— BUREAU OF —
RECLAMATION

QUALITY OF WATER

COLORADO RIVER BASIN

Progress Report No. 26

U.S. Department of the Interior **2019**

Acronyms and Abbreviations

AF	acre feet
ACEC	Area of critical environmental concern
AMD	acid mine drainage
ARC	Application Review Committee
BLM	Bureau of Land Management
BSP	Basin State Program
CFS	Cubic feet per second
CRB	Colorado River Basin
CWP	Colorado Parks and Wildlife
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FLPMA	Federal Land Management Policy Act of 1976
FOA	Funding Opportunity Announcement
Forum	Colorado River Basin Salinity Control Forum
FWS	Fish and Wildlife Service
GLCA	Glen Canyon Recreation Area
GKM	Gold King Mine
MAF	million acre feet
MWD	Metropolitan Water District
NEPA	National Environmental Policy Act
NPS	National Park Service
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PPM	Parts per Million
Reclamation	Bureau of Reclamation
Review	2014 Review, Water Quality Standards for Salinity, Colorado River System
RFP	Request for Proposal
SCP	Colorado River Basin Salinity Control Program
Secretary	Secretary of Interior
TDS	Total Dissolved Solids (salinity)
TMDL	Total Maximum Daily Load
UCRB	Upper Colorado River Basin
UDAF	Utah Department of Agriculture and Food
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USGS	United States Geologic Survey
WMIDD	Wellton-Mohawk Irrigation & Drainage District
WWDC	Wyoming Water Development Commission

TABLE OF CONTENTS

TABLES

FIGURES

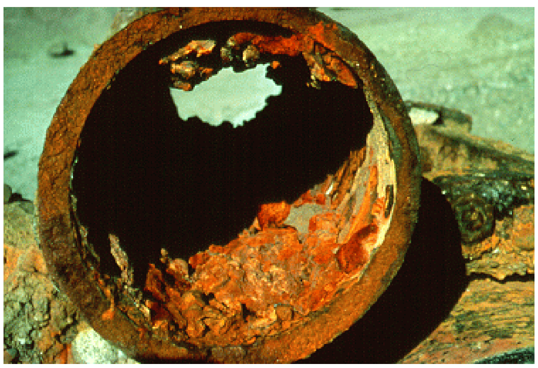
FIGURES (Continued)

FIGURES (Continued)

SUMMARY

The Colorado River and its tributaries provide water to about 35 - 40 million people and irrigation water to nearly 4.5 million acres of land in the United States (Moving Forward, 2015). The river also serves about 3.3 million people and 500,000 acres in Mexico (Cohen, 2011). The effect of salinity is a major concern in both the United States and Mexico. Salinity damages in the United States are presently estimated to be about $454 million per year at 2017 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).

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.



Salinity damages to municipal water pipe.

Salinity damages to crop production.

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.   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 opened the program to competition through a "Request for Proposal" process, which greatly reduced the cost of salinity control

by selecting the most cost-effective projects. However, the price of salinity control is expected to increase in the future as the more cost-effective projects are completed.

The Colorado River Basin Salinity Control Forum (Forum) in accordance with the requirements of the Clean Water Act, prepared the "2017 Review, Water Quality Standards for Salinity, Colorado River System" (Review). The Review reported the Forum would pursue a salinity control program designed to remove at least 1.66 million tons of salt annually by the year 2035 to minimize downstream economic damages while the Upper Basin States continue to develop their Compact apportioned water supplies. The Review shows that the Colorado River Basin Salinity Control Program (Program) is currently controlling over 1,336,000 tons of salt annually. In order to meet the 1.66 million tons of salt removal under the plan of implementation, it will be necessary to fund and build potential new measures that ensure the removal of an additional 330,000 tons by 2035. 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 18,300 tons of new or additional controls will need to be implemented each year to meet the Program goal. This Program goal is the combined target for the participating agencies within Interior and USDA.

The Upper Colorado River Basin regularly experiences significant year to year hydrologic variability, but overall is still in drought conditions. During the 18 year period 2000 to 2019 the unregulated inflow to Lake Powell, which is a good measure of hydrologic conditions in the Colorado River Basin, was above average in only 5 out of 20 years and had the lowest average annual (water year) unregulated inflow volume of any 20 year period since the closure of Glen Canyon Dam in 1963, with an average unregulated inflow of 8.76 MAF, or 80% of the 30-year average (1981-2010), which is 10.83 MAF. The unregulated inflow during the 2000-2019 period has ranged from a low of 2.64 MAF (24% of average) in water year 2002 to a high of 15.97 MAF (147% of average) in water year 2011. The water year 2019 unregulated inflow volume to Lake Powell was 12.95 MAF (120% of average). At the beginning of water year 2020, total system storage in the Colorado River Basin was 31.62 MAF (52% of 59.6 MAF total system capacity). Since the beginning of water year 2000, total Colorado Basin storage has experienced year to year increases and decreases in response to wet and dry hydrology, ranging from a high of 94% of capacity at the beginning of 2000 to a low of 50% of capacity at the beginning of water year 2005. One wet year can significantly increase total system reservoir storage, just as persistent dry years can draw down the system storage.

Salinity concentration has varied during this time period (with a downward trend) 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 future salinity modeling scenarios indicate that the numeric salinity criteria should be maintained over the next three years even with additional years of drought. The numeric salinity criteria could have been exceeded in 2007 without the salinity control program and other salt reductions.

Reclamation prepared this report in cooperation with State water resource agencies and other Federal agencies involved in the Salinity Control Program. This Progress Report 26 is the latest in a series of biennial reports that commenced in 1963.

The authorization for these reports and the legal aspects can be found in Chapter 1 of prior Progress Reports http://www.usbr.gov/uc/progact/salinity/pdfs/PR24final.pdf

CHAPTER 1 – SALINITY CONDITIONS

CAUSES OF SALINITY

The Colorado River basin has locations which contain areas of high salt concentrations. Historically at the USGS gauge below Hoover Dam, between 1940 and 1980, an annual average of approximately 9.4 million tons of salt was carried down the river. From 2000 to the present, an annual average load of approximately 7.6 million tons of salt have been measured in the river at this gage. The trend of the salinity, both load and concentration, below Hoover has been trending down over time, while over the last 17 years, from 2000 to present, the salinity appears to be leveling off as seen in figure 1 below. The flow of the river dilutes this salt, and depending upon the quantity of flow, salinity concentration 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.

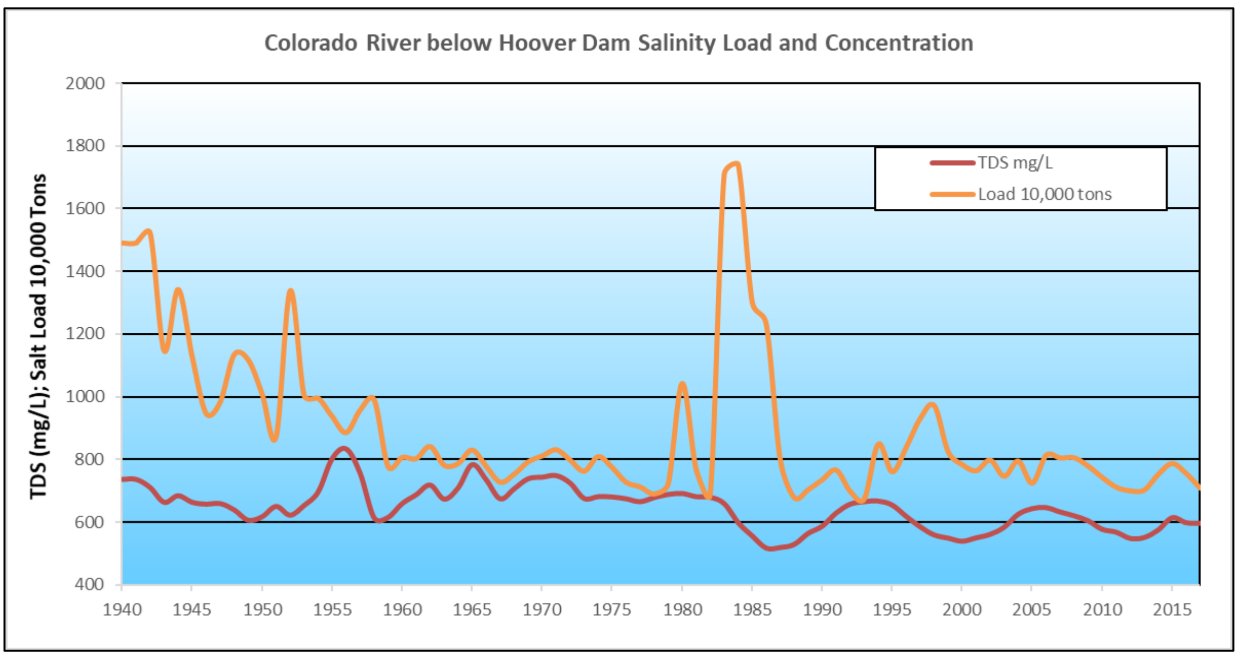


Figure 1 - Colorado River Salinity below Hoover Dam

Nearly half of the salinity concentration in the Colorado River System is from natural sources. Saline springs, erosion of saline geologic formations, and runoff all contribute to this background salinity. The EPA (EPA, 1971) estimated that the natural salinity in the Lower Colorado River at Imperial Dam is 334 milligrams per liter (mg/L). Irrigation, reservoir evaporation, and municipal and industrial (M&I) sources make up the balance of the salinity in the Colorado River Basin. Figure 2 shows the relative amount each source contributes to the salinity of the Colorado River, as estimated by the Environmental Protection Agency (EPA) in 1973. Table 1, on the following page, quantifies the salinity from several of the known sources.

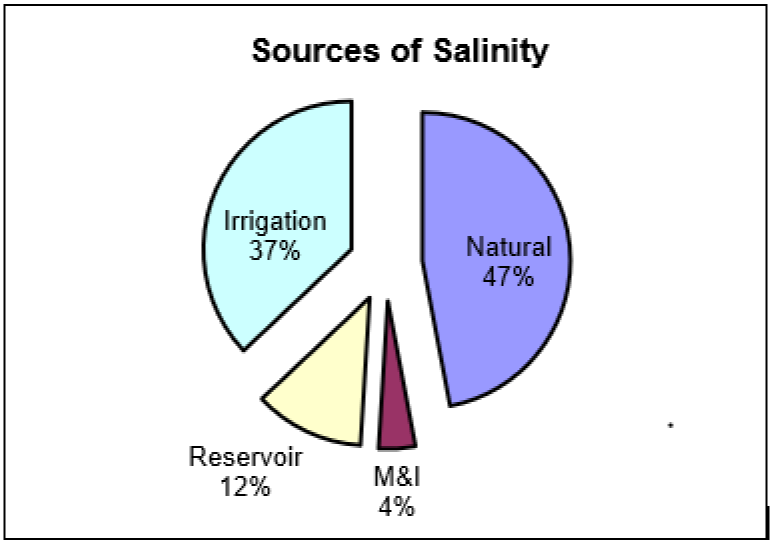


Figure 2 – Salinity Sources

Table 1 – 1971 Quantified Sources of Salt Loading

Source	Type of Source	Salt Loading (tons per year)
Paradox Springs	Springs / point	205,000
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
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
McElmo Creek	Irrigation / non-point	119,000
Price-San Rafael	Irrigation / non-point	258,000
Uinta Basin	mostly irrigation / non-point	240,000
Dirty Devil River Area	Irrigation / non-point	150,000
Price-San Rafael Area	Irrigation / non-point	172,000
Other, non-regulated areas	Various	5,200,000
Total		8,724,000

Values listed are pre salinity control project loading

Salinity of the Colorado River has increased due to 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 2000, has also had an influence on the present salinity of the Colorado River.
Any potential health concerns from the salinity levels in the Colorado River have previously been addressed in the health section of Progress Report 21
http://www.usbr.gov/uc/progact/salinity/pdfs/PR21.pdf

ECONOMIC EFFECTS OF SALINITY

Salinity related damages are primarily economical and due to reduced agricultural crop yields, corrosion, and plugging of pipes and water fixtures in housing and industry. Figure 3 breaks down the percentage of total damages estimated at 2017 with 1.79 million tons of salt controlled. 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 hydrologic conditions, but the goal of the Water Quality Criteria for the Colorado River Basin and the Salinity Control Program is to offset (eliminate/reduce) the salinity effects of additional water development.

Reclamation has developed an economic model that calculates damages for a given level of salt. The Salinity Economic Impact Model (SEIM) estimates the quantitative damages that are incurred in the metropolitan and agricultural areas in the lower Colorado Basin that receive Colorado River water. The model estimates the impacts from salinity levels greater than 500 mg/L TDS on household water using appliances, damages in the commercial sector, industrial sector, water utilities, and agricultural crop revenues. It also estimates the additional costs related to meeting statewide water quality standards for ground water and recycled water use in the Colorado River service area. The SEIM was last run for the 2017 Review and results and information on the SIEM can be found at http://www.coloradoriversalinity.org/documents.php?ctgy=Reviews.

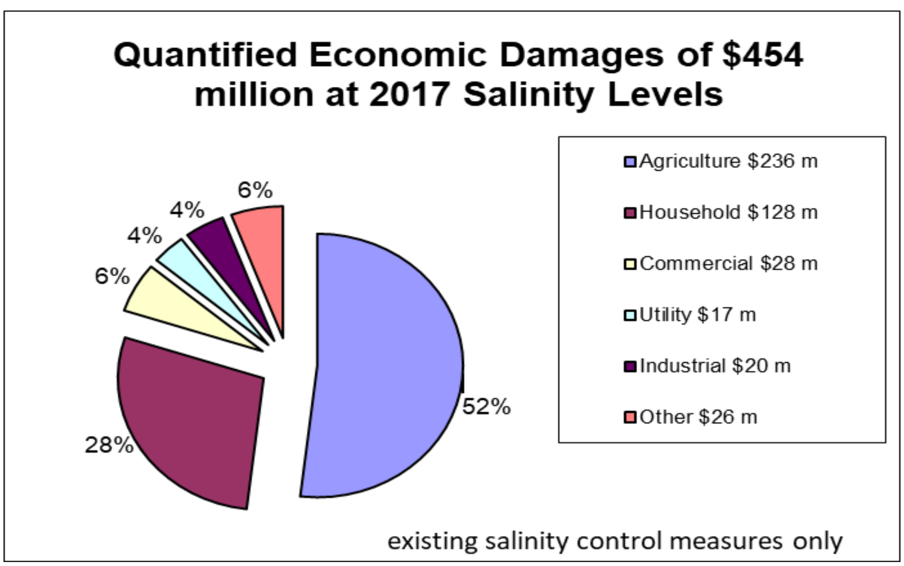


Figure 3 - Salinity Damages

HISTORICAL SALINITY CONDITIONS

Salinity in the Colorado River is monitored at 20 key stations throughout the Colorado River Basin. A map of station location is presented in Appendix A. Salt loads and concentrations are calculated from daily conductivity and flow records using methods developed jointly between Reclamation and USGS (Liebermann et al., 1986), Appendix B provides a methods summary. Historical annual streamflow, and salinity concentrations from 1940 through 2017 are included in graphical form in Appendix C. 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 numeric criteria locations (Hoover, Parker and Imperial Dams) since 1940 is shown in Figure 4. As Figure 4 shows, the last time the TDS exceeded or reached the salinity criteria at any of the numeric criteria locations, was in 1972 – the year that the salinity standard was established for the Colorado River.

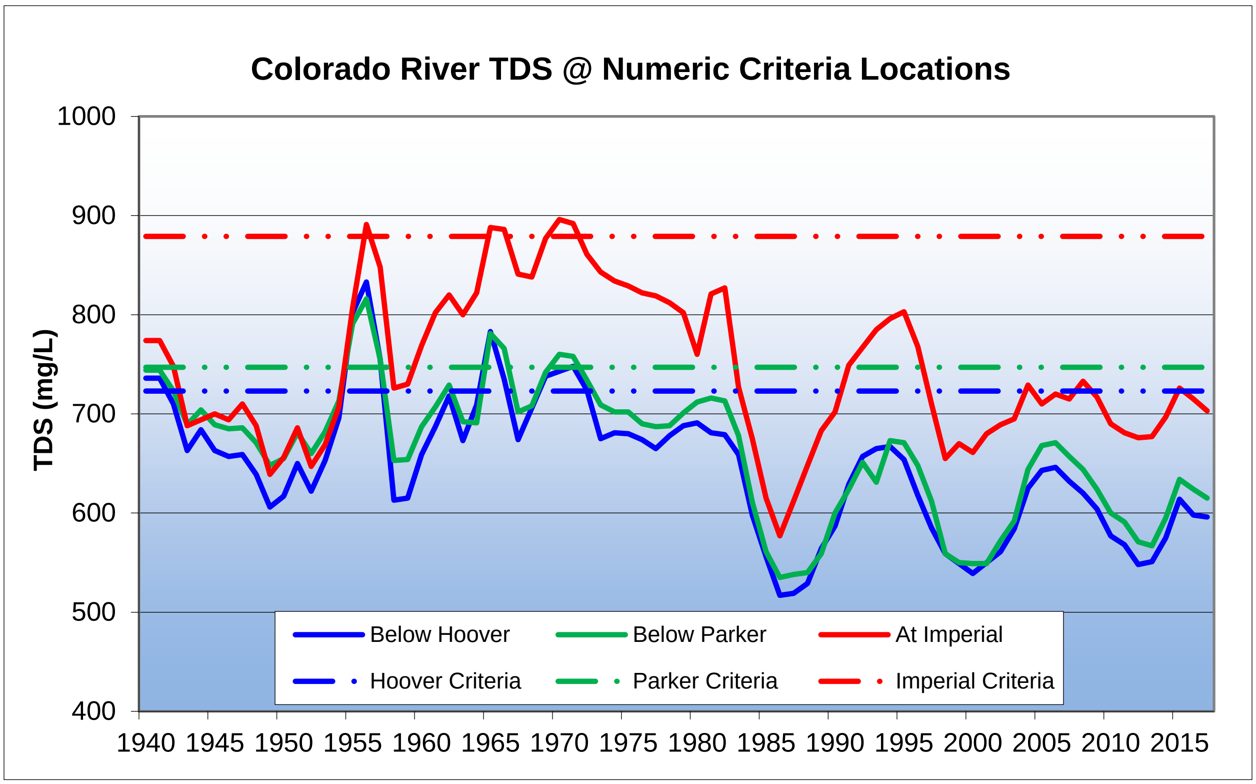


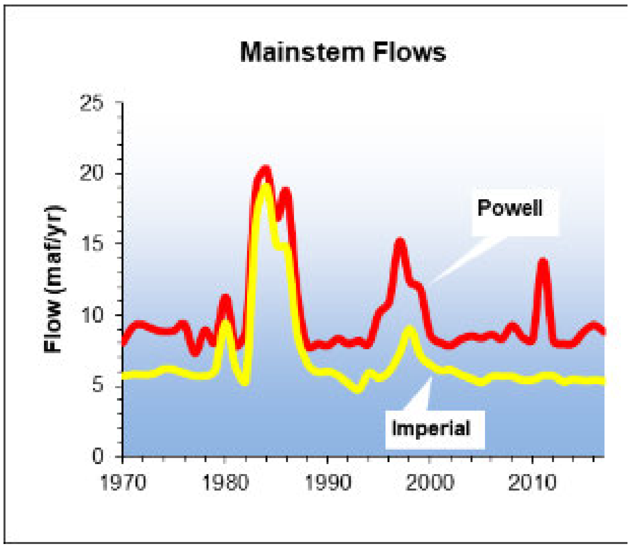
Figure 4 - Colorado River Numeric Criteria Locations

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 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.

