal and lateral system. Water is made available for livestock through an expansion of the existing culinary water system using relatively small, 2- to 6-inch polyvinyl chloride pipe. This modification reduces canal seepage during the non-irrigation season, reducing salinity from the system by about 50 percent. Work on this portion of the unit was completed in 1995.

The remaining portion of the project, the East Side Lateral portion, will compete for funding in Reclamation's Basinwide Salinity Control Program under the authorities of Public Law 104-20. In FY98, Reclamation solicited proposals for salinity control efforts under its basinwide authorities. The Uncompaghre Valley Water Users Association (UVWUA) submitted a proposal for a project which would cost share salinity control activities with the Department of the Interior's National Irrigation Water Quality Program (NIWQP). Cost sharing from the NIWQP enabled this project to be competitive with other projects. The project was recommended for implementation by Reclamation's salinity control evaluation committee. The project reduces salinity in the Colorado River by about 2,300 tons of salt per year. The Salinity Control Program has contributed $890,000. The NIWQP has contributed $730,000. Environmental compliance for this project was completed in 1995 as part of Reclamation's Lower Gunnison Basin Unit, Environmental Assessment/Finding of No Significant Impact. The UVWUA has replaced approximately 7.5 miles of unlined earthen irrigation laterals with buried pipe in the Uncompaghre Project's South Canal system. Construction of this portion of the project was completed in 2000. A report titled *Effects of Piping Irrigation Laterals on Selenium and Salt Loads, Montrose Arroyo, Western Colorado,* WRI Report 01-4204 by the USGS shows the project reducing both salinity and selenium. It is anticipated that more future joint projects will be pursued between the two programs.

Mancos Valley Unit

The Mancos Valley Unit is a 9,200-acre-irrigated area along the Mancos River, a tributary to the San Juan River. The area is very saline (Mancos shale) and should respond well to joint Reclamation/USDA irrigation efficiency improvements similar to those being implemented in Utah. Planning studies of this unit which began in 2002 continue.

McElmo Creek Unit - Dolores Project

The McElmo Creek Basin is located in southwestern Colorado and covers approximately 720 square miles. About 150 square miles of the basin, mostly in the east, are agricultural land. Early studies show that salt loading results from both irrigation and diffuse sources, with irrigation being the main contributor.

The total irrigation diversion into the area averages 105,200 af/yr. The average salt load contributed by the McElmo Creek Basin was estimated at 119,000 tons per year. The Montezuma Valley Irrigation Company diverts water from the Dolores River to serve irrigation in the McElmo Creek Basin. The salinity of the diversion averages 130 mg/L. Return flows from agriculture increase the salinity in McElmo Creek to about 2,600 mg/L at the Colorado-Utah State line.

The study included testing canal seepage, developing a hydrosalinity budget, and evaluating salinity control alternatives. The study tested canal seepage at 15 sites along 115 miles of canals. Groundwater monitoring included 125 wells for water table elevation, salinity, and hydraulic conductivity. Irrigation research was done on seven test farms representing various soil types, farm sizes, irrigation methods, and farm management.

Results indicate seepage rates for most of the Montezuma Valley Irrigation Company distribution system are low to moderate except for locations where canal sections have been cut through shale. The plan was to improve three sections of Montezuma Valley Irrigation Company canals, two on the Lone Pine lateral and one on the Upper Hermana lateral, and to install laterals from the Towaoc-Highline Canal to serve the Rocky Ford Ditch service area. The Rocky Ford Ditch would then be abandoned as part of the plan, and its flows would be combined into the Towaoc-Highline Canal. The plan will reduce groundwater seepage from canals by 4,060 acre-feet a year and reduce the amount of salt returned to McElmo Creek.

The McElmo Creek Unit was authorized for construction by Public Law 98-596 in October 1984 as part of the Dolores Project, a participating project of the Colorado River Storage Project. Included in the project were seepage control from the Towaoc-Highline Canal, Rocky Ford laterals, Lone Pine lateral, and the Upper Hermana lateral. The improvements have been completed.

Verification Studies -- Reclamation is maintaining a gauge in McElmo Creek to monitor the outflow from the unit area, but because of the unit's relatively small size and the concurrent construction of the Dolores Project (irrigation), the effects of canal and lateral lining will probably be masked. Irrigation efficiency improvements in other project areas have been shown to be effective.

Paradox Valley Unit

The Paradox Valley Unit was authorized for investigation and construction by the Salinity Control Act (Public Law 93-320) of 1974. The unit is located in southwestern Colorado along the Dolores River in the Paradox Valley, formed by a collapsed salt dome (Figure15). Groundwater in the valley comes into contact with the top of the salt formation where it becomes nearly saturated with sodium chloride. Salinities have been measured in excess of 250,000 mg/L, by far the most concentrated source of salt in the Colorado River Basin. Groundwater then surfaces in the Dolores River. Studies conducted by Reclamation show that without salinity controls the river would pick up more than 205,000 tons of salt annually as it passes through the Paradox Valley. This project intercepts the high saline water (brine), before it reaches the Dolores River, and disposes of it by deep well injection (injection interval about 14,000 feet below ground surface) (Figure 16).

In its definite plan report (September 1978), Reclamation recommended that a series of wells be drilled on both sides of the Dolores River to intercept the brine before it reached the river. The brine would then be pumped to an evaporation pond in Dry Creek Basin. A draft environmental statement was prepared for this plan and made public on May 11, 1978; a final statement was filed with EPA on March 20, 1979. Due to the potential for environmental impacts, EPA recommended that Reclamation investigate deep-well injection as an alternative method of disposal.

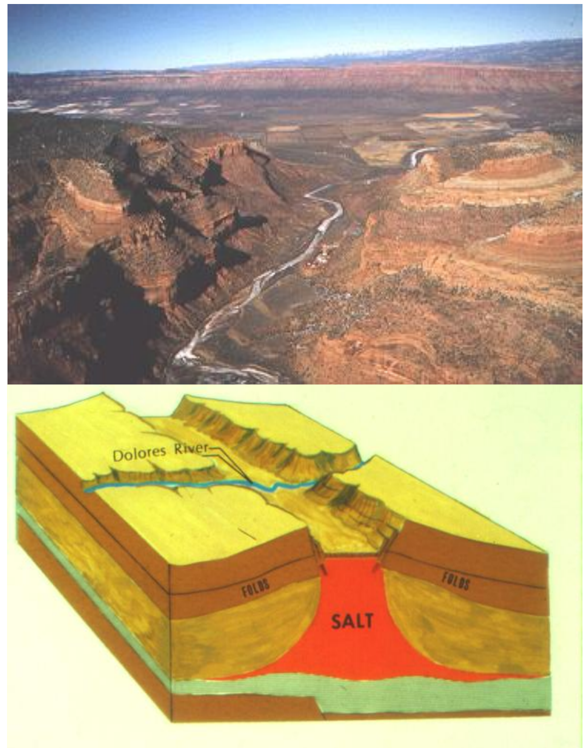

Figure 15 - Paradox Valley.