Streamflow

Streamflow directly influences salinity. For the most part, higher flows (or reservoir releases) dilute salt concentration. The left graph in Figure 5 shows streamflow at two key points in the mainstem. In 1983, Lake Powell (Glen Canyon Dam) filled for the first time and spilled.



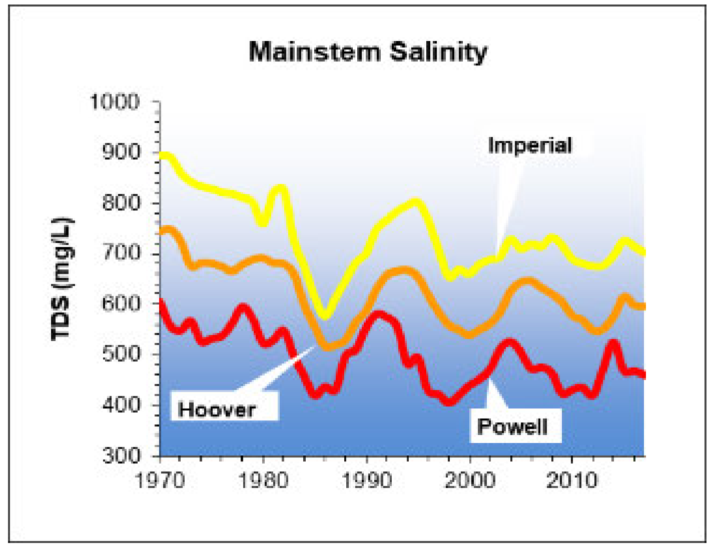


Figure 5 - Colorado River Flow and TDS

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 right graph of Figure 5, returning to average flows in the system after 1987 returned the salinity in the reservoir system to average levels.

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 effects of the reservoirs are beneficial and have greatly reduced the salinity peaks and annual fluctuation (Figure 6). 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, with a pre dam range of 1,106 mg/L and a post dam range of 694 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 effects of this selective retention and routing of salt has been shown below Glen Canyon Dam in Figure 6. Figure 7 further displays this retention. Figure 7 is a long-term depth vs. time profile of salinity in the forebay of Glen Canyon Dam and is an illustrated history of the salinity. The Y (vertical) axis is depth in the water column and the X axis is time in years. The color scale is the change in salinity.

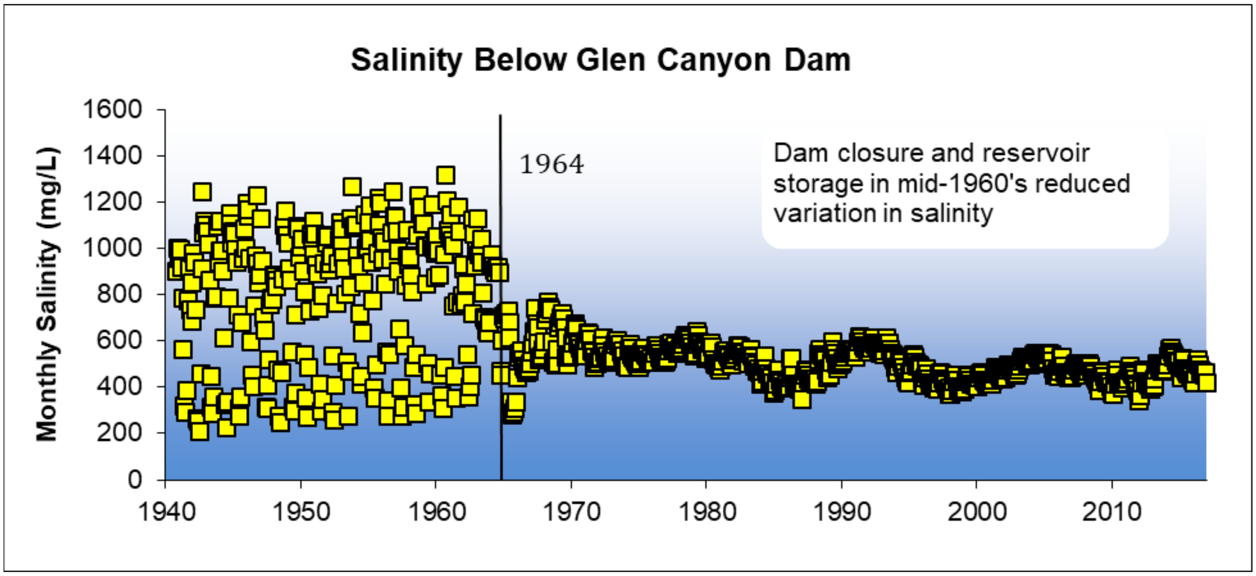


Figure 6 -Salinity below Glen Canyon Dam

Figures 6, 7 and 8 illustrate that Glen Canyon Dam causes Lake Powell to selectively retain higher salinity water during drier years of drought, and then routes it out with the increased mixing and shorter hydraulic retention times of wetter cycles as seen particularly in 1983, 1999 and 2011. During these wetter cycles there is a significant mixing and dilution of these previously stored salts.

There are 4 periods or trends, with regards to salt loads and concentration, which can be seen in the Colorado River salinity for the inflow to and outflow from Lake Powell shown in Figures 8 & 9 (yellow dash trend lines are the outflow and the green dash trend lines are the inflow). The overall inflow (red lines) in Figures 8 & 9 is calculated from the salinity at 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 overall outflow (blue line) comes from the salinity at Lees Ferry.

The 4 periods seen begin with the pre dam period, 1950 – 1964. The average salinity concentration in the river was increasing with divergence between the average annual inflow and outflow TDS concentrations while the salt loading was seen to be on a decreasing trend. This difference between outflow and inflow may be impacted by the beginning hydraulic conditions, since the actual annual levels appear to track each other closely.

Next there was the dam filling period where Lake Powell and the Upper Basin reservoirs were completed and filling, 1965-1983. The average annual salinity during this time decreased with a convergence occurring between the inflow and outflow concentrations. The salt loading converged during this time while the river flow stayed fairly constant, possibly due to the reservoir storing the salinity.

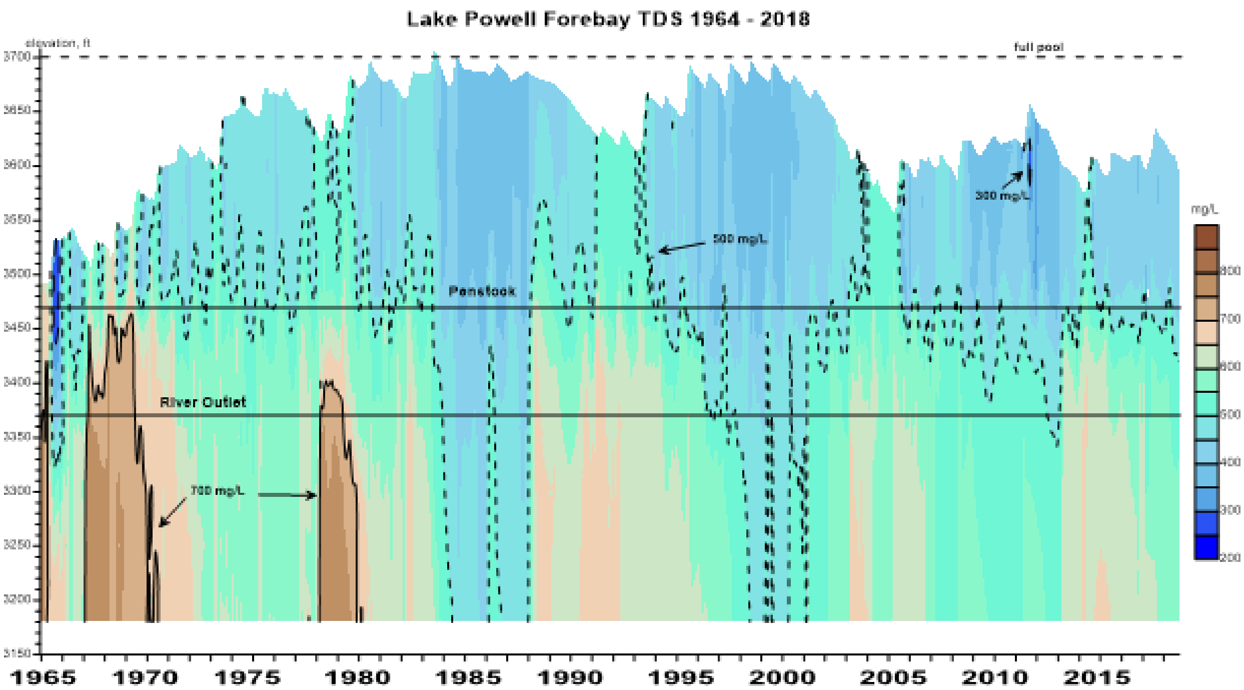


Figure 7 - Lake Powell Forebay TDS over Time

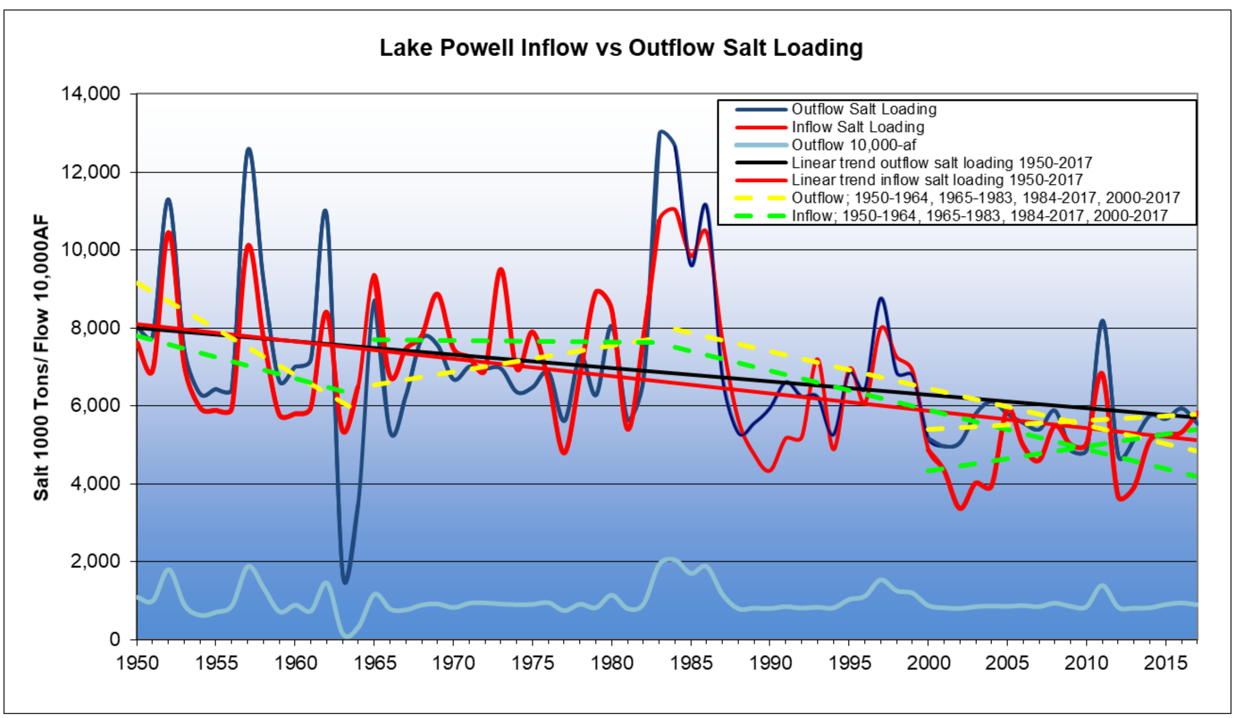


Figure 8 - Lake Powell Inflow and Outflow Salt Loading and Flow

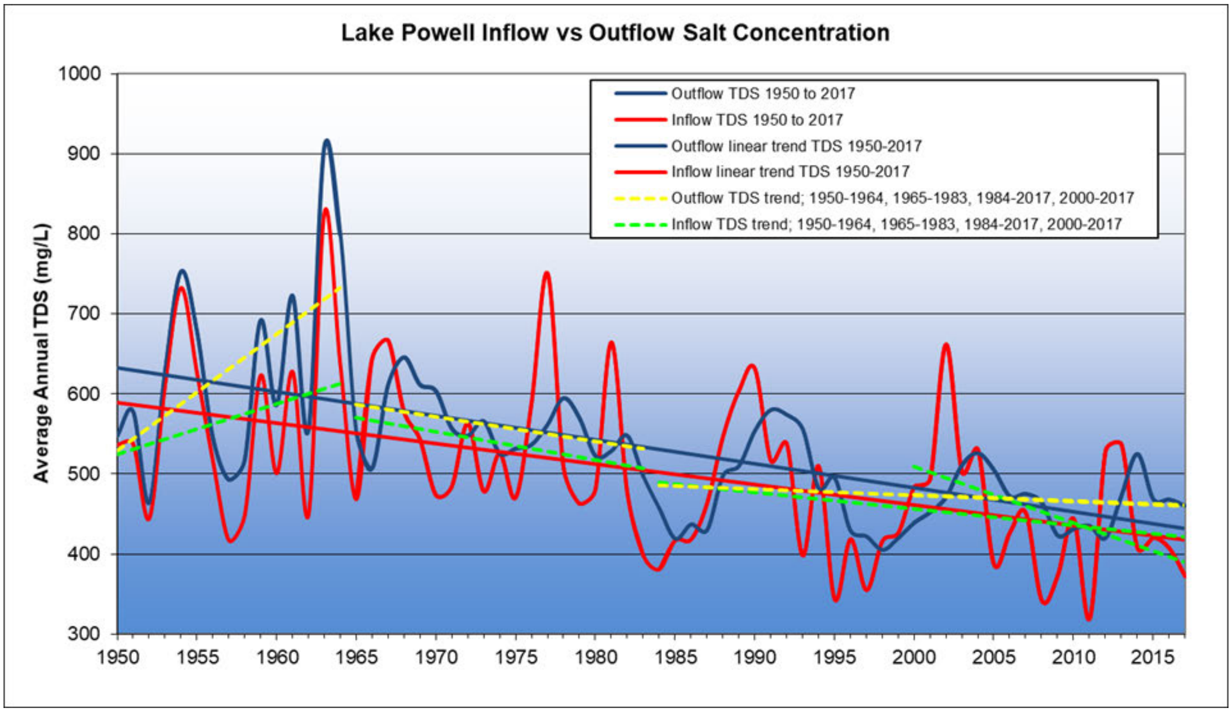


Figure 9 - Lake Powell Inflow and Outflow TDS

Then there was the period, 1983 to 2017, 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 and load during this time is seen to be constant between the inflow and outflow stations. The outflow for both the concentration and loading is seen to be a little higher than that of the inflow, possibly due to the release of some of the stored salt from the reservoir.

The last period, since 2000, covers the basinwide drought. The trend shows that the inflow TDS has declined, while the outflow TDS from Lake Powell has stayed constant with the 1983 to present TDS trend. The salinity loading during this time is shown to be slightly increasing possibly due to the higher than average flows in 2011.

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 (Figures 8 & 9, red and blue trend line). Overall, there is seen to be a decreasing trend of salt concentration and loading in the Colorado River.

The natural variation in salinity as well as the agricultural sources, energy development, and the municipal and industrial use impacts on salinity have been discussed in a prior Progress Report 24 http://www.usbr.gov/uc/progact/salinity/pdfs/PR24final.pdf

FUTURE WATER DEVELOPMENT

Tables 2 and 3 summarize projected future total depletions by water uses that are input into Reclamation's Colorado River System Simulation (CRSS) model. The schedules presented below were used in the CRSS modeling in support of the 2017 Review.

Table 2 summarizes the projected future depletions by water uses in the Upper Colorado River Basin as adopted for planning purposes by the Upper Colorado River Commission in December 2007. Figure 10 illustrates the historical annual consumptive use by water uses in the Upper Basin as reported in Reclamation's Colorado River System Consumptive Uses and Losses Reports (CUL), and the projected future total depletions from the CRSS model.

The annual depletions for the Lower Colorado River Basin shown in Table 3 include only depletions resulting from the use of water from the mainstem of the Lower Colorado River. Reclamation's CRSS model does not model or include as input consumptive uses made from tributaries to the Colorado River within the Lower Colorado River Basin. More detailed data on historical Colorado River Basin consumptive uses and losses (including tributary uses in the Lower Basin and reservoir evaporation losses) 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

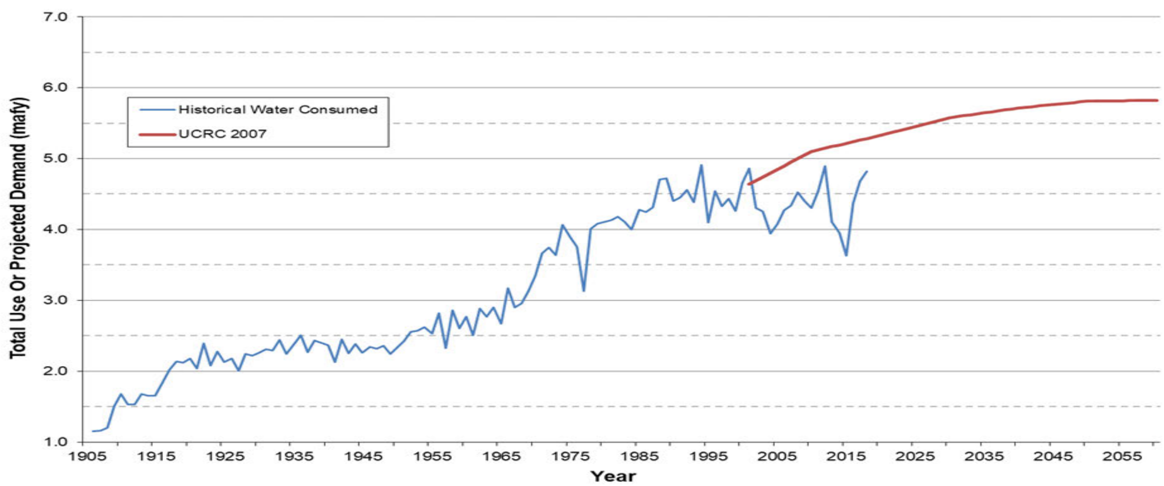


Figure 10 – Upper Basin Annual Consumptive Use and Projected Demands, includes CRSP Reservoir Evaporation

Table 2 - Upper Basin Total Projected Depletion Demand Scenarios (1000 AF/year)

UPPER BASIN	2020	2030	2040	2050	2060
Arizona					
Total scheduled depletion	50	50	50	50	50
State share of 2007 Hydro-Det Amount (6.01 MAF)	50	50	50	50	50
Remaining available	0	0	0	0	0
Percent of State share available	0	0	0	0	0
Colorado					
Total scheduled depletions	2,842	2,891	2,919	2,955	2,955
Critical Period CRSP Shared Evap. (% of 0.25 MAF)	129	129	129	129	129
Total	2,971	3,020	3,048	3,084	3,084
State share of 2007 Hydro-Det Amount (6.01 MAF)	3,084	3,084	3,084	3,084	3,084
Remaining available	113	64	36	0	0
Percent of State share available	4	2	1	0	0
New Mexico					
Total scheduled depletions	608	635	642	642	642
Critical Period CRSP Shared Evap. (% of 0.25 MAF)	28	28	28	28	28
Total	636	663	670	670	670
State share of 2007 Hydro-Det Amount (6.01 MAF)	670	670	670	670	670
Remaining available	34	7	0	0	0
Percent of State share available	5	1	0	0	0
Utah					
Total scheduled depletions	955	1,032	1,118	1,163	1,163
Critical Period CRSP Shared Evap. (% of 0.25 MAF)	58	58	58	58	58
Total	1,013	1,090	1,176	1,221	1,221
State share of 2007 Hydro-Det Amount (6.01 MAF)	1,371	1,371	1,371	1,371	1,371
Remaining available	358	281	195	150	150
Percent of State share available	26	20	14	11	11
Wyoming					
Total scheduled depletions	621	719	735	750	763
Critical Period CRSP Shared Evap. (% of 0.25 MAF)	35	35	35	35	35
Total	656	754	770	785	798
State share of 2007 Hydro-Det Amount (6.01 MAF)	834	834	834	834	834
Remaining available	178	80	64	49	36
Percent of State share available	21	10	8	6	4

Note 1: This depletion schedule does not attempt to interpret the Colorado River Compact, the Upper Colorado River Basin Compact, or any other element of the "Law of the River." This schedule should not be construed as an acceptance of any assumption that limits the Upper Colorado River Basin's depletion.
Note 2: This depletion schedule is for planning purposes only. This estimate does not constitute an endorsement of the Bureau of Reclamations 2007 Hydrologic Determination and should not be construed as in any way limiting the Upper Division States use of Colorado River water in accordance with the commission's resolution of 6/5/06.
Note 3: "Shared CRSP Evap." refers to the total and individual state portions of evaporation from the major Reservoirs constructed under the Colorado River Storage Project Act. These projects include Flaming Gorge, the Aspinall Unit Reservoirs and Glen Canyon.

Table 3 - Lower Basin Depletion Projections (1000 MAF/year)

LOWER MAINSTEM	2020	2030	2040	2050	2060
Nevada					
Southern Nevada Water Authority	287	287	287	287	287
Laughlin Area	4	4	4	4	4
Mohave Steam Plant	0	0	0	0	0
Fort Mohave Indian Reservation	9	9	9	9	9
Total	300	300	300	300	300
Arizona					
Lake Mead NRA	1	1	1	1	1
Marble Canyon Co	0	0	0	0	0
Fort Mohave Indian Reservation	73	73	73	73	73
Mohave Valley I&D District	24	24	25	25	25
Havasu NWR	5	5	5	5	5
Lake Havasu City & Other Users	32	35	39	44	47
Central Arizona Project	1372	1362	1351	1346	1343
Parker & Other Users	10	10	10	10	10
Cibola & Imperial NWR	4	4	4	4	4
Cibola Valley I&DD	8	8	8	8	8
Colorado River Indian Reservation	463	463	463	463	463
Gila Gravity Main Canal	774	770	776	776	776
Gila & Yuma Users	15	15	15	15	15
Fort Yuma Reservation	1	1	1	1	1
Other Users	20	29	29	29	29
Total	2800	2800	2800	2800	2800
California					
Fort Mohave Indian Reservation	9	9	9	9	9
City of Needles	1	1	1	1	1
Havasu NWR	0	0	0	0	0
Chemehuevi Indian Reservation	8	8	8	8	8
Other Users & misc. present perfected rights	2	2	2	2	2
Metropolitan Water District	847	854	854	854	854
Colorado River Indian Reservation	39	39	39	39	39
Palo Verde Irrigation District	366	366	366	366	366
Imperial Irrigation District	2645	2608	2608	2611	2611
Coachella Valley Water District	429	459	459	456	456
All American Canal (Yuma Project)	54	54	54	54	54
Total	4400	4400	4400	4400	4400
Unassigned					
Phreatophytes & Native Vegetation	632	632	632	632	632
Yuma Desalting Plant	109	109	109	109	109
Total	741	741	741	741	741

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 analyzed the effects on the salinity of the River for the 2017 Review. As part of the triennial review process, Reclamation used the Colorado River Simulation System (CRSS) model to evaluate whether enough 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 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

Existing salinity control measures prevent nearly 1.33 million tons of salt per year from reaching the river. In 2017 the Salinity Control Program for Reclamation has controlled approximately 550,000 tons of salt, while the NRCS program has reduced around 610,000 tons of salt, and the BLM has controlled an estimated 126,000 tons of salt per year from entering the Colorado River. In the 2017 Review it was determined that salinity control units will need to prevent nearly 1.66 million tons of salt per year from entering the Colorado River by 2035, in order to meet the standard and keep the economic damages minimized. To reach this objective, as shown in Table 4, the Salinity Control Program needs to implement 330,000 tons of new controls beyond the existing 1,330,000 tons of salinity control presently in place (2017) as reported by Reclamation, NRCS & BLM. On average about 18,300 tons per year of new salinity control measures must be added each year if the program is to meet the cumulative target of 1,660,000 tons per year by 2035, assuming no degradation of existing salinity projects. However, due to expected funding limitations in future years, more tons of salt will be controlled sooner than later.

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.

Table 4 - Salinity Control Requirements and Needs Through 2035

Measures in place (2017)	1,330,000 tons
Potential Salinity Control Available (2018-2035)	1,272,100 tons
Annual Plan of Implementation Target [a]	74,830 tons

a. This value is the amount of salt required on an annual basis to meet the potential available salt to control over the next 17 years.

CHAPTER 2 – TITLE I SALINITY CONTROL PROGRAM

The Salinity Control Act, 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).

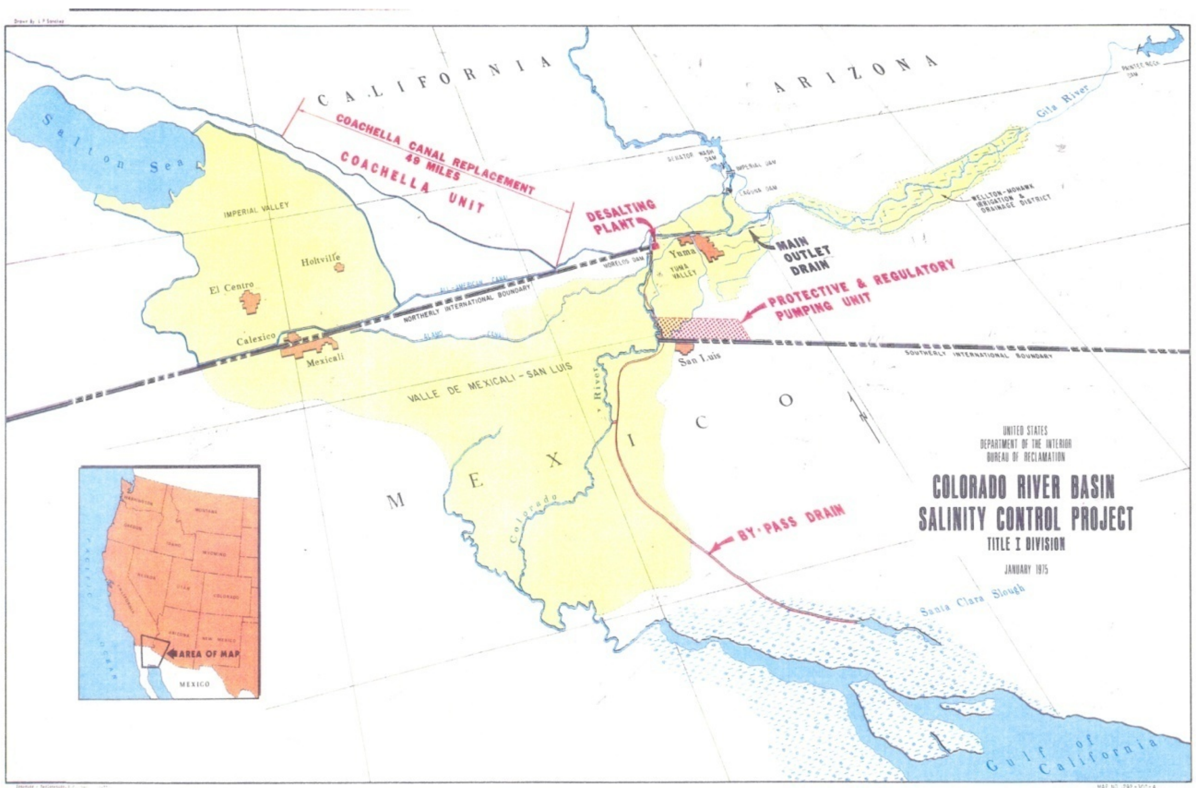


Figure 11 - Title I Salinity Control Projects

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 last Progress Report:

Coachella Canal

No new activity.

Protective and Regulatory Pumping

No new activity.

Yuma Desalting Plant

No new activity.

Wellton-Mohawk Irrigation and Drainage District (WMIDD)

Total crop acres have remained relatively stable since the early 1970's because more acreage is double-cropped than when the program was initiated. More vegetable crops are being grown in the district than in the past, with lettuce (iceberg and romaine) now the major crop. Irrigation efficiency levels and return flow levels for 1991-2017 are shown in Table 5. Efficiency values do not include a leaching fraction.

With the use of monthly groundwater table monitoring using observation well measurements as well as input from land users, WMIDD can 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 sprinkler, drip, dead level, high heads, and short runs.

Table 5 - WMIDD Irrigation Efficiency

Year	Drainage Return Flow (acre-feet)	Irrigation Efficiency, %
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	62.7
2010	111,170	66.1
2011	108,140	64.9
2012	115,630	64.1
2013	107,860	67.5
2014	111,390	64.6
2015	106,170	63.9
2016	99,130	67.6
2017	101,064	66.6

Note: data provided by WMIDD

CHAPTER 3 - 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 NRCS, Reclamation and BLM have a combined goal of controlling an additional 330,000 tons of salt by the year 2035. These federal agencies are required to work together under the Salinity Control Act, as amended; with Reclamation being the lead federal agency. The Salinity Control 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. New activities since the last progress report as well as ongoing and active projects are listed in this chapter.

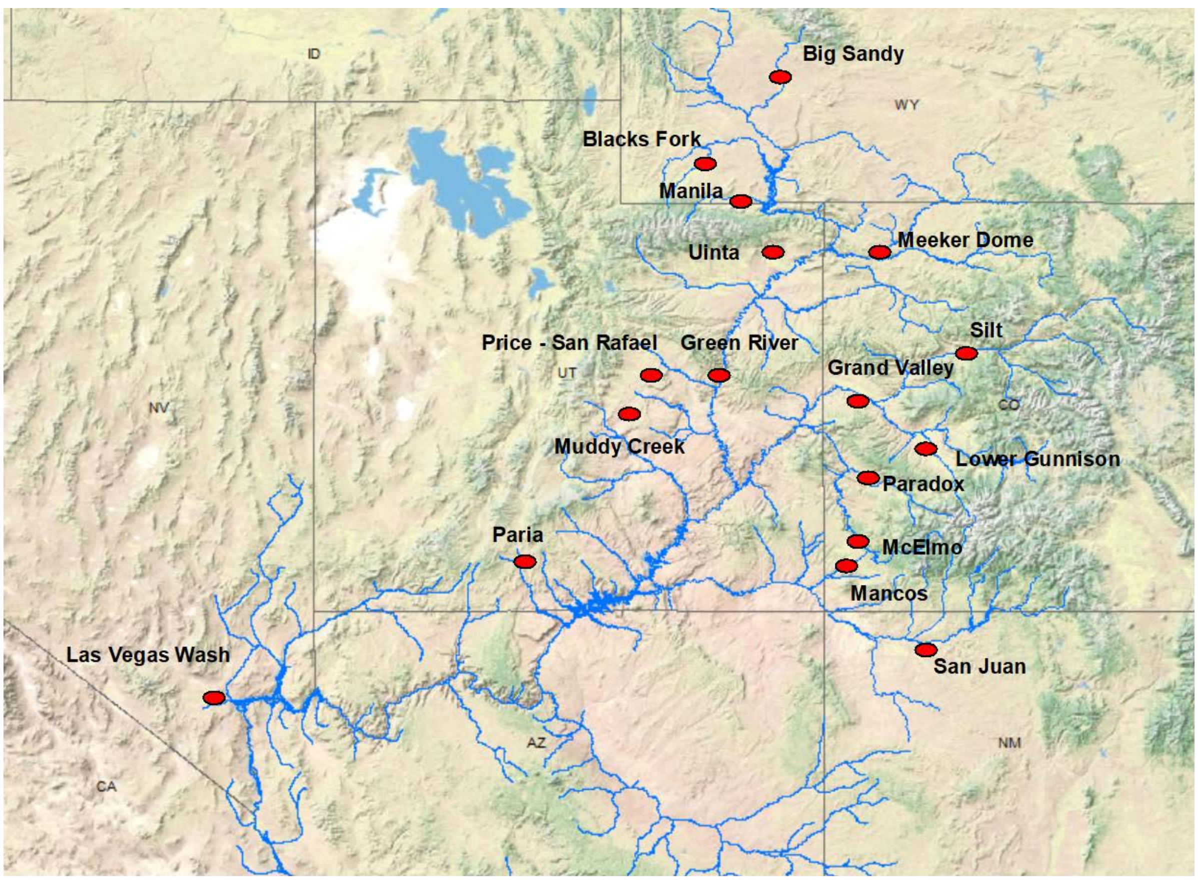


Figure 12 - Title II Salinity Control Projects

U.S. Bureau of Land Management (BLM)

The BLM administers about 53 million acres of public lands in the Colorado River Basin (CRB) above Yuma, Arizona. Substantial portions of these public lands are ecologically classified as arid or semiarid rangelands. Point sources of salt on public lands include saline springs, seeps from marine sedimentary formations, abandoned flowing wells, discharge from abandoned mines, and discharge of waters from authorized activities such as oil and gas production or mining. Nonpoint sources of salt include surface runoff, soil erosion, stream sediments, and groundwater discharge to streams. Salts can be transported in solution or with solids such as soils or coarse fragments. Past studies have indicated that salt loading in rangelands is closely associated with sediment loading and that wind transport is the dominant mechanism of sediment movement across semi-arid and arid rangelands. Salt concentrations on public lands tend to be highest in areas underlain by marine sedimentary rocks such as shales and mudstones that receive less than 8 inches of annual precipitation.

Although salt concentrations can be very high in runoff from these lands, the frequency and volume of runoff is low because of the low precipitation and ephemeral nature of stream systems. Runoff from areas with highly saline soils in the upper basin is estimated to contribute about one-third of the annual salt load from BLM public lands.

The greatest volume of salt contributed from BLM-administered lands, however, is sourced from areas with moderate to low salt concentrations in soils that are relatively well-covered with perennial vegetation and receive more than 12 inches of annual precipitation. Although salt concentrations in runoff from these lands are low, total loading is relatively large because of higher water yields. These areas comprise about 67 percent of BLM-administered lands in the upper basin. Runoff from these areas is estimated to contribute more than half of the annual salt load from BLM-administered lands in the upper basin.

The BLM attempts to reduce these impacts to help maintain land-health standards by utilizing best-management practices; including terms, conditions, and stipulations in land-use authorizations; and requiring actions to restore lands upon completion of authorized activities. BLM also engages in many activities to restore degraded ecosystems that contribute excessive sediment and salts to CRB watersheds. These activities include constructing and maintaining grade-control structures, spreader dikes, and retention structures; emergency stabilization and rehabilitation efforts following wildfires; removal of invasive plant species, channel stabilization, and other riparian enhancements; maintaining road culverts; remediation of abandoned mine lands, and fire fuels reduction treatments.
Salinity reductions for many of these activities continue to be difficult to quantify and report to the Forum because of factors such as the lack of adequate understanding about mobilization and transport of salts from rangelands and inability to conduct effectiveness monitoring for all projects. Reports from BLM State Offices (see below) reference many of these activities and the BLM is engaged in efforts with partner agencies to improve future ability to quantify salinity reductions from these efforts. To address these challenges, the BLM is co-developing a system of tools/models: RHEM-APEX-AGWA ((Rangeland Hydrology and Erosion Model; Al-Hamdan et al., 2011); (Agricultural Policy Extender model; Sharpley and Williams, 1990); (Automated Geospatial Watershed Assessment Tool; Hernandez et al, 2000)). The integration and linking of these tools/models were completed during FY2015. The collection of physical

data to model parameter value justification is still being conducted on BLM CRB rangelands as previously funded by the Basin States Program and continued by the BLM.

Program Summary and Administration

The 2017 budget included a total allocation of $1,500,000 for Colorado River Basin Salinity Control projects funded through the Soil, Water & Air Management Program. The Salinity Coordinator (SC) is placed administratively at the National Operation Center (NOC). Water resource specialist and soil, water, air program lead positions were filled at the Washington Office in fall of 2016. State soil, water, air program leads assist BLM field offices with support for salinity control projects and reporting. The present accounting method for BLM salt control is under review, so specific salt-controlled numbers are not reported here just the reported projects.

Basin Wide Activities

The BLM is not able to report reductions accomplished through many of these efforts to the Forum because of technical and programmatic issues but is working to develop approaches needed to quantify reductions. However, included in the $1.5 million funded projects is the BLM contracted work with USDA ARS for multiple rainfall sediment and salinity transport projects (final report to be ready summer, 2018). Data are being collected from New Mexico through October 2017. This data collected becomes the physical data that the RHEM-APEX model will use for simulations from small to large scale rangeland questions, as a policy tool, and for evaluating better procedures. The APEX tool will be used to detect sediment deposition and erosion in wind, water, and terrestrially through a less expensive method to answer the public's questions regarding salinity.

Fuels Treatment Effectiveness Monitoring Program

Since 2003, BLM has accomplished millions of acres of fuels management treatments including prescribed fire, seeding, thinning, mastication, and lop and scatter. Vegetation left on the ground from treatments such as lop and scatter, inhibits the transport of sediment and salts. Initially there may be increased erosion; however, overall per acre burned there is 1 cubic yard of sediment retained. Central to the success of the program is assessing the efficacy of those treatments. The BLM's Fuels Treatment Effectiveness Monitoring Program focuses on areas that are likely to intersect with wildfires leading to the destruction of vegetation and leaving paths for sediment and salinity surficial movement. Utilizing the Fuels Treatment Effectiveness Monitoring database (FTEM), field offices will complete a fuels treatment effectiveness assessment and input appropriate information into FTEM for all wildfires which start in, burn into, or burn through any portion of a fuel treatment area that has been completed. For example, since 2010, the Utah BLM Fuels Treatment Program has impacted sediment transport on over 260,000 acres resulting in more than 18,000 cu yd of sediment retained on BLM land with about half of it within the CRB Utah boundaries (approximately 8,900 cu yd of sediment retained = 2,450 tons retained).