A private consulting firm completed a feasibility study of deep-well injection and concluded it to be technically, economically, and environmentally feasible. Reclamation then contracted with a second consulting firm to do a more detailed study of injection and to design the disposal system including injection well and surface facilities. A final design for the test injection well was completed in August 1985.

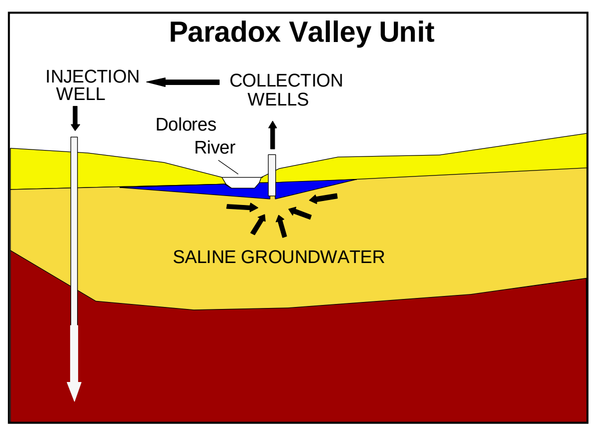

Figure 16 - Schematic of Paradox Project.

Facilities have been installed and mechanical tests performed. Over the years numerous mechanical and electrical problems with the facilities have been identified and solved. Several new technologies were developed to overcome the extremely high pressures created by the injection pumps. In fiscal year 2000, the Paradox Valley Seismic Network (PVSN) showed seismic activity at the injection site reached levels and frequencies that

were unacceptably high. Restricting the maximum injection rate to 230 gpm in July 2000 has reduced seismic activity, but has also reduced the effectiveness of the injection facility to about 76,000 tons per year.
In January 2002, a test to inject 100 percent brine was implemented after temperature logs of the well showed that the area around the well bore and injection zone had cooled sufficiently to prevent precipitation problems near the well bore. Since January, facility disposal has increased by approximately 35,000 tons per year and there is no indication of apparent adverse effects from 100 percent brine injection. Reclamation will continue to carefully monitor injection pressures for buildups that might suggest plugging of the aquifer near the well bore. Seismic activity remained low during fiscal year 2002 and remains at a very low frequency and magnitude. Figure 17 shows the number of seismic events measured on the Paradox Valley Seismic Network from 1998-2007.

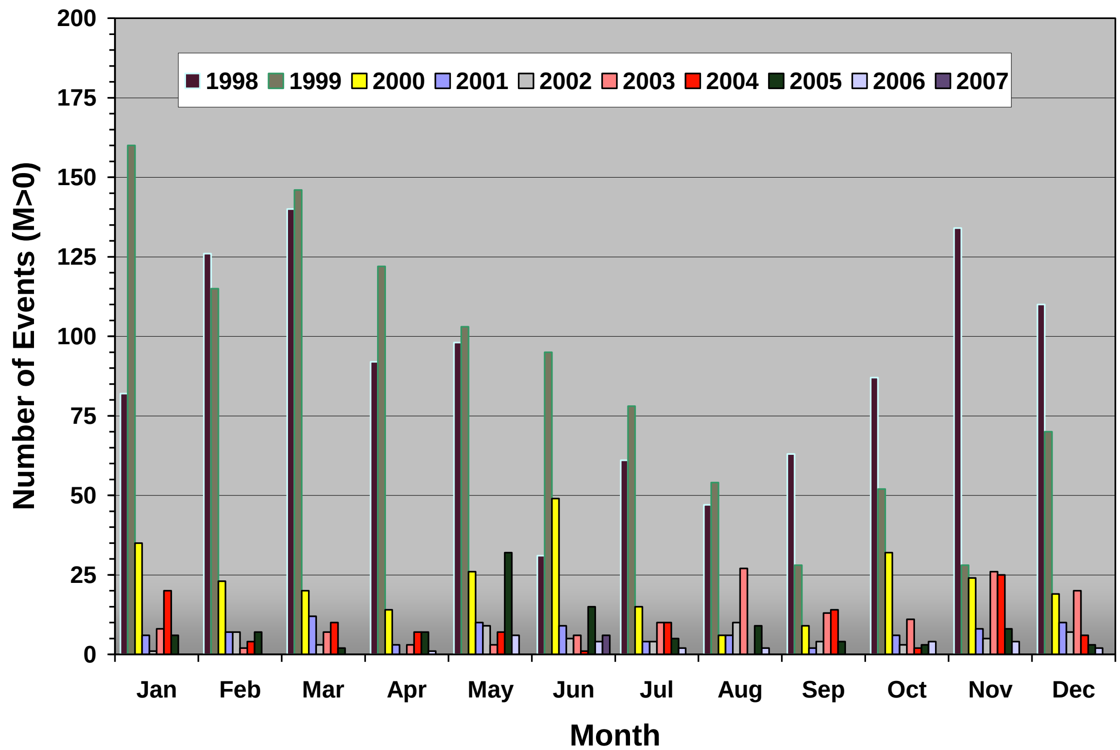

Figure 17 – Paradox Valley Seismic Network Events per Month (Magnitude > 0.0)

The project continues to intercept and dispose of 100,000+ tons of salt annually, but the pressure necessary to inject the brine into the disposal formation at 14,000 feet is increasing. Modification of the current facility to operate at a higher injection pressure to extend the life of the current injection well is under way. Reclamation has also initiated a Plan of Study to investigate the feasibility of other salt removal alternatives to augment the project, including a second injection well. As part of the Plan of Study, an investigation of alternative salinity control methods was completed in June in 2008. The results of the investigation indicated a need for a current characterization of the regional groundwater flow to determine the appropriate strategy for future salinity control efforts. The groundwater study started in 2009 and is ongoing.

Price-San Rafael Rivers Unit

The Price-San Rafael Rivers Unit is located in east-central Utah, 120 miles southeast of Salt Lake City, encompassing Carbon and Emery Counties. Agriculture and energy development (primarily coal mining) make up the principal economic base in the area. Both the Price and San Rafael Rivers drain into the Colorado River via the Green River.

Figure 18 - Salinity from Canal Seepage.

Salinity contributed to the Colorado River from the Price River and San Rafael River basins occurs principally as a result of the dissolution of soluble salts in the soil and substrata. Return flows from irrigation and runoff from precipitation transport salts to natural drains and eventually into the streams and rivers. An estimated 430,000 tons of salt per year reach the Colorado River from these two river basins. Of this amount, approximately 60 percent is attributed to agriculture.