Emergency Stabilization and Rehabilitation Program (ES&R)

ES&R is another BLM program that impacts sediment and salinity transport. Ten wildfires that have burned more than 10,000 acres, as addressed by the BLM, were identified for our modelling purposes. These fires included the Rattle Fire Complex, the State Fire, the Lakeside Fire, the Dallas Canyon Fire, the Patch Springs Fire, the Faust Fire, the Grease Fire, the Clay Springs Fire, the Woods Hollow Fire, the Wolf Den Fire and the Baboon Fire. An example of what is being accomplished to gain the sediment retained on BLM land is the Rattle Fire Complex that burned a total of 94,519 acres of which 50,000 acres was on BLM land. The ES&R report provides enough detail of the area and treatment as well as the related costs. That information is combined with existing vegetation, land use, soil, slope and climate data to compare pre-burn conditions to post-burn and post-rehabilitation conditions. Once approved by the BLM ES&R Program, the results will be added to sediment retained on BLM lands total.

Recreation-OHV (Off Highway Vehicle) Program

Within the entire CRB, we have calculated that the Recreation-OHV Program contains 89,700 miles of dirt roads that contribute to sediment transport. Based on a pound of soil having an average of 3 percent salt and that an average of 2 cubic yards are retained per mile of road maintained and it is assumed that a BLM OHV road has been maintained at least one time since it was built. It can then be estimated that a minimum of 20,560 tons of sediment with at least 3 percent salt have been retained on BLM land due to road maintenance on OHV dirt roads.

State Reports

BLM State Offices submitted the following reports describing activities related to salinity Control programs on BLM-administered lands. State reports include descriptions of projects conducted with designated Salinity Program funding through the SWA sub activity as well as summaries of activities conducted through other programs and permitted users that reduce the transport of sediment and salt to the Colorado River. Vegetation left on the ground inhibits the transport of sediment and salts. The BLM's Fuels Treatment Effectiveness Monitoring Program manages areas that are likely to intersect with wildfires leading to the destruction of vegetation and leaving paths for sediment and salinity surficial movement.

Within the FTEM and per IM-2015-001 which states that "offices will complete a fuels treatment effectiveness assessment and input appropriate information into FTEM for all wildfires which start in, burn into, or burn through any portion of a fuel treatment area that has been completed and reported in the Hazardous Fuels Module of the National Fire Plan Operations and Reporting System from FY2003 to present." Utah has 171 records where a record for example would be the Scipio Summit Wildfire in which there is 90 days to report it into the FTEM database. The records for Utah account for 21 percent of all of BLM's records. Since 2003, BLM has accomplished millions of acres of fuels management treatments including thinning, mastication, and lop and scatter. Wildfires have intersected many of these fuel treatments therefore, demonstrating fuels program effectiveness for a minimum of 17,363 acres (70.3 km^2) burned in Utah.

Another BLM Program that impacts sediment and salinity transport is the Emergency Stabilization and Rehabilitation (ES&R). Plans after the Toquerville Fire, Utah, in FY2012 were approved for reseeding to minimize soil erosion at a cost of $478,000 over a 4-year period; it burned 113 acres of public land. The action plan would not only establish a desired plant community but also suppress invasive annuals that can create a burn/re-burn cycle. The plan investigates understory and recovery to minimize erosion and reestablishment, fences, monitoring, soil stabilization, and road/trail diversions. The White Rock fire in Utah was approved for $1,636,000 in the BLM ES&R Program. Its plan of actions over three years was to apply a seed mix aerially, then use chaining to cover the seed. All livestock needed to be removed for two growing seasons so that the seeding could take effect. Based on site characterization of slope, topography, and ecology no additional measures were needed. The BLM was treating an area of 3,542 acres that included 263 State acres and 212 private acres for a total of 4,017 acres for a total cost of $950,000. This area also included the possibility of sage grouse and pygmy rabbit.

ARIZONA

Across the Arizona Strip Field Office there are hundreds of erosion control structures which have been built to slow down erosional runoff, salinity, and valuable soil loss which would eventually end up in the Colorado River system. Over 200 of these structures are in the 1,000,000-acre Fort Pearce flood and salinity control sub-basin. Many of these structures have deteriorated or have been breached by heavy runoff. Without maintenance, these structures fill up over time with saline silt causing them to lose their holding and functional capacity. This project would inventory and maintain many of these structures which range from 50 feet to over a quarter mile in length. The structures would be inventoried, assessed for needed repairs, and prioritized for maintenance and repair work to be completed. In the past few years, increases in runoff have occurred across the unit due to the encroachment of pinyon and juniper which has out competed the understory soil holding vegetation. This has allowed increased flows in nearly all drainages causing soil loss and salinity movement across the landscape. The purpose of this project was to slow the flow by repairing and maintaining the existing structures.

Current project: work in progress.

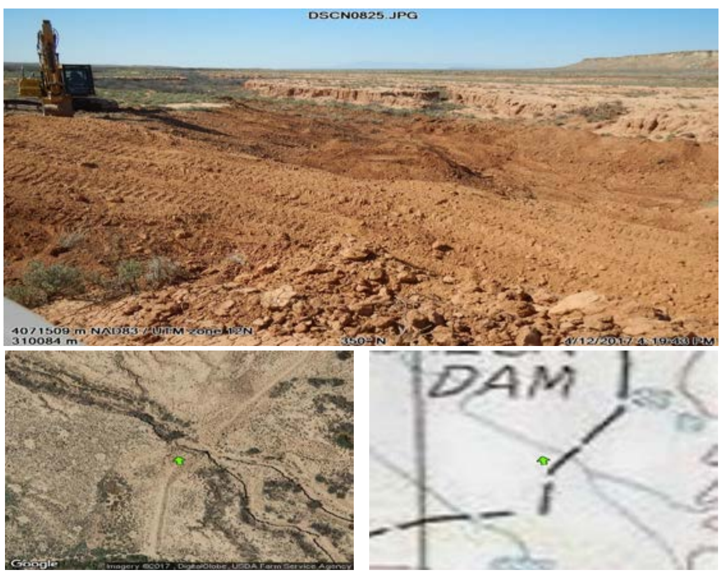


Figure 13 - Flat Top Dike #9; South view of repairs. All photos in this section provided by BLM

COLORADO

Colorado River Salinity Summary of Monitoring Activities-WRFO (2008-2017)

The Colorado River Salinity funding (CRS Funds) for the White River have been used to augment existing USGS Streamflow monitoring sites, support USGS reports based on data collected, purchased equipment for BLM monitoring, and hire seasonal personal for field work. This funding resulted in an unprecedented amount of baseline data being collected and analyzed for the White River, Piceance Creek, and Yellow Creek drainages. The reports and data generated can be used to contributions of anthropogenic impacts to salinity in surface waters specifically, the salinity loads from the White River. The BLM funded a data repository to collect and assess existing water resource information http://rmgsc.cr.usgs.gov/cwqdr/Piceance/). Data from the repository is being migrated to the Colorado Data Share Network (http://www.coloradowaterdata.org/). Accomplishments are similar to 2016 FAR.

USGS Yellow Creek Streamflow Site
Establishment of a new USGS streamflow site above Crooked Wash to bracket an area on the White River (White River Dome and Piceance and Yellow Creeks) known to be responsible for increasing salinity loads in the White River. Summary of all data available and funded by BLM is available at http://waterdata.usgs.gov/nwis/nwisman/?site_no=09306224&agency_cd=USGS.

Mancos Shale Oil and Gas Monitoring -CRVFO
The USGS in cooperation with the BLM will study the distribution, storage, and release of sediment, salinity, and selenium in area of Mancos Shale under two different land uses. The study will include 2 basins in Stinking Water Gulch near Rangely, CO, where one basin is dominated by oil and gas land use (Basin A) and the other basin is dominated by grazing/ranching land use (Basin B). The two basins are of similar size (~1.4 square miles) and similar slopes (~16 percent). This approach will provide insight into how different land uses effect the distribution, storage, and release of sediment, salinity, and selenium in surface-water systems.

Stinking Water Gulch-Grand Junction- UFO
The USGS, in cooperation with the BLM, is completing a study of four basins on BLM managed lands that are geographically similar and represent different land use histories on areas of Mancos Shale. This study will help resource managers gain insight on how different land uses may affect sediment, salinity, and selenium distribution and storage in Mancos Shale landscapes. The objectives of the project are to (1) characterize sediment, salinity, and selenium distribution and storage in four basins in Stinking Water Gulch under differing land uses (energy development and rangeland grazing); and (2) to evaluate the role of land use (energy development and rangeland grazing) and watershed processes that may increase sediment, salinity, or selenium inter-basin flux. Project is being updated and combined with additional projects.

Project Tasks and progress status through calendar year 2017:
The study includes four basins in Stinking Water Gulch near Rangely, Colorado. Two basins are dominated by energy development (Basin A1 and A2) and the other two basins are dominated by rangeland grazing (Basin B1 and B2). The basins in each basin group (A and B) include basins of similar size, aspects, soils, and slope. A comparison of sediment, salinity, and selenium storage characteristics between these two basin groups is used to evaluate the homogeneity of each system as well as to test for significant differences between the two groups. This approach aims to provide insight into how different land uses affect the distribution, storage, and release of sediment, salinity, and selenium in surface-water systems. Results were presented as part of a peer reviewed publication in calendar year 2017. The methods, background, and maps have been provided in the 2016 FAR. **Task 3.** Laboratory results are expected in September 2017. Identification of the age of geomorphic surfaces within the basins will aid in interpretation of the timing and correlation of incision of the stream channel observed in the basins. **Task 4.** An assessment of hillslope erosion potential was begun December 2015, using the USDA developed Water Erosion Prediction Project (WEPP) model (USDA, 1995). Comparisons of erosion predictions from the WEPP interface between the two basin groups and results of simulations using *WEPP:Road* will provide a comparison of the hillslope processes and transport rates of these two systems and can aide in understanding potential sediment inputs and erosion attributable to road and well pad disturbances

associated with land uses in the area. **Task 5.** A determination of the release rate for sediment, salinity, and selenium is being done through an assessment of volume changes within the channels of each basin in conjunction with annual load estimates from the WEPP analysis in 2017. The cross-section data is used with age dating to estimate channel incision rates and to evaluate total channel volume change through time (inter-basin sediment flux). Geomorphic surface present in the study area were identified, and cross-sectional area at these locations were related to basin morphology to determine the erosional volume. Correlations between cross sectional area and downstream distance in each basin were determined (and example is shown in figure 5). Volume estimates were related to bulk density of soils in the areas (USDA, 2017). The volumes of each basin and along multiple points within each basin are used to compare sediment storage between basins and basin groups.

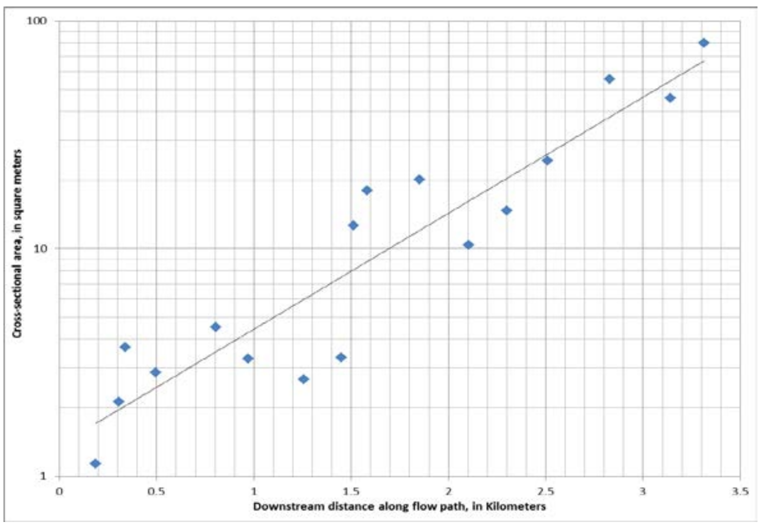


Figure 14 - Correlation between cross sectional area (volume of sediment removed below identified geomorphic surface) and downstream distance along study basin, Rio Blanco County, Colorado

Soil chemistry indicated varying concentrations of salts at locations sampled within a basin and between basins. Concentrations for salts showed a general decrease in concentration from higher-elevation terrace, lower-elevation terrace, and stream bed samples; whereas, selenium concentrations showed a general increase in concentration along this same progression of geomorphic surfaces. **Task 6.** Release of findings will be done in FY 2018 after receiving the remaining OSL-sample results and completion of the analysis. Water-quality data will be stored and available to the public through the USGS National Water Information System Web Interface (https://waterdata.usgs.gov/nwis). Results of this study will be published in a peer reviewed publication with applicable data sets in calendar year 2018.

Piceance Basin Salinity Groundwater Monitoring

In 2017, the USGS, in cooperation with the BLM, continued groundwater-monitoring efforts which began in 2008 in an areas of energy development in the Piceance Basin (Uinta and Green River Formations). Results from this monitoring effort indicate that (1) shallow aquifers are vulnerable to dramatic changes in water-levels and water quality (salinity) which may be the result of solution mining or drilling activities including hydraulic fracturing; and (2) verified that plug and abandoned wells on BLM lands can act as conduits for the migration of gases and fluids from deeper sources to shallow, freshwater aquifers.

NEW MEXICO

San Juan River Basin Erosion Reduction

Focus is on noxious weed removal that threatens native riparian habitat, cutting trees, and showing lack of understory plant growth leading to loss of topsoil due to rain/snowmelt events that lead to surface products in the stream. Sediment fences are being built, Youth Conservation Corps are involved to restore native vegetation and soil erosion and salinity will be reduced. Work is progressing.

La Manga Canyon Watershed Improvement - Degraded rangelands including sagebrush grasslands and pinyon and juniper woodlands are on steep hillsides. The trees have minimal understory and excessive soil erosion. Sediment retention dams are being built to hold sediment on the watershed.

Road Improvements - Roads have been regularly maintained and reconstructed to meet road standards. BLM's Civil Engineering technician developed the San Juan Public Roads Committee. This committee includes oil and gas producers, members of the local ranching community, and the Forest Service. The Committee has greatly improved the conditions of the local unpaved roads and has helped reduce the amount of sediment reaching the river systems from the road network. The Surface Protection staff at the BLM-FFO has completed several road and sediment retention upgrades for the fiscal year on BLM managed lands. Table 6 has a list of sediment retention and erosion control features installed or maintained for roads in FY17.

Table 6 - List of sediment retention and erosion control features installed or maintained for roads in FY17

Road name/Area	Miles of road improvement	# of sediment retention structures built	# of retention structures cleaned	# of culverts installed	# of sediment ponds built
Truby Road/Largo Canyon	2 miles	3	0	0	0
Bradly Road/Carrizo Canyon	0.75 mile	2	0	5	3
Newberry Road/Heartly Springs	0.5 mile	2	2	3	0
Simon Canyon Roads/Simon Canyon	25 miles	0	2	4	1
Cabin Canyon Road/Hart Canyon	1.5 miles	0	0	4	3
Carrizo Road/Carrizo Canyon	0.25 miles	0	0	3	1
La Plata Roads/La Plata River	1 mile	3	1	3	0
Hart Canyon Road/Hart Canyon	0.125 mile	1	0	2	0
Rodeo Development Unit	1 mile	1	0	4	0
Total	32.125 Miles	12	5	28	8

Vegetation Treatments - Approximately 2,500 acres of Federal land that was infested with weeds were sprayed to promote native vegetation recovery. Approximately 3000 acres of weed treatment areas were monitored to establish the effectiveness of treatment. Farmington plans on applying Tebuthiuron (Teb) to approximately 13,300 acres of sagebrush/grassland that had become unhealthy due to excessive densities of sagebrush. The project will begin in the fall when chemical applications are most effective. Funding has been allocated through the BLM/NMACD agreement for this project. Sagebrush in high densities tends to dominate the available soil moisture causing a loss of grass species and an increase in bare ground resulting in increased soil erosion. Tebuthiuron is applied at an appropriate rate to thin the sagebrush but not to eliminate it. Reducing sagebrush densities generally results in increased water availability for grass and forb species which typically increase ground cover and reduce soil erosion.

Pinyon and juniper lop and scatter projects are beneficial to multiple resources on the landscape. Reestablishing a grass understory in project area increases infiltration rates and decreases runoff and erosion during high flow precipitation events. Slash created by the project is used to protect seeded areas and decrease sheet runoff in the project areas. Seed mixes used include a wildlife forb component. Approximately **35 acres** of lop and scatter/ seeding have been completed with three types of Southwest Conservation Corps crews with an additional 500 acres planned and funded for the fall. This amount may vary based on availability of contractors.

Silt Traps- 83 Applications for Permit to Drill (APDs) have been approved this year so far. Oil and gas operators have been granted an exemption from storm water runoff by the EPA. A common Best Management Practice (BMP) associated with the building of these well pads are the construction of silt traps to contain sediment runoff associated within the disturbance from the well pad. Each location generally had a minimum of one silt trap associated with it. For this fiscal year an estimated 83 silt traps were constructed, assuming 1 silt trap per well pad. Approximately 640 silt traps have been built to help curtail sediment and salt loading and improve water quality in the San Juan Basin.

San Juan River Watershed Salinity Reduction and Vegetation Management

Rangeland areas have been identified for vegetation treatments to increase native understory recovery. The funding for this project has been allocated through an agreement with NMACD to conduct aerial treatment of 13,300 acres of decadent sagebrush communities lacking sufficient understories. Approximately 35 acres of pinyon and juniper encroachment have been thinned and seeded; an approximate 500 acres of pinyon and juniper encroachment in the Simon Canyon Watershed and Middle Mesa are being treated using heavy equipment.

The 300 acres of a previously treated area on Pump Canyon Mesa has been reseeded to ensure the success of the project Approximately 40 acres of thinning projects in La Manga Canyon are being reseeded to ensure project success. There is also a project planned to mow approximately 300 acres of Tamarix (salt cedar) within Gobernador Canyon. NEPA compliance for the project is in the final stages. The salt cedar leaf beetle biocontrol has eliminated most of the salt cedar communities in the canyon, and this project is designed to seek and eradicate the remaining clusters with small equipment.

San Juan River Watershed Integrated Salinity Reduction

Funding for this project has been allocated to purchase materials used for sediment capture fences. Two major structures in Largo Canyon and La Manga Canyon are planned to have maintenance and upgrades.

Figure 15 - Current Lop and Scatter Project (SCC/USJW); La Manga Project Area (Two years post-treatment); Previous La Manga Project (one-year post-treatment) W/ Native Grass

Figure 16 - 2016 Teb Sagebrush Treatment 1. Photos provided by BLM

Figure 17 - Previous Teb Treatment (Post-treatment)

Figure 18- Recently Installed Silt Trap (Simon Canyon)

Figure 19 - Previous Bradley Road (completely impassible-eroded by Carrizo Wash)

Figure 20 - Previous Bradley Road Ripped and Reseeded with Erosion Control Structure

Figure 21 - New Bradley Road Complete with Culverts and Sediment Retention Ponds

UTAH

Sediment Collection and Salinity Reduction on the GSENM Eight Mile Salinity Control Structure

In 2013 and 2014 the Grand Staircase-Escalante National Monument repaired the Eight Mile Salinity Control Structure. In 2013 and 2014, the dam was extended approximately 150 feet, the spillway was repaired and armored with geotextile material and riprap, and approximately 13,000-15,000 yd^3 of salt-laden sediment was excavated from the control structure's primary settling pond to restore the holding capacity of the reservoir.

Figure 22 - Eight Mile Impoundment with water July 1, 2016 (Impoundment is approximately 5 acres)

In 2017 the Eight Mile Salinity Control Structure collected sediment and water during the summer 2016 monsoon rains. As of July 1, 2017, the pond was inundated with water, so it was not possible to measure the depth of sediment that accumulated during the previous year. Work was completed during summer 2017 to repair a large washout in the Eight Mile dam and to lower the spillway and install culverts that will prevent water from flowing over the dam in the future.

Telegraph Flat and Finn Little Wash Salinity Control Structures

In 2016, five salinity control structures were cleaned and repaired on Telegraph Flat (Telegraph Flat 1-4 and Finn Little: (see map below), north of Hwy 89 at the southern end of the Monument. From August 2016 to July 1, 2017, the Telegraph Flat salinity control structures captured approximately 21.7 yd^3 of sediment.

The Finn Little structure was breached by flooding shortly after being repaired in 2016 and did not collect sediment for the year.

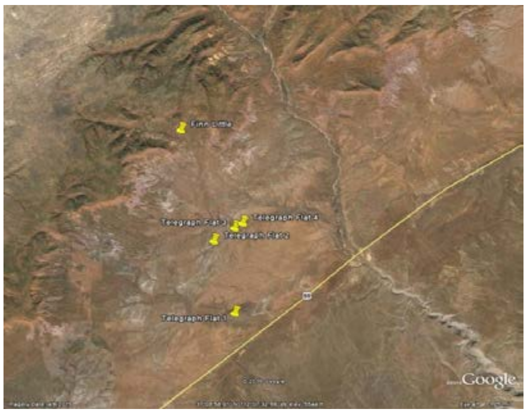


Figure 23 - Google Map Imagery of Telegraph Flat and Finn Little Wash Salinity Control Structures

Figure 24 - Telegraph Flat 1 - Photos show wetted area where sediment collected in 2016-2017.

Figure 25 - Photos of Telegraph Flat 2 (a), 3 (b) & 4 (c) showing the wetted area where sediment collected in 2016/2017.

Paria Town Area, Kimble Valley 1, & Kitchen Corral 1 Salinity Control Structures
Three salinity control structures near the Old Paria Town were cleaned and repaired in the summer of 2016. Approximately 7,155 yd^3 of sediment was removed from the structures and used to maintain and repair the adjacent dams.

Kimble Valley 1 was cleaned in the spring of 2017. Approximately 18,252 yd^3 of sediment was removed from the structure and used to maintain and repair the adjacent dam. At Kitchen Corral 1 (see Paria Town area map), a small amount of material from the salinity control structure was used to repair a hole in the dam. The pond was not cleaned because it was full of water.

Kimble Valley Salinity Control Structures
Three salinity structures (Kimble Valley 2, 3, and 4) were cleaned in the Kimble Valley area of the Monument, north of Hwy 89 (see Kimble Valley Area Map), in 2014, but were not documented in the 2016 report. Over the last 3 years, the ponds collected approximately 2,800 yd^3 of sediment.

Figure 26 - Photos of Kimble Valley salinity control structures in 2017. Kimble valley 2 (a), 3 (b) & 4 (c).

Salinity Control Structures Cleaned and Repaired
Buckskin Area Salinity Control Structures Four salinity control structures north of Buckskin Mountain were cleaned and repaired in the spring of 2017 in the area south of Hwy 89 (see Buckskin area map). Approximately 22,593 yd^3 of sediment was removed from the structures and used to maintain and repair the adjacent dams. The last clean-out dates are not known.

Figure 27 - Photos of Buckskin salinity control structures cleaned in spring 2017. Photos provided by BLM.

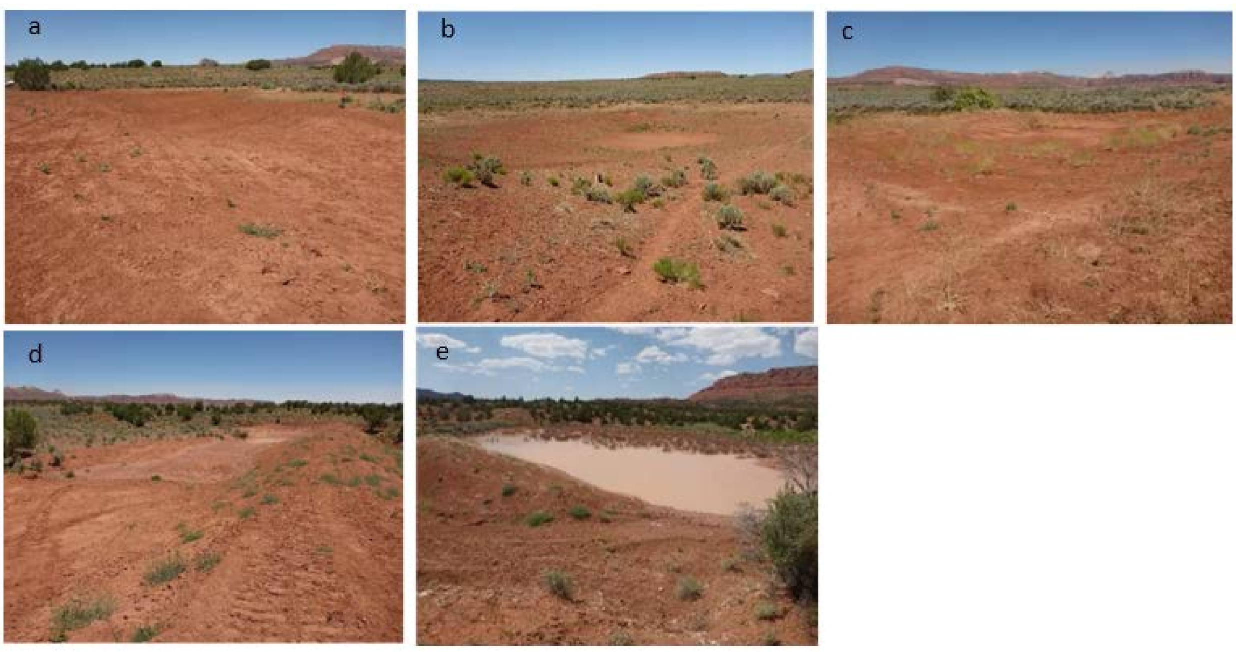


Figure 28 *- Photos of Paria Town area (a, b and c), Kimble Valley 1 (d), and Kitchen Corral 1 (e) Salinity Control Structures.*

Summary: GSENM Salinity Work 2016 – 2017 In summary, salinity control structures cleaned and repaired prior to July 1, 2017 collected 3,268 yd^3 of sediment. From July 1, 2016 to July 1, 2017, 15 additional structures were cleaned and repaired on the Monument. A total of 114,010 yd^3 of sediment was removed from these structures and used to repair and maintain the dams.

Five-Mile and House Rock Valley Area Salinity Control Structures

Four salinity control structures along House Rock Valley Road, south of Hwy 89 were cleaned and repaired in the spring of 2017 (see House Rock Valley area map; names are 5-Mile 1 & 2 and House Rock Valley 1 & 2). Approximately 17,031 yd^3 of sediment was removed from the structures and used to maintain and repair the adjacent dams. The last clean-out dates are unknown.

Figure 29 - Photos of House Rock Valley salinity control structures cleaned in Spring 2017. Five mile 1 (a), Five mile 2 (b), House Rock Valley 1 (c), and House Rock Valley 2 (d). Big Flat Grazing Allotment. Photos provided by BLM.

The Big Flat Grazing Allotment has a new grazing strategy due to the recent permit renewal process. In order to better manage a large area of moderately saline soils, a new grazing pasture has been delineated allowing a shorter period of use on these soils. Salinity funding was used to construct the multiple mile long pasture fence.

Progress- The fence is under construction, figure 30. The extent of the fence will be known once all funds from all sources are utilized. The total fence length will be 5-miles long, creating a new pasture about 15,000 acres in size. The new pasture has 90 percent moderately to highly saline soils, and 90 percent of the saline soils are Chipeta soils.


Figure 30 - A grazing exclosure on right, in the new pasture area.

WYOMING

The following information is an estimate of the amount of salt retained on the landscape because of actions taken by the Rock Springs, Rawlins, Kemmerer, and Pinedale Field Offices in FY2017.

Nonpoint Sources

Nonpoint sources are addressed through regular maintenance of BLM roads and facilities as well as reclamation of well pads and other disturbances. Salt savings from nonpoint sources are estimates only. The exact amount, location, and duration of surface disturbance and the associated sediment and salt concentrations are unknown. With the increase in soil data availability and improvements in GIS mapping, more accurate estimates are anticipated but as of this time are unavailable.

There have been increased levels of stream bank erosion associated with rain events. At the same time, broad scale vegetation cover has improved, which reduces nonpoint erosion and aids in grazing distribution. It is unknown which process dominates. The Wyoming Lands Conservation Initiative (WLCI) http://www.wlci.gov/ and Jonah Interagency Office (JIO) http://www.wy.blm.gov/jio-papo/index.htm provided funding for several projects http://www.wy.blm.gov/jio-papo/whatsgoingon.htm in the area that, while not focused on direct salt reductions, have the potential to reduce salt volumes by improving wildlife habitat and thus focus primarily on vegetation, which also benefits salinity. The volume and cost savings of these projects is unknown.

A variety of activities occurred as part of normal operations in FY 2016 that had the secondary impact of reducing non-point erosion on public lands. Because of these activities and monitoring, exact volumes of salt saved and the efficiency of each activity yielded general estimates with a wide range of uncertainty. All of the figures below are for the Green River Basin located in the southwestern corner of Wyoming and falls within the Rock Springs, Kemmerer, Pinedale, and Rawlins Field Offices. A portion of these activities occurred outside the Colorado River Catchment, but much of the activity occurred within the area of interest.

The standard practices of road maintenance and grazing management help to reduce potential erosion. The costs and salt savings vary widely. Though not specific to salt savings, these practices are key to broad scale erosion reduction and salt retention. The following assumptions were made for the calculations below:

1. **Road Maintenance and Reclamation** (Approximately the same as 2006 to 2017) 350 miles of road maintained; Assumption: 2 cu yd of sediment retained per mile of road maintained**.**

2. **One Reservoir Repair RFO** 1000 cu yd of soil retained over life of project = 4,467,000 pounds sediment**.** Structures mentioned in previous reports for this area are still operating and have not required any maintenance expenditures. Given that they are still preventing the upstream advancement of channel drops (headcuts), these structures could be highly cost efficient in preventing salinity contributions.

3. **Grazing Management** (Same as 2006-2017); 28,000 acres of land managed; Assumptions: 3 cu ft of soil retained for each acre properly managed.

Cottonwood Creek Headcut Repair This project plans to stabilize a headcut on Cottonwood Creek, which is an intermittent tributary to Lower Muddy Creek. In 2011, this reach of Cottonwood Creek failed PFC Assessments due to channel instability. A headcut is in Section 6 of T13, R91 and is actively moving at an approximate rate of 10 feet per year. As the headcut migrates up gradient, it continues to contribute large amounts of sediment and salinity to down gradient reaches. Management actions such as grazing rotations, are currently in-place to allow for better growth of stabilizing riparian vegetation; however, the head cut is continuing to migrate. Efforts to repair or stabilize the headcut involve installing gradient control structures at the current headcut location.

The Cottonwood Creek Headcut Repair project was planned to go to construction in August of 2016. NEPA has been completed along with preliminary site visits with RFO operations staff. Boulders and rocks located on the hill slopes near the project area were used to construct the gradient control structures. NEPA analysis has been completed along with a Free Use permit for the boulders.

Muddy Creek Watershed Stabilization

Muddy Creek is a major tributary to the Little Snake River within the CRB. Cooperative efforts by BLM, WGFD, TU, USFWS, local conservation districts and landowners began in 2010 to restore degraded stream channels and improve riparian and aquatic habitat across the watershed. Efforts continue with 2 stream restoration projects planned for 2017 and 2018. One project is on East Muddy Creek (Phase II) while the other is on Littlefield Creek; both streams are tributaries to Muddy Creek. Engineered stream restoration designs will be implemented on both stream channels to restore natural channel stability, reduce in-channel erosion. Implementation of these projects will reduce in-channel erosion, which will in turn reduce sediment and salinity loadings to Muddy Creek. The Muddy Creek watershed encompasses 471 km^2 and is a major tributary to the Little Snake River within the Colorado River Basin.

Figure 31 - Savery Creek Stabilization

The Savery Creek project is a multi-year project (approximately 4 stream miles) that will be completed in 3 to 4 phases. Reaches of Savery Creek below High Savery Reservoir exhibit unstable channel characteristics including mass wasting on outside bends, excessive in-channel erosion and sedimentation and large width to depth ratios. All these factors are contributing large amounts of sediment to downstream waterbodies within the CRB. The Savery Creek is a major tributary to the Little Snake River, located within the Upper Colorado River watershed.

This project proposed to implement natural channel design techniques on the target reaches that would reduce in-channel erosion, sedimentation and salinity loadings. Phase 1 is planned to go to construction in 2018. Preliminary surveys and conceptual engineered designs have been completed. Construction was initially planned for 2017, however, the complexity of permitting and designing a restoration project of this scale and consideration of the numerous concerns of all involved cooperators have delayed construction of Phase 1 to 2018. Conceptual plans have been completed which allows for the fund raising and permitting phases to begin.

Colorado River Basin BLM Salinity Risk Assessment and Mapping

Identifying where moderate to high saline soils occur is critical for mitigating potentially deleterious impacts of land-use on Colorado River salinity in conjunction with erosive soils that could be more readily transported from public lands to the Colorado River and its tributaries. The soil survey geographic (SSURGO) database in the CRB is incomplete and where it is complete is often coarse in scale, making it difficult for land managers to fully address these erosion prone areas.

The objective of this work is to identify saline soils in the upper Colorado River Basin (CRB) at high risk of erosion. This is being accomplished using digital soil mapping (DSM) strategies and soil erosion modelling applied within geographic information systems. Recent research has demonstrated increasing DSM success in mapping regional to global scale soil maps (including areas previously unmapped) from archived soil survey field observations (Hengl et al., 2017; Nauman and Duniway 2016) and from original soil survey maps (Chaney et al. 2016). These efforts all utilize extensive environmental raster datasets (e.g. Landsat imagery, digital elevation models) to extend the inference of the soil observations available. The state of Utah has 9,368 field soil observations of varying detail available that can be leveraged in different ways to help map salinity using a DSM framework. The location of saline soils relative to drainages, as well as the local conditions that control erosion risk, are important factors to consider when designing salinity control management actions. Primary erosion risk factors include soil texture, slope steepness and length, and proportion of the soil surface exposed (not protected by rocks, lichens, litter, plants, and other protective armoring).

This work is being done in collaboration with the BLM SC and is funded by the BLM Salinity Program with in-kind contributions from the USGS Ecosystems Mission Area. The MUSLE erosion equation is likely to be used for the region based on NRCS suggestion and SC modeling experience with the region.

Electrical Conductivity (EC)

We chose to map at 30-meter resolution using a suite of raster environmental mapping layers (terrain, landform, landscape position, and geologic indices, see Nauman and Duniway 2016). We employed a machine learning algorithm using the 3D mapping strategy employed by Tomislav Hengl for the SoilGrids.org project using approximately 292 pedons (857 horizons) from the NRCS national laboratory database to train this model.

Risk Mapping

To create salinity risk maps, we will overlay erosion predictions and the new soil EC map to identify areas with saline soils that are in moderate to high risk of erosion. Using the sediment loss (mass/area) and estimates of potential total dissolved solids (TDS) based on soil EC, we can then estimate potential mass of TDS contributed from each 30-m pixel. Finally, by overlaying salinity risk maps and CRB hydrology layers (flow accumulation and stream networks), we can further refine saline risk mapping by identifying those areas with moderate to high saline soils that are more likely to contribute salts to perennial river and stream tributaries to the CO River.

Progress to date includes a hydrologically consistent D-infinity flow accumulation map for the entire upper UCRB for use hydrologic and erosion modelling; a new surface soil EC map of UCRB that will be used to identify saline soils (Fig. , RMSE = 1.8%); Soil erodability (K-factor) map of UCRB for erosion modelling (not shown, RMSE = 0.006%); a rainfall-runoff erosivity factor (R-factor) map of UCRB for erosion modelling (not shown); a bare ground (BG) exposure map of UCRB for erosion modelling (Fig. , RMSE = 12.5%); and a cover (C) factor map of upper CRB calculated from bare ground (BG) layer (C = [%BG]/[100+[100-%BG]]).

Deliverables

September 30, 2017. The following will be submitted to the BLM SC for review and comments: New salinity soil maps of UCRB along with metadata, accuracy reporting, and uncertainty analysis identifying any potential accuracy gaps; New maps of bare ground of the UCRB based on remote sensing; Salinity risk maps, depicting relative risk of lands contribution of TDS to the UCRB surface waters based on soil salinity, hydrological cost-path analysis, and bare ground; March 31, 2018. Peer reviewed publication(s) documenting research approach and resulting risk mapping.

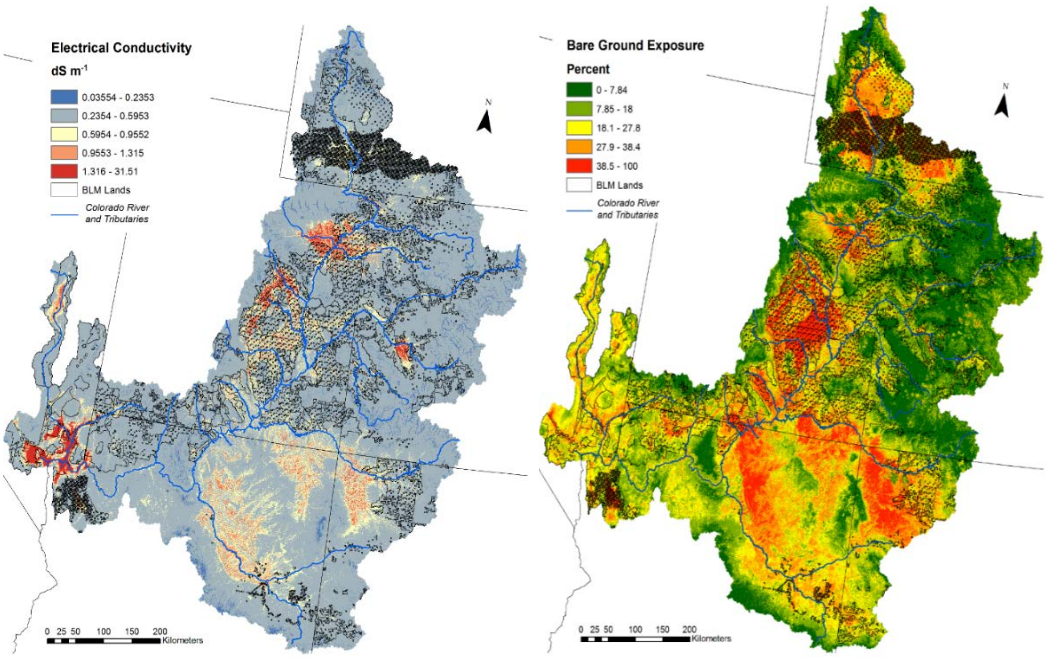


Figure 32 - New surface soil EC map in dSm-1 for Upper Colorado watershed (RMSE=1.8%)

U.S. Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS)

The NRCS of the USDA conducts Colorado River Basin salinity control activities primarily under the authorities of the Environmental Quality Incentives Program (EQIP). EQIP was authorized by the 1985 Food Security Act (1985 Farm Bill) but received its first appropriation with passage of PL104-127, Federal Agricultural Improvement Act of 1996, a.k.a. "1996 Farm Bill."