Reclamation has evaluated five alternative plans. These alternatives involve improving irrigation systems; using drain water for powerplant cooling; collecting saline water and disposing of it through deep-well injection, evaporation ponds, or a desalting plant; using saline water for energy development (coal washing, tar sands, or coal slurry pipeline); and retiring land from irrigation. Of these, the irrigation systems improvement alternative passed the four tests of viability (completeness, effectiveness, efficiency, and acceptability).

Figure 19 - Price-San Rafael Irrigation Improvements.

The selected plan being implemented combines the Reclamation and USDA programs of irrigation improvements. Water pressure developed by piped laterals is being used to run sprinkler irrigation systems. The plan also eliminates winter water from the canal system by installing a rural domestic water distribution system. This method is similar to the winter water program in the Lower Gunnison Basin Unit.

The unit will ultimately include installing 97 miles of pipe for off-farm delivery of irrigation water; 26,000 acres of improved systems; 10,040 acres of improved surface systems; 36,050 acres of improved irrigation water management; lining 83 stock ponds; adding 213 connections to culinary systems to provide winter livestock water; and installing 10.6 miles of pipe to improve the Cottonwood Creek livestock water system. Through its new competitive Basinwide Program, Reclamation is funding local water districts to install pipeline systems and winter water facilities. Local landowners then install onfarm sprinkler systems with technical and financial assistance from USDA. A joint Reclamation/USDA planning report and final environmental impact statement was completed in December 1993.

Reclamation has a total of eight projects in the Price-San Rafael Rivers Unit area. The projects are being funded by Reclamation's Basinwide Program and cost sharing from the Basin States. The water conservation based projects include the Ferron, Wellington, Cottonwood, Allen Projects, North Carbon, Moore, Seeley-Collard, and Lawrence South. All of the projects have been completed. These projects will reduce salinity by improving the efficiency of existing irrigation projects by piping selected canals and laterals to gain pressure to run sprinkler irrigation systems.

San Juan River Unit

Figure 20 - Unimproved Canal at Hammond Project.

The San Juan River Unit area includes the entire 23,000-square-mile watershed from the San Juan River's headwaters in south-central Colorado to its mouth at Lake Powell. The drainage contributes approximately 1 million tons of salt annually to the Colorado River Basin. Early reconnaissance shows significant salt loading in the San Juan River between Shiprock, New Mexico, and the Four Corners area. At Bluff, Utah, the annual flow of 2,047,000 acre-feet of water contains 1,165,000 tons of salt. About 18 percent of this salt loading occurs between Shiprock and Bluff, but only 7 percent of the water is added in this reach.

The Hammond Project, Navajo Indian Irrigation Project (NIIP), and the Hogback Irrigation Project (also a Navajo Indian project) are the principal irrigation sources of salt in the San Juan River Basin. Reclamation focused its planning efforts in the San Juan River Unit by preparing a planning report/environmental assessment for the Hammond area. A final report and finding of no significant impact was published in December 1994.

The Hammond Project was awarded a contract late in 1996 under Reclamation's Basinwide Salinity Control Program. The project has replaced unlined canals and laterals, which were extremely leaky due to sandy soils. The local water district constructed the project. The district retained Reclamation to design the facilities. The district awarded a contract, and construction started in FY98 and was completed in 2003.

Uinta Basin Unit


Figure 21 - Salinity in Uinta Basin Unit Area.

The Uinta Basin Unit is located in northeastern Utah. The area includes portions of Duchesne and Uinta Counties and is situated between the Uinta Mountains on the north and the Tavaputs Plateau on the south. The principal communities within the area are Duchesne, Roosevelt, and Vernal.

Reclamation has conducted extensive studies in the area. Most of the salt pickup from the unit area is from the dissolution of salts from the soil and subsurface materials, principally from soils of marine origin that underlie most of the Uinta Basin. Seepage from conveyance systems and deep percolation resulting from irrigation are the primary processes that dissolve salts from the soils and shale and convey the salts through the groundwater system to natural drainages and ultimately to the Colorado River. The Uinta Basin contributes an estimated 450,000 tons of salt per year to the Colorado River.

Reclamation has a total of 14 projects in the Uinta Basin Unit area. The projects are funded jointly by Reclamation's Basinwide Program and cost sharing from the Basin States. The water conservation based projects include the Burns Bench, BIA-Ute Tribe, Duchesne County, Farnsworth, Lower Brush Creek, Western Uintah, South Lateral, River Canal, Union Canal, Hicken, Dry Gulch Class E, Dry Gulch Class C, Ouray Park, and Duchesne Water Conservancy District projects. These projects will reduce salinity by improving the efficiency of existing irrigation projects. Several will pipe selected canals and laterals to gain pressure to run high-efficiency sprinkler irrigation systems

Verification Studies -- In their *National Water Summary 1990-91, Water Supply Paper 2400*, the USGS reported a downward trend in dissolved solids concentration (salinity) in the Duchesne River, immediately downstream of the project area. They pointed out that much of the base flow of the river was from irrigation return flows. Salinity discharge has dropped from 206,000 tons in 1981 when USDA first started irrigation improvements to 169,000 tons in 1993 -- a 37,000-ton reduction. Based on the amount of irrigation improvements installed, USDA estimates that irrigation improvements through 1992 have reduced the salinity discharge by about 55,500 tons per year (*1993 Joint Evaluation Report*). Recent studies have also shown a downward shift in the salt/flow relationship (for a given flow, salinity is lower). These data support the theory that onfarm irrigation practices can be effective at reducing salt loading. Monitoring and analysis will continue.

Colorado River Basin Salinity Control Program Summary Data

See pages 55-57.

Table 9 – Summary of Federal Salinity Control Programs (2008)

Salinity Unit		Tons / Year Removed
MEASURES IN PLACE BY Reclamation		
Basinwide Program 3/		246,843
Meeker Dome		48,000
Las Vegas Wash Pitman		3,800
Grand Valley		122,300
Paradox Valley		113,000
Lower Gunnison Winter Water (USBR)		41,400
Dolores		23,000
	Subtotal (rounded)	598,300
MEASURES IN PLACE BY USDA 1/		
Grand Valley		92,658
Price-San Rafael		53,930
Uinta Basin		137,426
Big Sandy River		55,957
Lower Gunnison		93,113
McElmo Creek		23,326
Mancos		2,438
Muddy Creek (USDA)		0
Manila		2,183
Silt		2,908
	Subtotal (rounded)	463,900
MEASURES IN PLACE BY BLM		
Nonpoint Sources 2/		81,900
Well-Plugging		14,600
	Total (rounded)	1,158,700
POTENTIAL NEW MEASURES		
Reclamation Basinwide Program (not including P-SR) 3/		382,609
Price-San Rafael (Reclamation/USDA) 3/		92,970
Grand Valley (USDA)		39,342
Uinta Basin (USDA)		3,074
Big Sandy River (USDA)		27,743
Lower Gunnison (USDA)		92,887
McElmo Creek (USDA)		22,674
Mancos River (USDA)		9,502
Muddy Creek (USDA)		11,677
Manila		15,157
Silt		1,082
unidentified (USDA)		40,000
New Well Plugging and Nonpoint Source (BLM)		Unknown
	Subtotal (rounded)	738,700
	Total (rounded)	1,900,000

1/ May include off-farm controls that were not goaled.

2/ BLM non-point source are estimates.

3/ The off-farm tons of salt are presently being evaluated by Reclamation. The tons of salt shown are only rough estimates.

Table 10 – Summary of Colorado River Basin Salinity Control Program Funding for Federal Agencies (In 1,000 Dollars)

Federal Fiscal Year	Bureau of Reclamation	USDA - NRCS	Upfront Cost Sharing from Basin Funds	Bureau of Land Management[1]	Total
1988	20,783	3,804		500	25,087
1989	16,798	5,452		500	22,750
1990	14,185	10,341		700	25,226
1991	24,984	14,783		873	40,640
1992	34,566	14,783		873	50,222
1993	33,817	13,783		866	48,466
1994	32,962	13,783		800	47,545
1995	13,622	4,500	[2]	800	18,922
1996	17,420	9,561	6,028	800	33,809
1997	11,942	3,152	5,850	800	21,744
1998	15,876	3,906	8,011	800	28,593
1999	15,422	5,132	9,594	800	30,948
2000	15,776	5,330	9,698	800	31,604
2001	13,880	5,785	9,444	800	29,809
2002	14,892	9,721	11,524	800	36,937
2003	11,507	12,714	11,442	800	36,463
2004	12,418	19,488	14,691	800	47,397
2005	11,250	19,798	14,200	800	46,048
2006	11,915	19,661	13,256	751	45,583
2007	12,226	19,667	12,729	800	45,422
2008	11,936	19,500	11,390	800	43,626

[1] Funds expended by BLM for salinity control cannot accurately be determined. This amount reflects what has been reported as having been designated within the BLM budget.

[2] Prior to 1996 Basin Funds were used to repay the reimbursable portion of Reclamation's Salinity Control Projects within a fifty-year period or within a period equal to the estimated life of the project, whichever is less.

Table 11 – Reclamation Salinity Control Unit Summary (P.L. 93-320 and 98-569)

Unit/Study	Implementation	Controls (tons/y)	Reclamation Capital Cost	Annual O&M Costs	Cost per Ton
Meeker Dome	1980-1983	48,000	$3,100,000	$0	$5
Las Vegas Wash	1978-1985	3,800	$1,757,000	$0	$28
Grand Valley	1980-1998	127,500	$160,900,000	$887,000	$83
Paradox Valley	1988-1996	110,000	$66,199,000	$2,692,000	$60
Dolores Project	1990-1996	23,000	$44,700,000	$437,000	$185
Lower Gunnison	1991-1995	41,380	$24,000,000	$0	$35
Total		353,680	$300,656,000	$4,016,000	$66

Note: Cost per ton based on amortization over 50 years at the project authorized interest rate.

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APPENDIX A – SALINITY DATA

The historical flow and quality of water data have been calculated using the U.S. Geological Survey (USGS) database and computer techniques developed jointly by the Bureau of Reclamation (Reclamation) and USGS. The purpose of the analysis was to develop a consistent, documented methodology for the calculation of monthly salt loads in the Colorado River Basin.

The salinity computation method was originally developed for the trend studies conducted by Reclamation and USGS (Liebermann, et al., 1986). Several procedures were evaluated. A 3-year moving regression was determined to be the best overall method in terms of providing the most complete record, preserving short-term fluctuations, and being insensitive to minor errors in the data. Using this method, daily salt load (L) was computed from discharge (Q) and when available, conductivity (S): $L = aQ^bS^c$. For days without specific conductivity data, a slight variation of the equation for load as a function of discharge was used: $L = a'Q^{b'}$.

The coefficients a, b, and c for each year of record were typically estimated by regression analysis using data from a 3-year period surrounding the year of interest. For example, coefficients for 1990 were derived with data from l989 through 1991. The last year of salinity data computed for this report uses 2 years of data for obvious reasons. It is subject to change and will be updated in the next report as data become available to complete the analysis for that year.

Daily loads were added to yield the monthly values given. Monthly values were then added to yield annual values. All values shown are rounded but were computed using un-rounded values.

For this analysis, salt-load data were based on total dissolved solids (TDS) as the sum of constituents, whenever possible. Sum of constituents was defined to include calcium, magnesium, sodium, chloride, sulfate, a measure of the carbonate equivalent of alkalinity and, if measured, silica and potassium. If a sum-of-constituents value could not be computed, TDS as residue on evaporation (at 180 degrees Celsius) was substituted.

Extensive error analyses were performed on the data. Suspect values were corrected according to published records or deleted. The resultant data set is considered by Reclamation and USGS to be the best available for stations in the Colorado River Basin. Annual values based on the new method were compared to values in previous Quality of Water Colorado River Basin Progress Reports for selected stations. The observed differences were between plus or minus 5 percent, with mean differences approximately zero. Changes in the progress report database can, therefore, be considered generally insignificant and unbiased.