EQIP has been reauthorized in each "farm bill" through 2018. 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 12 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 habitat impacted as a result of the salinity measures.
In FY 2017, about $12.0 million of appropriated-EQIP financial assistance funding was obligated into new EQIP contracts for salinity control and wildlife habitat as follows:

Obligation	
Colorado -	$5,959,221
Utah -	$6,003,188
Wyoming -	$78,853
Totals	$12,041,262

Program History

Progress in implementing the various projects is controlled primarily by annual federal appropriations. The Salinity Control Act provides funds for additional implementation from the Basin States Salinity Program. From the 1970s through 1986, the Agricultural Conservation Program (ACP) administered by the Agricultural Stabilization and Conservation Service (ASCS) provided financial assistance (cost share) to land users through long term agreements (LTAs) and the Soil Conservation Service (SCS) provided the technical assistance to plan, design, and certify practice implementation. From 1987 through 1996, the Colorado River Salinity Control Program (CRSCP) received dedicated annual funding, again with the ASCS administering the financial assistance and SCS providing the technical assistance. In 1995, Public Law 103-354 authorized the reorganization of several agencies of USDA. The ASCS was reorganized as the Farm Service Agency. The SCS was reorganized as the NRCS. Financial administration of the CRSCP was transferred to the NRCS where it has remained to the present.

The Federal Agricultural Improvement and Reform Act (FAIRA) of 1996 (Public Law 104127) combined four existing programs including the CRBSCP into the newly authorized EQIP.
Since 1996, EQIP has been reauthorized through four consecutive farm bills and is currently authorized through FY 2018.
In FY 1997, Reclamation began on-farm cost sharing from the Basin States funds that would parallel and supplement the EQIP.

Monitoring and Evaluation

NRCS personnel from project and area offices monitor and evaluate the effectiveness and quantity of salinity control, wildlife habitat, and economic trends in order to improve overall performance and management of the program. The program continues to function effectively and economically, though the nominal cost per ton of salt control is escalating in some areas.

Status of Planning and Implementation

USDA-NRCS continues to provide technical and financial assistance to landowners and operators to implement on-farm salinity control measures in twelve approved project areas in three Upper Basin states.

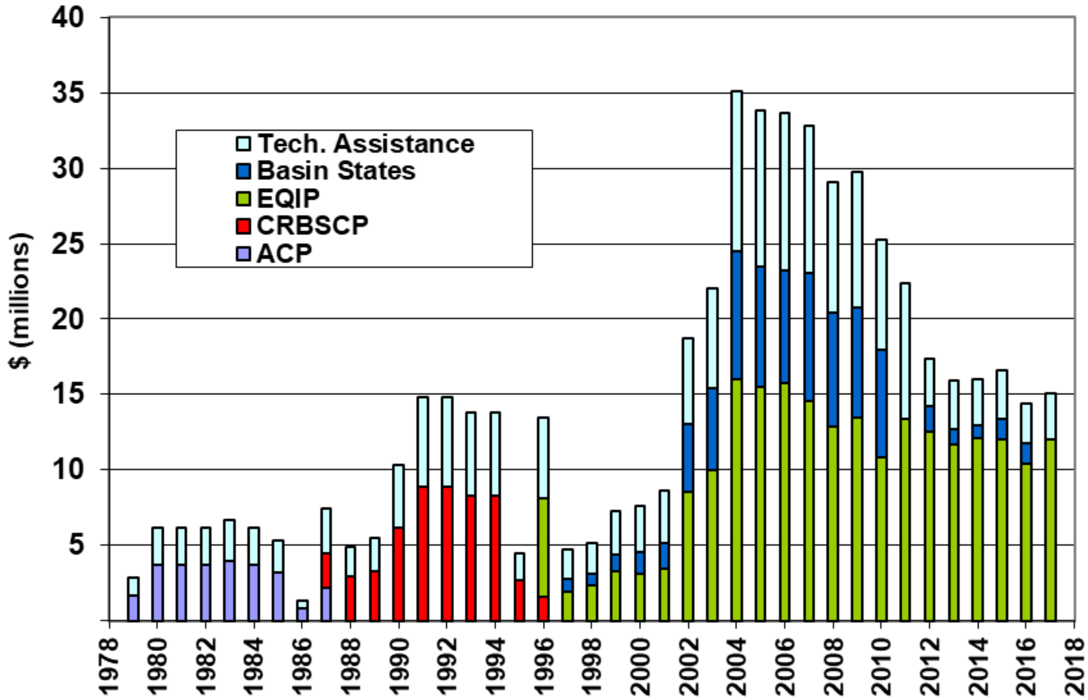


Figure 23 - USDA On-farm / Near - farm Allocations

Grand Valley, Colorado
Implementation has been underway in this unit since 1979 and NRCS considers that the salt control measures of the project have been successfully completed as planned. In 2010, a status report was compiled from field visits and observations. The report indicated that at least 12,000 irrigated acres are no longer in agricultural production. Approximately 44,700 acres remain in production. This project is considered complete and has contracted no new projects in 2017.

Lower Gunnison Basin, Colorado
This project, which began in 1988, encompasses the irrigated farmland in the Gunnison and Uncompahgre River valleys. With the expansion into the upper headwaters of the Uncompahgre River in 2010, implementation continues in Delta, Montrose, and Ouray Counties. Nearly 60 percent of the salt control goal has been achieved.

Interest remains high in the project area particularly in those service areas that were awarded Reclamation grants for irrigation infra-structure improvements. Nearly $4.8M of EQIP was obligated into 58 new contracts with plans to control an additional 4,711 tons of salt on 2,004 acres.

Four new wildlife projects on 535.1 acres were funded in the Lower Gunnison Project area at a cost of $237,305.

Mancos Valley, Colorado

This project, near the town of Mancos, Colorado, was initiated and approved for funding and implementation by USDA-NRCS in April 2004. An additional 6 new EQIP contracts were developed in 2017 to control 14 tons of salt on 17 acres at a cost of $153,501.

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. In 2017, 20 new contracts were developed for $577,387. These contracts will provide 391 tons of salt control when fully implemented.

Silt, Colorado

In 2017, 6 new EQIP contracts were developed for $187,310 to control 186 tons of salt on 263 acres. One wildlife project was also contracted on 5.8 acres at a cost of $19,020.

Green River, Utah

There was one new contract in the project area in 2017 for $35,402. When implemented, this contract will control about 21 tons on 13 acres.

Significant new lands are being brought under irrigation on the bench east of the Green River. As many as 200 center pivots may eventually be installed. None of these practices receive incentives from the salinity control program.

Manila-Washam, Utah

Two new contracts were developed in 2017 for $25,990 that will control 35 tons of salt on 16 acres.

Muddy Creek, Utah

There were two new contracts in the project for 2017 for $353,577 that will control 306 tons of salt on 214 acres.

Price-San Rafael, Utah

In 2017, 28 new contracts on 1,173 acres were either approved or pre-approved for a sum of about $2.3M. When implemented, these measures will control about 3,375 tons. The installation of the next phase of the Cottonwood Creek Irrigation Company's pipeline projects has generated quite a few new applications for the EQIP. One new wildlife contract was planned on 2 acres which will cost about $2,500.

Uintah Basin, Utah

Implementation began in this unit in 1980. The original salt control goal was reached several years ago but about 60,000 acres might still be improved. This project obligated more contracts than other projects in Utah. Producer participation is exceeding the original projections. In 2017 there were 48 new contracts on 1,803 acres for a sum of about $3.3M to control approximately 1,433 tons of salt. One new wildlife contract was planned on 20 acres at a cost of about $14,771.

Big Sandy River, Wyoming

Implementation has been underway in this unit since 1988. Approximately 13,650 acres of the planned 15,700 acres have been treated (87 percent) and about 70 percent of the salt control goal has been reached. 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. There was one new contract in 2017 to install 1,430 ft of pipeline at a cost of $11,228 that will reduce about 57 tons of salt per year.

Henrys Fork (of the Green River), Wyoming

The Henrys Fork Project was officially adopted with the issuance of the Record of Decision, June 2013. In 2017, one new project was funded in the Henrys Fork Project Area for a cost of $67,625. This new 40-acre sprinkler irrigation system will provide about 35 tons of new salt control at an annualized cost of $178 per ton.

San Juan Basin, New Mexico and Arizona

The San Juan River Dineh Water Users, Inc. (SJRDWU, Inc.) provides irrigation water to Navajo Nation farmers along the San Juan River from Farmington past Ship Rock, New Mexico. The SJRDWU, Inc. has been aggressive in seeking funding to upgrade its delivery system. While NRCS has never designated this area a salinity control project there is hope that the improvement of delivery infrastructure will spur on-farm irrigation improvements.

Areas Beyond Current Project Boundaries

Even though some relatively high salt loading basins exist in both Colorado and New Mexico, local sponsors have not yet been inclined to pursue a salinity project designation. In 2017 there were no new salinity contracts in areas outside of current project boundaries.

Table 7 - Implementation Status (October 1, 2017)

Location			Irrigated Acres	Treated Acres	EIS Goal (tons)	On-Farm Controls (tons)	Off-Farm Controls (tons)	Total Tons Controlled	Indexed Initial Cost per ton $	Nominal 2017 Cost per ton $
Colorado	Grand Valley	1977	44,600	43,151	132,000	137,055	6,768	143,823	52	90
	Lower Gunnison	1982	171,000	69,942	186,000	101,013	21,483	122,496	88	84
	McElmo Creek	1989	29,000	16,706	46,000	27,681	2,454	30,135	100	98
	Mancos Valley	2004	11,700	2,798	11,940	2,480	2,113	4,593	68	62
	Silt	2005	7,400	1,784	3,990	1,461	865	2,326	94	N/A
Utah	Uintah Basin	1982	226,000	159,901	140,500	140,498	9,152	149,650	179	227
	Price-San Rafael	1997	66,000	36,090	146,900	85,930	1,553	87,483	36	69
	Manila-Washam	2005	8,000	3,900	17,430	8,299	0	8,299	54	68
	Muddy Creek	2004	6,000	328	11,677	366	6	372	97	233
	Green River	2009	2,600	818	6,540	2,643	0	2,643	105	27
Wyoming	Big Sandy River	1988	18,000	13,663	83,700	58,293	57	58,350	40	18
	Henrys Fork	2013	20,700	143	6,540	124	0	124	238	178
Tier II	(all)	---	0	34	0	6,602	966	7,568	0	81

Bureau of Reclamation - Colorado River Basin Salinity Control Program

Desert Lakes Monitoring

The monitoring of the Huntington Cleveland Project drainage basins has been completed this year. The salinity project, the pressurization of irrigation water in a high salinity soil, is complete. The monitoring of surface waters and groundwater's was reduced to once per quarter and end completely in calendar year 2016.

Over the salinity project's build, the elevation of the groundwater in these three basins has dropped thus causing an increase in TDS in the groundwater. The salt does not reach the surface as often since the water table is now lower. In the case of one area, Shoemaker Wash, the surface water has been all but eliminated as it now seldom flows, and the canal is dry except when a large storm.

Over the course of the project, it was determined from monitoring locations along the canals and the adjacent wells that the groundwater flows from the surface water to the groundwater. The amount of surface water in the system has decreased due to lower runoff water amounts. The Salt transport that occurred with flood irrigation, decreased. The elevation of the groundwater system has also decreased over time due to the lack of water infiltration from the flood irrigation.

The monitoring program was set up to monitor the drainage basins as well as the Desert Lake Complex under the assumption that improved water going in would result in improved water leaving the system and entering the Price River system and improve it. At the present time, that has not been the case. Desert Lake Complex is a dynamic entity that is under the influence of weather, natural disasters-forest fires, inflow from irrigation runoff and precipitation, and human manipulation. It was therefore determined that measurements from the individual washes would be more reliable in monitoring of the project rather than the downstream location below the Desert Lake Complex.

The TDS levels through the various surface flumes has declined overall. Various individual components of TDS are currently being analyzed and will be included in a monitoring report that is in the process of completion.

TDS Forecast Modeling

The Water Operations Group of Reclamation publishes a 24-month forecast for Lake Powell. This forecast includes a minimum, most likely, and maximum hydrology scenarios for the next 24-month period. The three scenarios (min, most, and max) are published in January, April, August, and October. The remaining months consist of a most likely hydrology scenario.

The Water Quality Group takes the forecasts and uses them to run the two-dimensional model, Ce-Qual W2. This model is used to forecast temperatures, TDS, and occasionally DO (Dissolved Oxygen). In FY 2017 (WY 2017), the model has been run each month. The model continues to be done in version 3.6 and the standardized Meteorological data file has been updated with each run. The various regressions (EC to TDS) used for the inflows to Lake Powell have also been updated for the most recent samples sent to the lab.

Colorado River Simulation System (CRSS)

In FY 2017 Reclamation continued modeling studies for the 2017 Triennial Review. Reclamation worked with USDA and BLM to refine salinity control projections from 2017-2035 under 4 scenarios. The revised salinity control scenarios include:

1. No Additional Controls beyond 2017 (1.33M tons control)
2. No Additional Controls beyond 2020 (1.39 M tons control)
3. Controls based on available funding by 2035 (1.66 M tons control)
4. Controlling 1.82M tons by 2035 (1.79M tons control)

Based on these salinity control scenarios revised Colorado River Simulation System (CRSS) results were presented to the Salinity Control Forum workgroup in February and September 2017. Presented results included average annual flow weighted salinity concentration and the probability of exceeding the numeric criteria at each of the three criteria stations.

Reclamation also provided additional data and figures required for the 2017 Review to document recent extensions to the historical record since the 2014 Review for salinity concentration throughout the 20-gauge monitoring network including the 3 numeric criteria location, below Hoover and Parker Dams and above Imperial Dam.

Reclamation has worked with CADSWES through FY17 to further enhance the CRSS salinity algorithms. A recent study completed by CADSWES developed new rules to estimate local inflow salt concentration when using the new multi-layered and - segmented reservoir user method for Lake Powell. This study was required to ensure the local salt inflow above Powell considered the impacts of changes in temporal routing of salt due to Lake Powel's new salt mass balance algorithm. During FY 2018 Reclamation will continue to test and evaluate the new multi-layered and - segmented reservoir user method.

Economic Impacts Model

In FY 2017 Reclamation continued to work with the Salinity Damages Task Force. Reclamation released multiple updates to the Salinity Economic Impacts Model (SEIM) throughout the year with the latest released version dated 09/29/17. This latest model includes updated model data provided from the Lower Basin States and requested changes based on reviews from the SEIM committee and Reclamation personnel completed during FY2017.

Reclamation and the SEIM committee worked together to draft a new 2017 Review Appendix F – Salinity Economic Impact Model Executive Summary, which presents a brief description of the steps recently completed to improve and verify the data and methods in this latest SEIM. Salinity damages estimates based on this latest SEIM were included in Appendix F and the main 2017 Review report.

Reclamation and the SEIM committee worked with Reclamation's Lower Colorado Region personnel to draft and complete a new request for proposals to choose a contractor in FY2018 who will update Reclamation's SEIM, including the Arizona, California, and Nevada areas. Key project objectives include:

- Review, validate, and update the existing impact functions. Evaluate the applicability of the existing impact functions to model areas outside of the original areas for which they were developed.

- Update cost and other input values applied to existing impact functions for the following categories: residential, commercial, agricultural, water and wastewater utilities, industrial, groundwater, and water recycling.
- Identify and create new impact functions not currently considered in the existing SEIM and indicate the applicability of the new impact functions to all or any specific subareas.
- Update the existing SEIM to include the new input data and impact functions, and test the model ensuring all updates are functioning as intended.
- Prepare a report documenting the data analyses and methodology used to update the SEIM, including references to where the data are obtained and prepare a SEIM User Manual.
- Provide Model training.

The contract is projected to run from Nov 1, 2017 through Oct 31, 2019.

Science Team

To further improve and expand our knowledge of salinity control methods, data, and modeling within the Colorado River basin, the Salinity Science Team was created. This team incorporates technical experts and coordinators from each Federal agency (Reclamation, USDA, NRCS, BLM, and USGS) that provides salinity data and/or modeling and the Forum's Executive Director.

The following are some of the topics that were addressed by the Science Team during meetings held in January and August 2017:

1. Funding/contract update of approved Research, Studies, and Investigations (SIRs)
2. 2017 FOA
3. Review of Basins assessment ranking discussion; SPARROW II
4. Review of SIR proposals for funding and recommending to the Advisory Council's Technical Advisory Group (TAG) which proposals should receive funding.
5. Update on Paradox Valley Unit Groundwater model and simulations
6. Pah Tempe Study, Desert Lakes Monitoring
7. New areas for salinity studies
8. Economic Damages Model – Matching funds with Reclamation's Southern California Area Office to hire contractor to collect inputs. Solicitation out in FY18, looking for award in February 2018.
9. Future science direction, needs, priorities, and funding

Basinwide Salinity Control Program (Basinwide Program)

Funding Opportunity Announcement (FOA)

Applications to reduce salinity contributions to the Colorado River are being solicited through a FOA for both the Basinwide Program and Basin States Program (BSP). The FOA was released on August 4, 2017 and closed on November 14, 2017.

Applications will be selected through a competitive process under the evaluation criteria set forth in the FOA. Applications will be evaluated and ranked by an Application Review Committee (ARC). It is anticipated that $30-40 million will be awarded in the Basinwide Program and $5-10 million in the Basin States Program.