MONITORING STATIONS

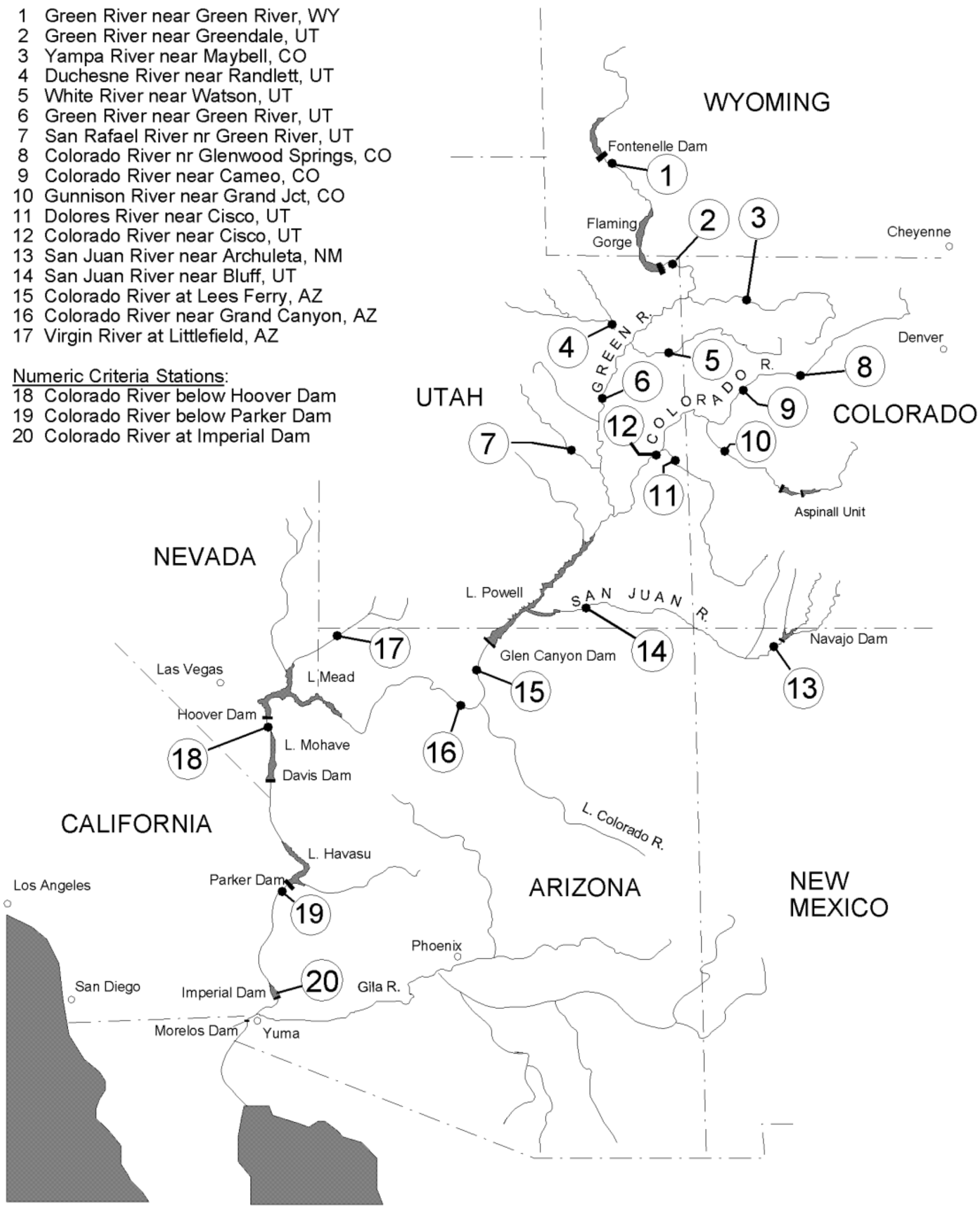


Figure A1 - Colorado River Water Quality Monitoring Stations.

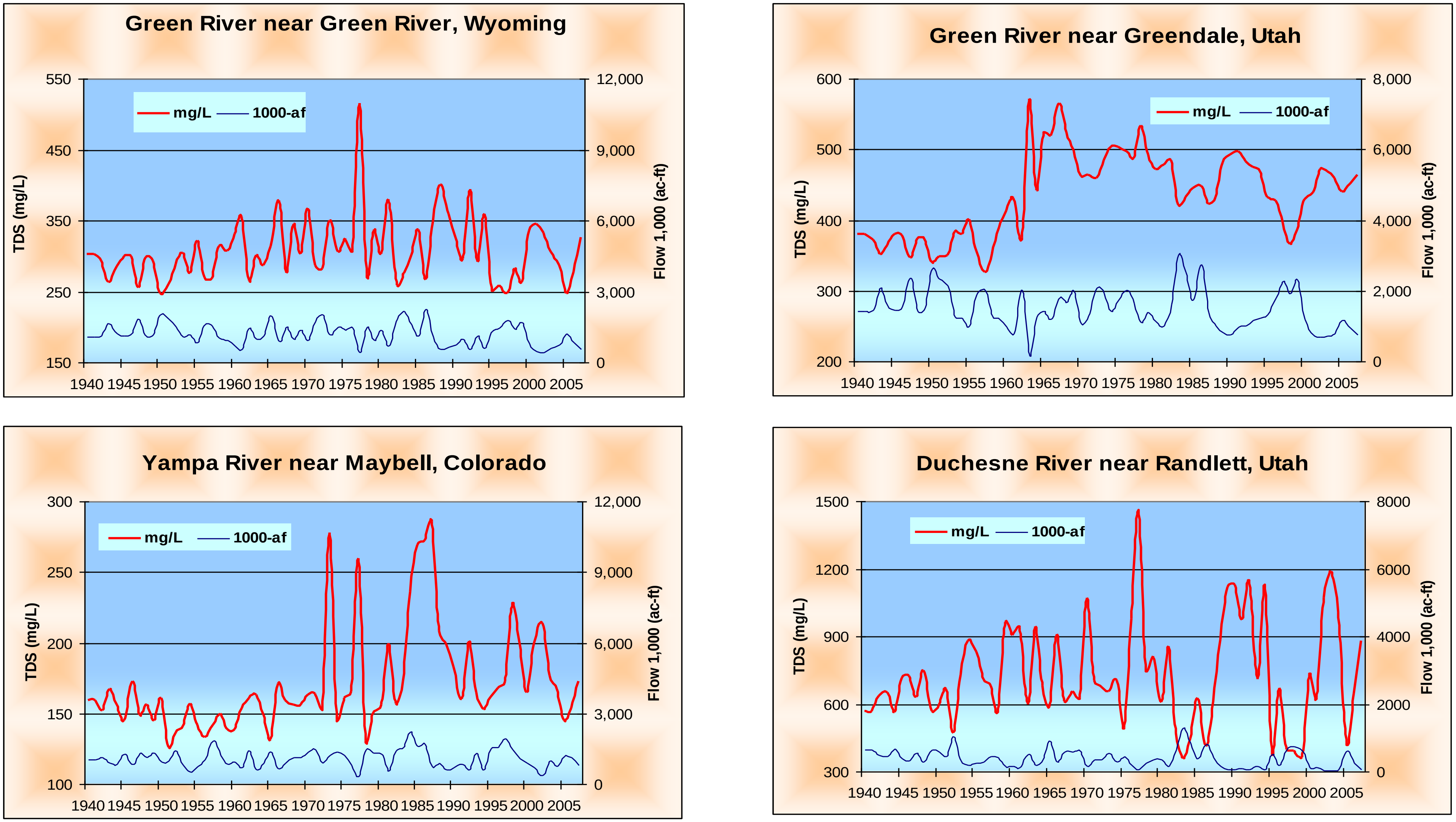


Figure A-2 - Flow and TDS over time for sites 1-4. Site locations shown in Figure A-1.

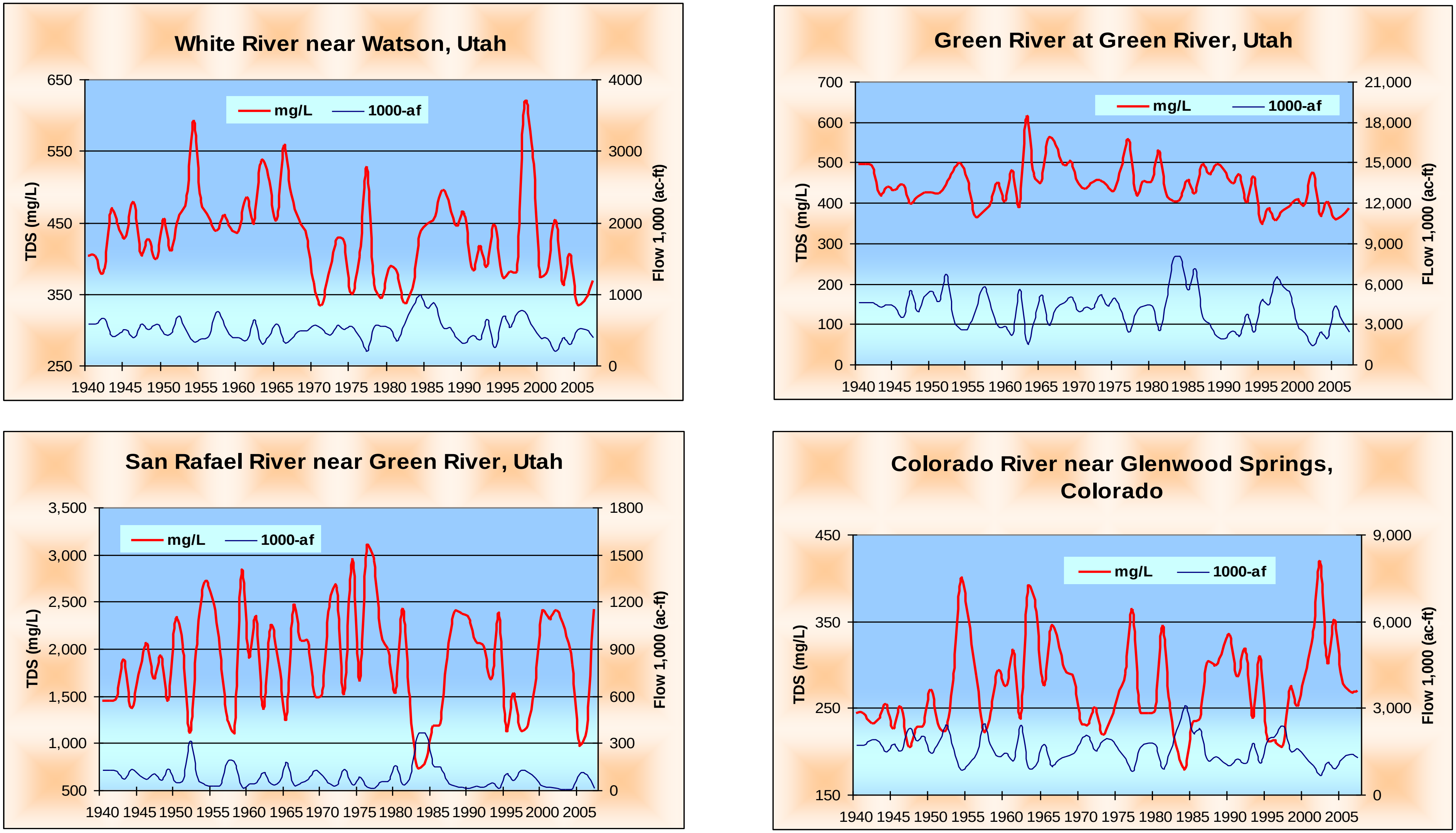
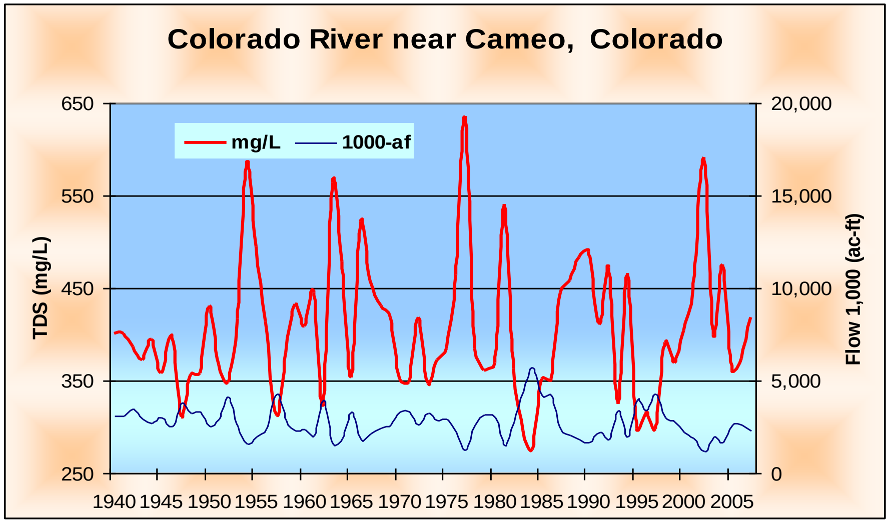
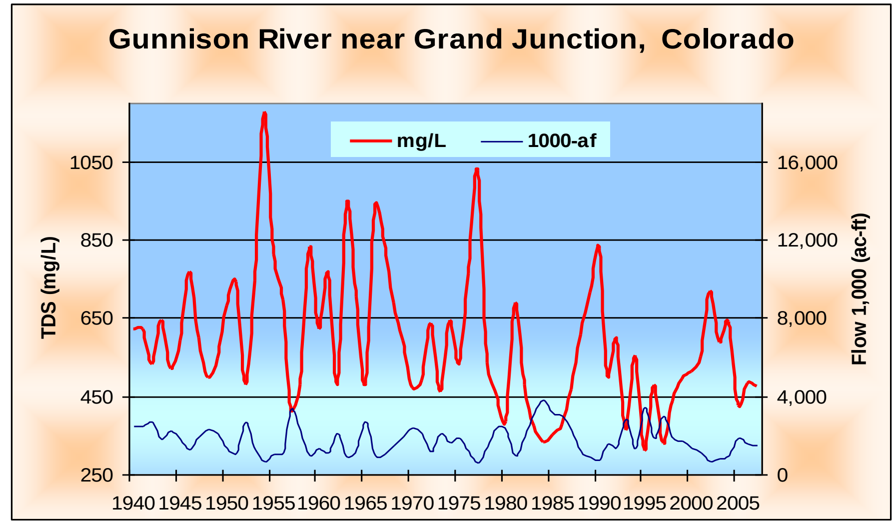
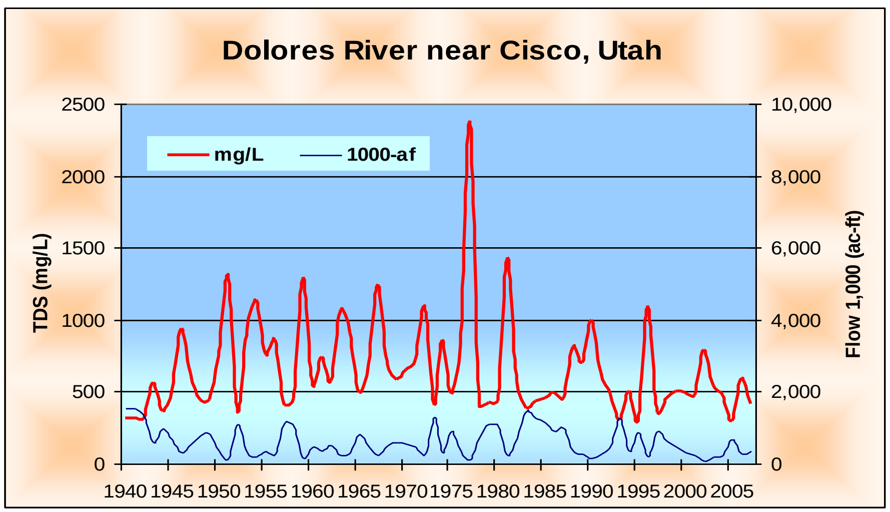