Price – San Rafael River Basins, Utah

Huntington Cleveland Irrigation Company (HCIC) Project (Project): The Project is in northern Emery County, in and around the towns of Huntington, Lawrence, Cleveland, and Elmo. The Project was selected in the 2004 Request for Proposals (RFP) and awarded a cooperative agreement in September 2004. A new cooperative agreement was executed in November 2006 and was modified again in September 2009. Approximately 350 miles of open earthen canals and laterals are being replaced with a pressurized pipeline distribution system (Distribution System) to accommodate sprinkler irrigation on about 16,000 acres. Funding for this project is being shared between Reclamation's Basinwide Program, HCIC, 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 Distribution System was obligated in 2008. Reclamation can provide up to an additional $6,000,000 in funding equally 50/50 with HCIC funds for completion of the Distribution System. Since 2009, Reclamation has provided over $4,000,000 in additional funding. The Project was completed in the first quarter of 2017 resulting in the annual reduction of 59,000 reportable tons of salt in the Colorado River at an anticipated cost of approximately less than $100/ton. Of the 59,000 tons of salt, 13,000 are attributed to the Off-Farm Distribution System and 46,000 tons are attributed to the On-Farm Distribution System and the on-farm salinity control measures (sprinklers).

Blue Cut/Mammoth Unit, Cottonwood Creek Consolidated Irrigation Company Salinity Project: The $5,500,000 Blue Cut/Mammoth Unit, Cottonwood Creek Irrigation Company Irrigation Project was selected from the applications received in the 2012 FOA. A cooperative agreement was executed in August 2013. This project will replace approximately 45.6 miles of earthen canals and laterals with a pressurized pipeline system resulting in the reduction of 3,789 reportable tons per year of salt in the Colorado River at an anticipated cost of approximately $67.57 per ton of salt. The pressurized pipeline will serve 5,680 acres resulting in additional on farm salt savings. Pipeline construction was complete as of September 8, 2016. Approximately 55 percent of the served acreage is under contract for on-farm improvements. The recipient continues to add valves and meters as those systems come online. It will take 2 to 3 more years for NRCS to contact the remainder of the acreage and the last canals can be taken out of service.

Manila-Washam Salinity Area, Utah

South Valley Lateral Salinity Project: This project is in Daggett County south of the town of Manila, Utah. It was selected from the applications received in the 2012 FOA and was submitted by the Sheep Creek Irrigation Company. A cooperative agreement was executed in May of 2013, for $4,026,264.75. This project replaced approximately 27,400 feet of earthen laterals with irrigation pipe resulting in the annual reduction of 3,373 reportable tons of salt in the Colorado River at an anticipated cost of approximately $55.57 per ton of salt. The project began in the fall of 2014 and went into service for the 2015 irrigation season ahead of schedule and under budget. The recipient was approved to use unexpended funding to make improvements to their Antelope Wash Lateral. That construction was completed in early 2017 and went into service for the 2017 irrigation season.

Big Sandy Project, Sweetwater County, in the vicinity of Farson and Eden, Wyoming

Eden Valley, Farson/Eden Pipeline Project: This project was selected in the 2008 FOA. A Cooperative Agreement was executed in February of 2009, for $6,453,072. This project will replace approximately 24 miles of earthen laterals with irrigation pipe resulting in the annual reduction of 6,594 reportable tons of salt in the Colorado River at an anticipated cost of approximately $52.57 per ton of salt. Laterals E-7, E-8, and E-13 are completed, and work on the West Side Canal was completed and operational in the spring of 2014. Due to some pipeline leaks the Recipient is withholding retainage funds through the end of the 2016 irrigation season to ensure all leaks had been addressed. That retainage was paid in December of 2016 allowing close-out of the project.

West Blacks Fork Salinity Area, Wyoming

Austin/Wall Off-Farm Irrigation Project: This project is in Uintah County in the vicinity of Lyman, Wyoming. It was selected from the applications received in the 2012 FOA and was submitted by the Austin/Wall Irrigation District. A cooperative agreement was executed in May 2013, for $1,350,000. This project will replace approximately 32,000 feet of earthen canal and laterals with irrigation pipe resulting in the annual reduction of 1,092 reportable tons of salt in the Colorado River at an anticipated cost of approximately $57.55 per ton of salt. The project began construction in the fall of 2016 and was completed and went into service in the spring of 2017.

Gunnison Basin, Colorado

UVWUA Phase 8 – ESL: As a result of the 2012 FOA, the UVWUA was selected to be awarded a $3.5 million cooperative agreement for Phase 8 of the ESL. This phase involves piping an additional 14.1 miles of laterals off the South Canal, East Canal and Loutzenhizer, resulting in an expected annual salt reduction of 3,307 tons, at a cost effectiveness of $49.86 per ton. The cooperative agreement was executed in FY 2014. Construction began in the summer of 2015 and will be complete in 2018.

Cattleman's Harts, Hart/McLaughlin, Rockwell, Poulsen Ditches: Selected in the 2012 FOA, this project involves piping a portion of the Cattleman's Ditch, operated by the Cedar Canon tributary to the Gunnison River near Crawford, Colorado. In July 2013, Reclamation entered into an agreement to provide up to $2.01 million to pipe 6.3 miles of existing laterals with an expected salt load reduction of about 1,855 tons/year, at a cost effectiveness of $47.72 per ton. Construction began in the fall of 2015 and will be completed in the spring of 2018.

Cattleman's Ditch Salinity Control – Phase 2: Selected under the 2015 FOA, the Cedar Canon Iron Springs Ditch and Reservoir Company was awarded a $2.67 million cooperative grant to pipe approximately 6.0 miles of existing, unlined earthen irrigation canal and laterals located near Crawford, Colorado and along Alkali Creek, a tributary to the Gunnison River. This will result in an annual salt load reduction of approximately 2,183 tons to the Colorado River, at a cost effectiveness of $51.00 per ton. The piping project will consist of buried HDPE, PVC, and gravity flow pipe. The cooperative agreement was executed in April 2016, and construction will begin in October of 2017. It is expected to be completed in the spring of 2019.

Clipper Center Lateral Pipeline Project: Selected under the 2015 FOA, the Crawford Clipper Ditch Company was awarded a $3.15 million cooperative grant to pipe approximately 4.3 miles of existing, unlined earthen irrigation canals located near Crawford, Colorado and along Cottonwood Creek, a tributary to the Gunnison River. This will result in an annual salt load reduction of approximately 2,606 tons to the Colorado River, at a cost effectiveness of $50.43 per ton. The piping project will consist of buried PVC and HDPE pipe. The cooperative agreement was executed in March 2016, and construction will begin in 2018. It is expected to be completed in 2019.

North Delta Canal – Phase 1: Selected under the 2015 FOA, the North Delta Irrigation Company was awarded a $5.56 million cooperative grant to pipe approximately 5.97 miles of existing, unlined earthen irrigation canals located near Delta, Colorado and along the north side of the Gunnison River. This will result in an annual salt load reduction of approximately 4,383 tons to the Colorado River, at a cost effectiveness of $52.92 per ton. The piping project will consist of 1.41 miles of buried HDPE pipe and 3.02 miles of gravity flow pipe (piping is providing a 1.54-mile shortcut). The cooperative agreement was executed in April 2016, and construction will begin in 2018. It is expected to be completed in the spring of 2020.

Orchard Ranch Ditch Piping Project: Selected under the 2015 FOA, the Orchard Ranch Ditch Company was awarded a $1.28 million cooperative grant to pipe approximately 2.0 miles of existing, unlined earthen irrigation canals located near Orchard City, Colorado and along Surface Creek, a tributary to the Gunnison River. This will result in an annual salt load reduction of approximately 1,004 tons to the Colorado River, at a cost effectiveness of $53.16 per ton. The piping project will consist of buried HDPE pipe. The cooperative agreement was executed in April 2016, and construction will begin in 2018. It is expected to be completed in 2019.

Fire Mtn. Canal Salinity Reduction Piping Project: Selected under the 2015 FOA, the Fire Mountain Canal and Reservoir Company was awarded a $2.95 million cooperative grant to pipe or abandon approximately 4.24 miles of existing, unlined earthen irrigation canals located near Hotchkiss, Colorado and along the north side of the North Fork of the Gunnison River. This will result in an annual salt load reduction of approximately 2,365 tons to the Colorado River, at a cost effectiveness of $52.07 per ton. A portion of the project is funded by the USDA, NRCS, through the Regional Conservation Partnership Program (RCPP) in the amount of $1.32 M. The cooperative agreement was executed in September 2017, and construction will begin in 2018. It is expected to be completed in the spring of 2019.

UVWUA Phase 9 – ESL: As a result of the 2015 FOA, the UVWUA was selected to be awarded a $5.4 million cooperative agreement for Phase 9 of the ESL. This phase involves piping or abandoning an additional 21.6 miles of laterals from the Selig and East Canals, resulting in an expected annual salt reduction of 6,030 tons, at a cost effectiveness of $37.07 per ton. A portion of the project is funded by the USDA, NRCS, through the RCPP. The cooperative agreement was executed in September 2017. Construction is expected to begin in 2018 and will continue to 2021.

Grand Valley, Colorado

Grand Valley Irrigation Company (GVIC) Canal Improvement Grant 2012: As a result of selection under the 2012 FOA, the GVIC was selected to be awarded a $4.9 million cooperative grant to line about 2.4 miles of their main canal within the Grand Valley. A salt loading reduction of approximately 4,001 tons annually is expected, at a cost effectiveness of $53.31 per ton. The canal lining will consist of a PVC membrane with a shotcrete cover. The cooperative agreement was executed in FY 2014 and construction began in December 2014. It is expected to be completed in the spring of 2018.

Grand Valley Irrigation Company (GVIC) Canal Improvement Grant 2015: Selected under the 2015 FOA, the GVIC was awarded a $2.8 million cooperative grant to line approximately 1.65

miles of their main irrigation canal within the Grand Valley. This will result in a salt load reduction of approximately 2,363 tons annually at a cost effectiveness of $49.64 per ton. The canal lining will consist of a 30-mil PVC membrane with 3-4 inches of shotcrete cover. The cooperative agreement was executed in August 2016, and construction will begin in January 2018. It is expected to be completed in 2020.

Grand Valley Water Users Association (GVWUA) Government Highline Canal – Reach 1A Middle: Selected under the 2015 FOA, the GVWUA was awarded a $3.6 million cooperative grant to line approximately 0.97 miles of their main irrigation canal within the Grand Valley. This will result in a salt load reduction of approximately 2,583 tons annually at a cost effectiveness of $58.63 per ton. The canal lining will consist of a 30-mil PVC membrane with 3-4 inches of shotcrete cover. The cooperative agreement was executed in April 2016, and construction began in November of 2016. It is expected to be completed in December 2018.

Basin States Program (BSP)

Public Law 110-246 amended the Act creating the BSP to be implemented by the Secretary of Interior through Reclamation. Section 205(f) of the Act was amended to provide that cost share obligations be met through an up-front cost share from the Basin Funds. The amendment also authorizes Reclamation to expend the required cost share funds through the BSP for salinity control activities established under Section 202(a)(7) of the Act.

Reclamation has determined that agencies within the upper Basin states to be appropriate partners and has executed cooperative agreements to utilize the services of these state agencies to assist in seeking and funding cost-effective activities to reduce salinity in the Colorado River system. Activities will also benefit the upper Basin states by improving water management and increasing irrigation efficiencies.

Utah Department of Agriculture and Food (UDAF)

The Utah Department of Agriculture and Food received two projects from Reclamation's most recent FOA. One project is with Sheep Creek Irrigation Company, Manila, Utah and is a canal piping project that will retain 1,474 tons of salt per year at a cost of $1,947,929.99. The project is titled "Antelope and North Laterals Salinity Project" and will pipe two laterals of the Sheep Creek Canal. The other project is in the Vernal area and will pipe the Rock Point Canal retaining 740 tons of salt with a total project cost of $1,422,849.00, with $976,549.00 coming from Basin States Program funds.

During the 2016-2017 winter construction season, Sheep Creek Irrigation Company substantially completed the piping of the Antelope and North laterals. Both new pipelines were put in use during the 2017 irrigation season. During the fall of 2017 Sheep Creek Irrigation Company intends to complete its project.

Rock Point Irrigation Company has hired an engineering firm, procured final design, and purchased pipe for their project. The pipe is stored at previously approved storage sites not requiring Cultural Resource or NEPA clearance. Rock Point Irrigation Company has obtained all easements and is awaiting NEPA clearance to begin construction. They intend to start construction late fall of 2017. Because Steinaker Dam will be drained, Rock Point Irrigation Company will need to adjust their construction timeline and method of water delivery until Steinaker is refilled.

UDAF, at the direction of the Advisory Council and Reclamation, continues to employ the Uintah basin salinity coordinator using BSP funds. The value of this coordinator has been demonstrated by the success of obtaining four 2015 FOA projects. These projects were competitive because of the coordinator's efforts to confederate historically opposing companies into accepting unified systems that improve each company and the significant cost share match being provided by local funding sources to buy down the cost per ton of salt control. Improvements with the Ute Tribe have also been made and it is anticipated that in future FOA's the tribe will submit applications. UDAF feels that using BSP funds for this position has greatly benefited the salinity control program in the Uintah Basin area. The coordinator has also been successful in helping entities submit applications with the NRCS Regional Conservation Partnership Program.

Colorado Department of Agriculture - Colorado State Conservation Board (CSCB)

In Colorado, the Basin States Program (BSP) has been delivered through six local Conservation Districts that operate within the boundaries of the approved salinity control areas in the state. These salinity control areas include the Silt Mesa, Grand Valley, Lower Gunnison, McElmo Creek and Mancos River salinity areas. The Bookcliff, Mesa, Delta, Shavano, High Desert (formerly Dolores), and Mancos Conservation districts receive funds from the Colorado Department of Agriculture (CDA) which, prior to 2017, had received projects to implement based upon the agreement with Reclamation. There is an active agreement in place, however, due to no new BSP projects being assigned to CDA, administrative funding for a CDA salinity coordinator was insufficient so this position remained vacant.

Historically, the projects were planned, designed and certified by NRCS or Conservation District employees. Eleven District employees were paid from BSP Technical Assistance (TA) funding earned by NRCS in Colorado and provided to the Conservation Districts through CDA. Due to staffing constraints and an unusually high EQIP workload, the NRCS withdrew future participation in the BSP and will no longer administer Salinity Technicians under this agreement after remaining funds are spent.

Over the last year, the Work Group explored the value of State Agriculture Agency participation for implementing the BSP, coordinating with ditch companies to apply for the FOA, and assisting in local oversight/implementation of some FOA projects. Because of NRCS' EQIP workload demands and unusually high staff vacancies, the Colorado State NRCS office elected not to screen and submit new EQIP ineligible applications. Historically, applications have been funded in order of cost effectiveness and any future applications will be treated similarly. In the future, applications that are strategic in nature and result in less than $150/ton would be eligible for the BSP, so long as NRCS is not expected to provide NEPA or engineering documentation and provided the applications are awarded through a competitive process. The NRCS formula is used to calculate cost effectiveness and salt loading data.

All projects have been and will continue to be planned, designed and certified based upon current NRCS Standards and Specifications. Each participant signs an Operation and Maintenance (O&M) agreement to remain in effect for the life of the irrigation and wildlife improvements installed (usually 25 years). Each participant is required to perform proper Irrigation Water Management on the fields in which irrigation improvements were installed. The projects are planned and contracted using the current NRCS EQIP payment schedule.

BSP Projects

Reclamation provided $6,000,000 in a five-year funding agreement for Colorado in 2016 that continues from the former agreement that expired in April 2017. In 2015, $1,300,000 was obligated for eight EQIP-like BSP projects and one wildlife habitat replacement project. Some of those projects were completed and two were cancelled. The previous report indicated that five BSP EQIP-ineligible projects are behind schedule, awaiting cultural resource inventories to be completed by NRCS. The Duke Ditch NEPA was approved and is presently being designed by NRCS and is now targeted for spring construction. The Delta Duck Club Wildlife Habitat project incurred numerous Endangered Species Act challenges due to the presence of the Yellow-billed Cuckoo on the site. Alternative measures were considered but the cooperator decided to cancel the project. Two Grand Valley (Ward HL275, Lateral 110) projects and one Silt (Johnson) project area pipelines met NEPA compliance and have completed engineering plans. One Grand Valley project, ML47 pipeline continues to be delayed until NRCS can complete the engineering and NEPA compliance. Excepting the ML47, the applicants either have selected or are selecting contractors for construction to occur after the irrigation season, this fall.

Other Projects Completed

The Sanchez Wildlife Habitat project construction was completed last winter. The Crawford Clipper – Zanni lateral Basin States FOA project was completed in March and was functional for the 2017 irrigation season.

Lower Gunnison Basin Salinity Program Coordinator

The Lower Gunnison Basin Salinity Program Coordinator continues to be an important resource for off-farm irrigation system improvement projects, assisting interested ditch companies to secure funding for planning and implementing delivery system piping projects, and informing their water users of NRCS Salinity, and LGB-RCPP funding available for on-farm improvements. She provided grant application assistance to BSP and Basinwide Salinity Program participants, Conservation Districts, and other ditch companies to complete financing for salinity control related projects. The LGB Salinity Coordinator cost $70,000 per year (salary, benefits and operational costs) and secured over $3,300,000 in additional State grant funding to support Salinity Program projects. The Forum authorized the LGB Salinity Coordinator to help other salinity areas prepare for FOA processes, as time allows. The Coordinator has assisted two ditch companies in the Mancos River salinity area.

Grand Valley Wildlife Project:

CDA contracted with Colorado Parks and Wildlife (CPW) in 2013 to fund approximately 491 acres of wildlife improvements along the Colorado River in the Grand Valley. Additional weed management work was accomplished in 2017 to complete the Grand Valley wildlife habitat replacement obligation. A similar project (C ½ Road) was approved for state wildlife land near the main project.

Wyoming Water Development Commission (WWDC)

In August 2015, a new BSP agreement was put in place with the WWDC that will end in 2020. The new BSP agreement is like the agreements with Utah and Colorado. The agreement has a value of $2,800,000 for construction and salinity studies in Wyoming. Projects can either be a FOA pass-off, EQIP pass-off or through a solicitation that meets Reclamation's requirements.

The WWDC provides state funding through grants and loans for water studies, master plans, and construction projects across Wyoming. WWDC project funding is provided to a public entity for projects including, but limited to, transmission pipelines, storage, reservoirs, irrigation improvements, canal to pipe conversions, and system improvements. Day-to-day operations are managed by the Wyoming Water Development Office (WWDO) staff. The WWDO construction division will be administering the construction and study components of the Wyoming BSP program.

Eden Valley, Farson/Eden Pipeline Project:

Currently, WWDC has one BSP project that came through Reclamation's 2015 FOA process. The project is for a canal to pipeline conversion project with the Eden Valley Irrigation and Drainage District (EVIDD). The project will convert approximately 6 miles of irrigation canal to pipeline. The project includes piping the Farson F-2, F-3, F-4 and F-5 laterals. The project budget is $4,390,413 with funding provided by the WWDC of $2,366,000 and the WY BSP of $2,024,413. The project will result in salt control of 1,619 tons and a cost effectiveness of $52.11/ton.

Currently, the project has secured the services of an engineer and has entered the design phase of the project. The project is currently finalizing the design, securing necessary permits, and conducting necessary reviews. The project is anticipated to go to construction in the fall of 2018. The project will connect to a project being managed by Reclamation using MOA funds. Reclamation's MOA project has experienced delays, resulting in delays for the WY BSP and WWDC project.