Figure A-3 - Flow and TDS over time for sites 5-8. Site locations shown in Figure A-1







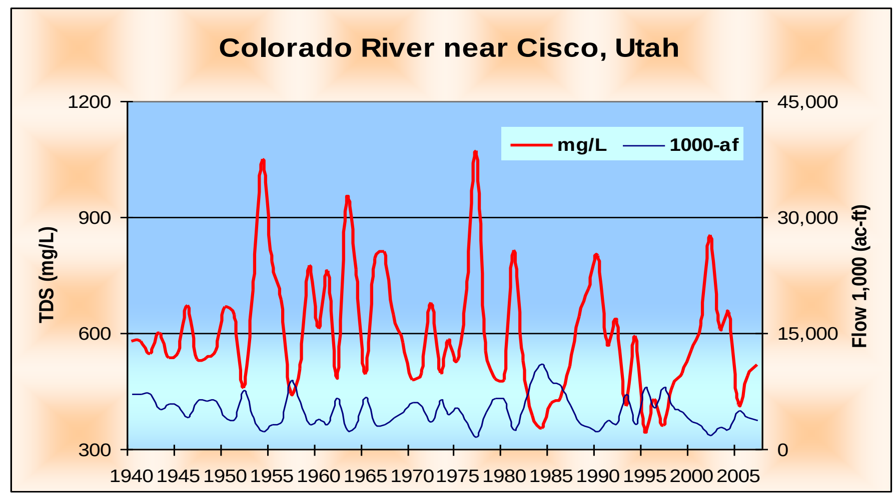
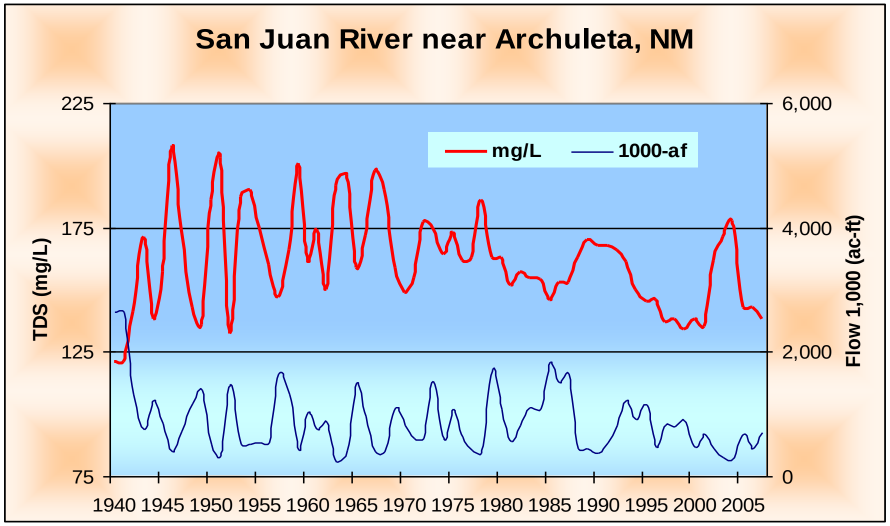
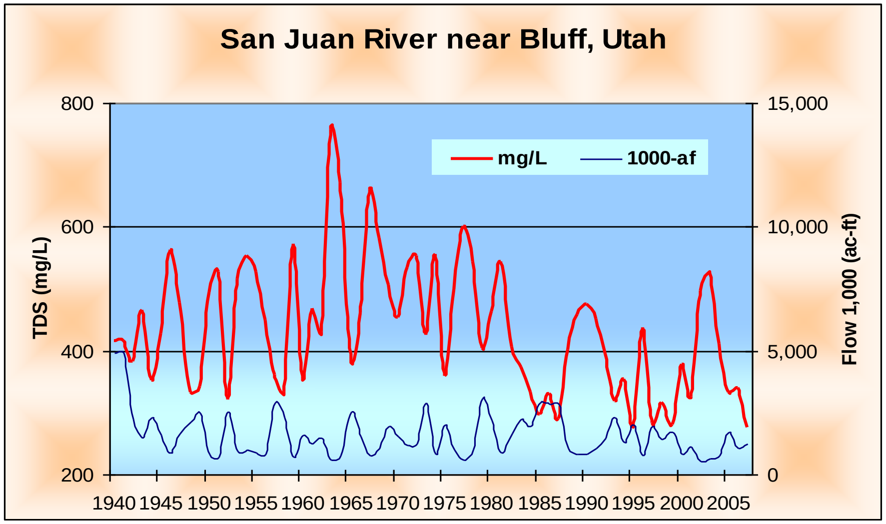
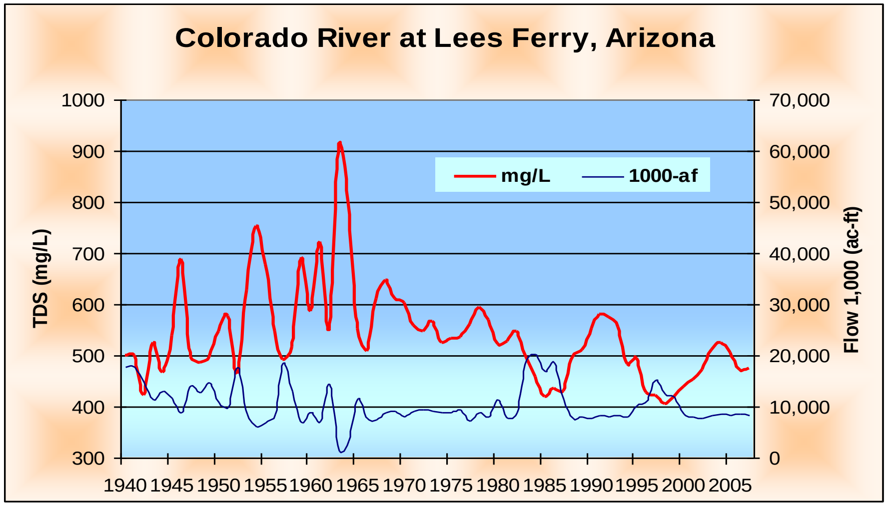


Figure A-4 - Flow and TDS over time for sites 9-12. Site locations shown in Figure A-1.







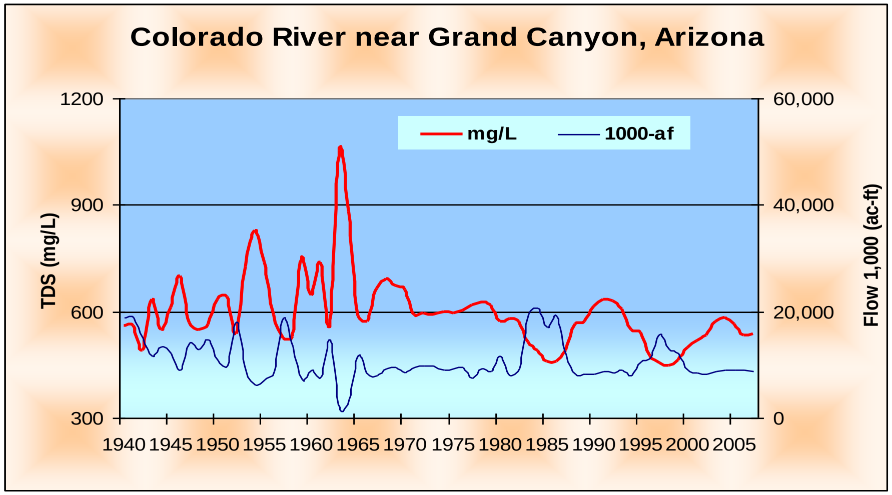


Figure A-5 - Flow and TDS over time for sites 13-16. Site locations shown in Figure A-1.

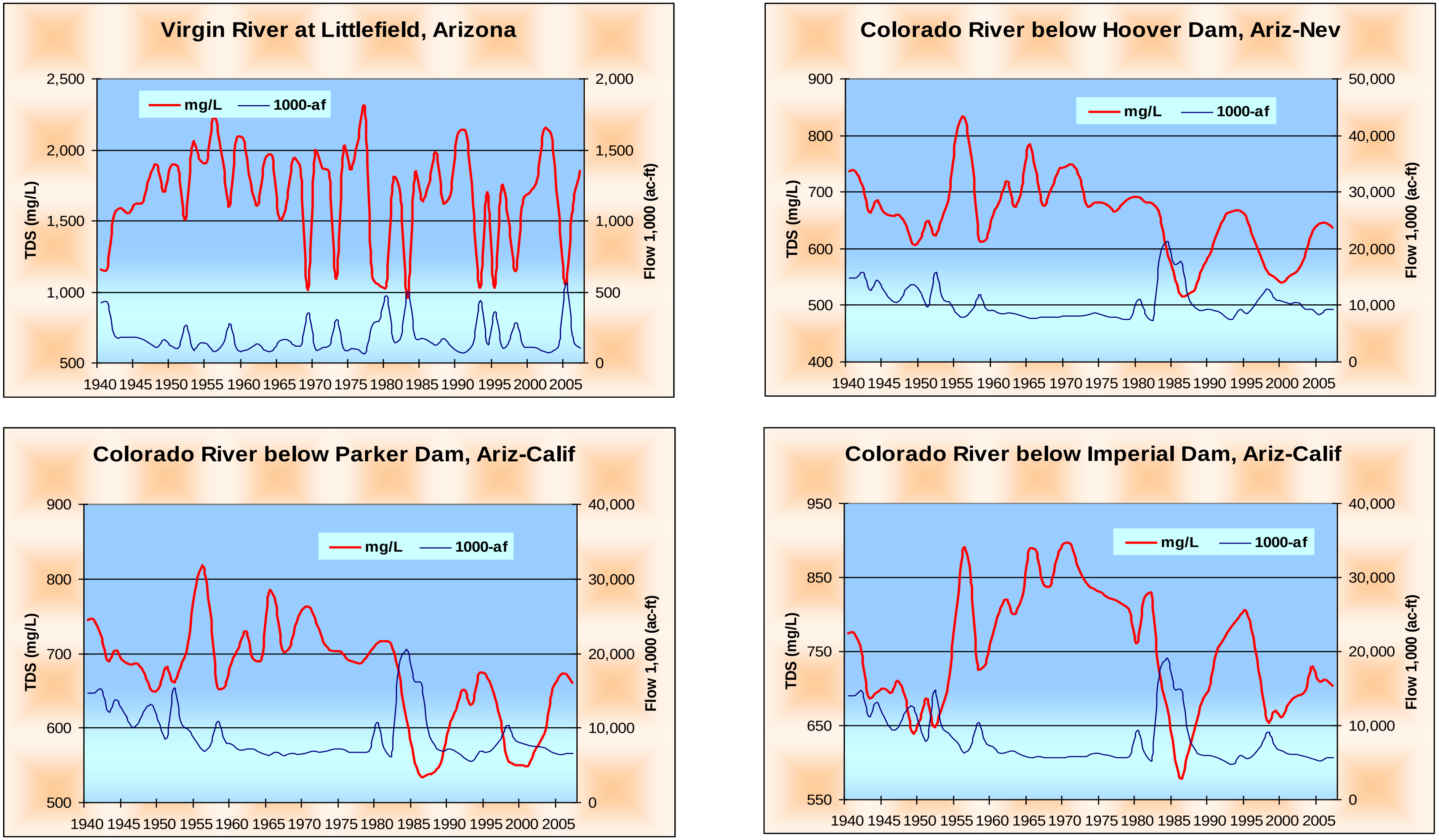


Figure A-6 - Flow and TDS over time for sites 17-20. Site locations shown in Figure A-1.