Reclamation

In the 2015 FOA, two projects were selected for BSP funding that are being administered by Reclamation. The two projects are:

Minnesota L-75 Lateral Salinity Control Project: Selected under the 2015 FOA, the Minnesota L-75 Lateral Company was awarded a $153,412 cooperative grant to pipe approximately 3,100 feet of existing, unlined earthen irrigation ditch located near Paonia, Colorado and along the south side of the North Fork of the Gunnison River. This will result in an annual salt load reduction of approximately 129 tons to the Colorado River, at a cost effectiveness of $49.57 per ton. The piping project will consist of buried PVC pipe. The cooperative agreement was executed in March 2016, and construction will begin in the winter of 2017-18. It is expected to be completed in the spring of 2018.

Whiterocks and Mosby Canals Rehabilitation Project: This project was selected from the 2015 FOA. A cooperative agreement was executed in September 2016 for $2,412,462. This project, located in Uintah County, will replace approximately 13.7 miles of earthen canals with a pressurized pipeline system resulting in the annual reduction of 1,635 reportable tons of salt in the Colorado River at an anticipated cost of approximately $61.50 per ton of salt. The project is anticipated to begin construction in the fall of 2017.

Paradox Valley Unit (PVU), Colorado

The Paradox Valley Unit was authorized for investigation and construction by the Salinity Control Act. The unit is in southwestern Colorado along the Dolores River in the Paradox Valley, formed by a collapsed salt dome (Figure 34). Groundwater in the valley meets the top of the salt formation where it becomes nearly saturated with sodium chloride. This project intercepts extremely saline brine (260,000 mg/l total dissolved solids) before it reaches the Dolores River and disposes of the brine by deep well injection (injection interval about 14,000 feet below ground surface). As of calendar year 2018 the project continued to intercept and dispose of 95,000+ tons of salt annually (Table 8).

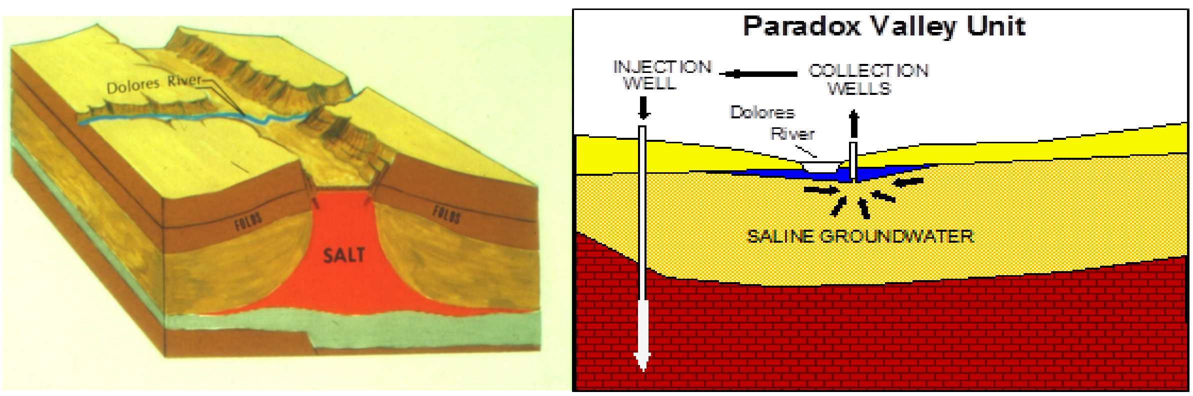


Figure 34 - Paradox Valley with Schematic of Paradox Project

Induced seismicity and the pressure necessary to inject the brine into the disposal formation at 14,000 feet have been the limiting factors of the project. Since injection rate reductions in 2013 and 2017 have substantially reduced the injection pressure, seismicity is now the main concern. Although the projected life of the well was estimated to be 3 to 5 years, new geomechanical and flow modeling is now being conducted to determine the injection well life based on seismicity and well performance.

Alternatives Study

An Alternatives Study/EIS process to evaluate alternative methods for salt disposal at Paradox is continuing with three alternatives and a "no action" alternative being evaluated. The three action alternatives are a second injection well, evaporation ponds, and zero liquid discharge technologies. As these alternatives have been developed and an EIS prepared, Reclamation has continued to have related meetings and discussions with the BLM, EPA, Colorado Department of Public Health and Environment, and other stakeholders. A draft EIS is scheduled to be completed by the end of 2019, a Final EIS in July 2020, and a ROD issued in August 2020.

Table 8 – Paradox Well Injection Evaluation

Injection Month	Avg Injection Pressure	Monthly Pressure Change	Tons of Salt Injected[1]	Tons Injected in the Past 12 Months	Estimated Salt Load in tons[2]	Estimated Salt Load in tons in Past 12 Months	Estimated Salt Load Plus Injected Total in tons in Past 12 Months	# of Induced Seismic Events M ≥ 0.5[3]	Max Mag of Seismic Events	No. of Seismic Events in Past 12 Months, M ≥ 0.5	Comments
Jan-16	4610	-128	8,671	8,671	3,341	3,341		4	1.6	4	No significant down time
Feb-16	4589	-21	7,824	16,495	9,505	12,846		9	2.1	13	No significant down time
Mar-16	4636	47	8,655	25,150	5,033	17,879		5	1.5	18	No significant down time
Apr-16	4641	5	8,367	33,517	3,542	21,421		2	1.1	20	No significant down time
May-16	4647	6	8,655	42,172	3,175	24,595		4	1.4	24	No significant down time
Jun-16	4643	-4	8,163	50,335	4,024	28,619		3	1.4	27	No significant down time
Jul-16	4662	19	8,704	59,039	1,285	29,904		4	1.4	31	No significant down time
Aug-16	4663	1	8,485	67,524	937	30,841		2	0.7	33	Seismic event count for August may be under-represented
Sep-16	4677	14	8,376	75,900	967	31,808		2	1.2	35	Seismic event count for September may be under-represented
Oct-16	4689	12	8,844	84,744	1,155	32,964		3	1.1	38	No significant down time
Nov-16	4684	-5	8,225	92,969	1,904	34,867		8	1.3	46	No significant down time
Dec-16	4655	-29	8,540	101,509	4,482	39,349	140,858	8	1.6	54	PLC problems - plant down 4 hours
Jan-17	4672	17	8,566	101,404	8,209	44,217		5	1.1	55	No significant down time
Feb-17	4687	15	7,760	101,340	7,882	42,594		1	0.3	47	No significant down time
Mar-17	3377	-1,310	3,021	95,706	4,021	41,581		7	2.9	49	Plant down from 3/12 to 3/31 for M 2.9 earthquake
Apr-17	3178	-199	6,088	93,427	504	38,543		11	1.8	58	Plant down from 4/1 to 4/7 for M 2.9 earthquake; Injection resumed on 4/7 at 176 gpm and 6 hour weekly shutdowns
May-17	4510	1,332	8,182	92,954	2,836	38,204		4	1.4	58	No significant down time
Jun-17	4565	55	7,848	92,639	1,956	36,137		3	1.5	58	No significant down time
Jul-17	4596	31	8,103	92,038	1,590	36,441		2	0.6	56	No significant down time
Aug-17	4613	17	8,144	91,697	2,104	37,609		15	2.5	69	No significant down time

Sep-17	4628	15	7,850	91,171	2,559	39,200		15	2.6	82	Reinstalled 2" and 2-1/8" plungers in two injection pumps on 9/20 to continue operation due to 1-7/8" plunger problems. Changed shutdown schedule to compensate for increased rate.
Oct-17	4670	42	8,112	90,439	2,706	40,751		3	0.9	82	Changed individual pump shutdown schedule to accommodate different plunger sizes. At least one pump operating at all times.
Nov-17	4680	10	7,884	90,098	3,975	42,822		7	1.4	81	No significant down time
Dec-17	4686	6	8,135	89,693	5,738	44,078	133,771	9	2.9	82	No significant down time
Jan-18	4706	20	8,138	89,265	6,673	42,543		4	2.5	81	No significant down time
Feb-18	4700	-6	7,343	88,848	9,880	44,541		3	1.2	83	No significant down time
Mar-18	4711	11	8,138	93,965	6,819	47,340		11	2.3	87	No significant down time
Apr-18	4464	-247	6,751	94,628	4,759	51,595		0	0.4	76	Plant down from 4/16 to 4/20 for SCADA/PLC upgrade
May-18	4631	167	8,044	94,490	3,291	52,050		5	1.8	77	No significant down time
Jun-18	4685	54	7,739	94,381	2,458	52,551		1	1.5	75	No significant down time
Jul-18	4689	4	8,159	94,437	1,604	52,566		4	0.9	77	No significant down time
Aug-18	4693	4	8,190	94,483	464	50,926		4	1.5	66	No significant down time
Sep-18	4694	1	7,881	94,514	408	48,776		15	1.8	66	No significant down time
Oct-18	4723	29	8,127	94,529	266	46,336		7	1.2	70	No significant down time
Nov-18	4739	16	7,880	94,525	939	43,300		7	1.7	70	No significant down time
Dec-18	4753	14	8,138	94,528	3,440	41,002	135,530	3	0.6	64	No significant down time

[1]Tons of salt injected based on 260,000 mg/l. PVB density varies slightly due to seasonal and environmental fluctuations.

[2] Salt load is estimated based on regression equations developed by USGS (Ken Watts, USGS Administrative Report - "Estimates of Dissolved Solids Load of the Dolores River in Paradox Valley, Montrose County, Colorado, 1988 through 2009, dated August 5, 2010") and provisional data provided by USGS. Some daily EC and streamflow discharge values are estimates. See Salt Load Notes tab.

Colorado River Basin Salinity Control Program Summary Data

The following tables and figure summarize the salinity control program and funding using the latest available data.

Table 9 – Summary of Federal Salinity Control Programs (2017)

Salinity Unit		Tons / year Removed
MEASURES IN PLACE BY RECLAMATION		
Basinwide Program		223,700
Basin States Program	1/	18,200
Meeker Dome		48,000
Las Vegas Wash Pitman		3,800
Grand Valley (stage 1 & 2)		122,300
Paradox Valley	2/	100,900
Lower Gunnison Winter Water (USBR)		41,400
Dolores (McElmo Ck)		23,000
Reclamation Subtotal		**581,000**
MEASURES IN PLACE BY NRCS/BSP	3/	
Grand Valley		143,600
Price-San Rafael		88,200
Uinta Basin		157,200
Big Sandy River		59,600
Lower Gunnison		124,200
Dolores (McElmo Ck)		30,600
Henry"s Fork, WY		400
Mancos		4,700
Muddy Creek		600
Manila		8,400
Silt		2,400
Green River		1,600
Tier 2	4/	7,500
NRCS/BSP Subtotal		**621,000**
MEASURES IN PLACE BY BLM		
Nonpoint Sources	5/	113,400
Well-Plugging		14,600
BLM Subtotal		**128,000**
Measures in Place Total		**1,330,000**
GOALS TO REACH TARGET		
Reclamation Basinwide Program		182,100
NRCS Program		118,700
BLM		32,500
Goals Subtotal		**330,000**
Target Total (Measures in Place + Goals)		1,660,000
Target by 2035	6/	**1,660,000**

1/ Off-farm projects funded by the BSP

2/ Paradox injection well capacity estimated to decline beginning in 2020; assumed continuation of well or alternative control after methods after 2020

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

4/ Measures in areas outside approved projects.

5/ BLM non-point source are estimates. of implementation

6/ Based on the 2017 Triennial Review Plan

Table 10 – Summary of Colorado River Basin Salinity Control Program Appropriations and Cost Share from the Basin Funds 2008 thru 2018

Total Program ($1,000)

Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Subtotal
Grand Valley O&M	1,125	1,757	1,021	1,373	1,289	1,515	1,885	2,247	2,494	1,609	2,416	18,731
Paradox Valley O&M	3,621	3,121	3,764	3,660	3,236	3,124	3,501	3,575	4,994	4,439	4,079	41,114
Lower Gunnison O&M	0	0	0	0	0	0	0	0	0	0	0	0
McElmo Creek (Dolores) O&M	559	603	676	491	480	563	479	576	528	621	745	6,321
USBR Basinwide Program	11,406	24,686	9,577	12,104	11,854	12,399	10,021	10,419	13,279	12,882	14,853	143,480
Subtotal (USBR Program)	16,711	30,167	15,038	17,629	16,860	17,600	15,887	16,816	21,295	19,550	22,093	209,646
USDA Program	22,803	23,346	20,833	23,403	22,121	19,077	20,697	21,751	18,655	21,790	23,774	238,250
BLM (no Basin Funds)	800	800	800	800	800	800	800	800	800	1,000	1,500	9,700
Total	40,314	54,313	36,671	41,832	39,781	37,477	37,384	39,367	40,751	42,340	47,367	457,597

Appropriations Expended ($1,000)

Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Subtotal
Grand Valley O&M	844	1,318	766	1,030	967	1,133	1,414	1,685	1,734	1,116	1,812	13,819
Paradox Valley O&M	2,716	2,341	2,823	2,745	2,427	2,343	2,626	2,681	3,732	3,329	3,059	30,822
Lower Gunnison O&M	0	0	0	0	0	0	0	0	0	0	0	0
McElmo Creek (Dolores) O&M	391	422	473	344	336	394	335	403	321	434	524	4,377
USBR Basinwide Program	7,984	17,280	6,704	8,473	8,298	8,679	7,015	7,293	9,391	8,547	10,374	100,038
Subtotal (USBR Program)	11,935	21,361	10,766	12,592	12,028	12,549	11,390	12,062	15,178	13,427	15,769	149,056
USDA Program	15,962	16,342	14,583	16,382	15,485	13,354	14,488	15,226	11,791	15,319	17,618	166,550
Total	27,897	37,703	25,349	28,974	27,513	25,903	25,878	27,288	27,770	29,745	34,888	318,908

Upper Basin Fund Cost Share Payments ($1,000)

Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Subtotal
Grand Valley O&M	42	66	38	52	48	57	71	94	119	74	91	752
Paradox Valley O&M	136	117	141	137	121	117	131	212	189	166	153	1,620
Lower Gunnison O&M	0	0	0	0	0	0	0	0	0	0	0	0
McElmo Creek (Dolores) O&M	25	27	30	22	22	25	22	26	31	28	30	288
USBR Basinwide Program	513	1,111	431	545	533	558	451	469	583	650	700	6,544
Subtotal (USBR Program)	716	1,321	641	756	725	757	675	713	922	919	973	9,204
USDA Projects	1,026	1,051	937	1,053	995	858	931	979	1,005	778	897	10,510
Total Payment	1,743	2,371	1,578	1,809	1,720	1,616	1,606	1,692	1,928	1,696	1,870	19,629

Lower Basin Fund Cost Share Payments ($1,000)

Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Subtotal
Grand Valley O&M	239	373	217	292	274	325	401	477	641UCR	418	513	4,170
Paradox Valley O&M	770	663	800	778	688	664	744	760	1,072	943	867	8,749
Lower Gunnison O&M	0	0	0	0	0	0	0	0	0	0	0	0
McElmo Creek (Dolores) O&M	142	154	172	125	122	144	122	144	176	158	191	1,650
USBR Basinwide Program	2,908	6,295	2,442	3,087	3,023	3,162	2,555	2,657	3,305	3,684	3,779	36,897
Subtotal (USBR Program)	4,060	7,485	3,631	4,281	4,107	4,294	3,822	4,037	5,194	5,204	5,350	51,466
USDA Projects	5,815	5,953	5,312	5,968	5,641	4,865	5,278	4,291	5,859	5,694	5,259	59,935
Total	9,874	13,438	8,944	10,249	9,748	9,159	9,100	8,328	11,053	10,898	10,609	111,400

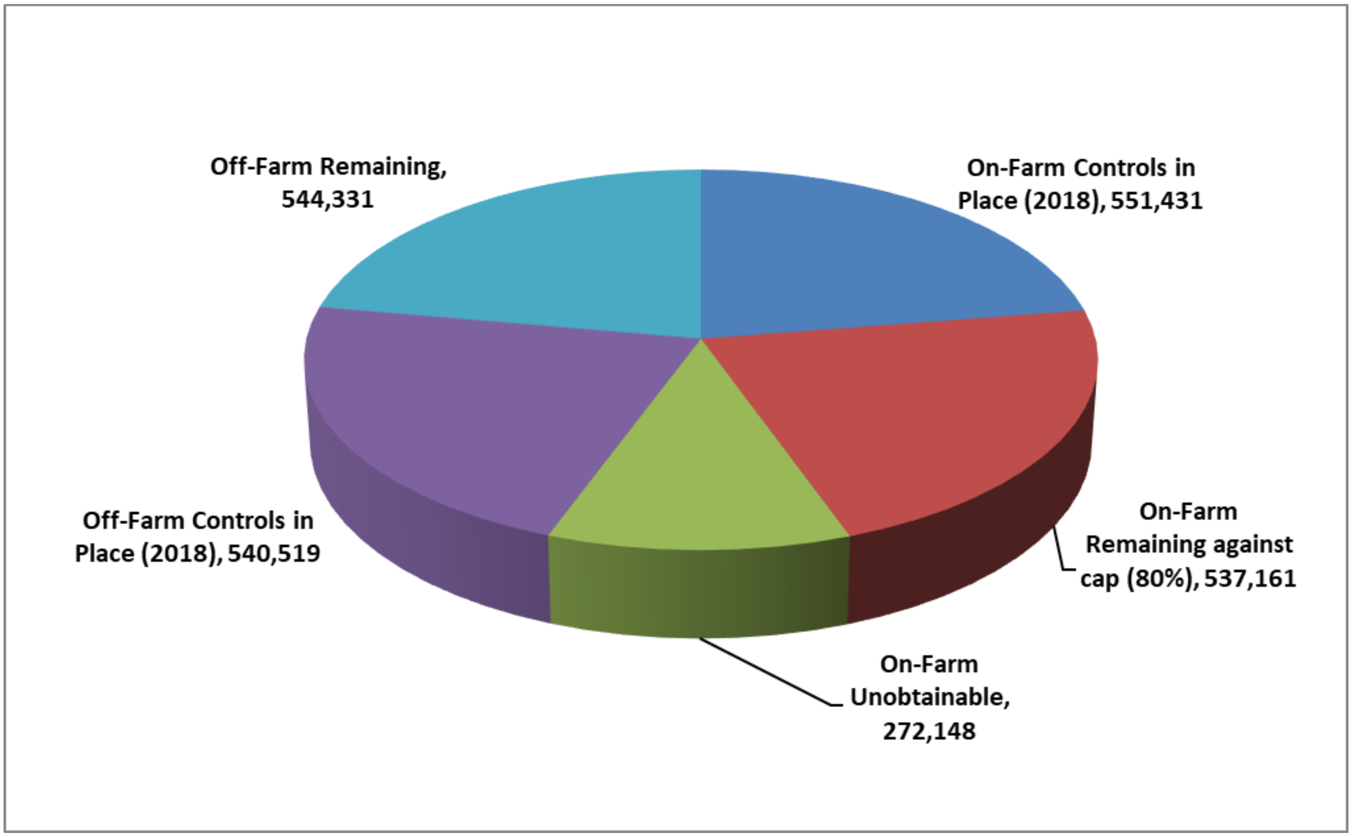


Figure 34 - UCRB Salinity Control Summary

CHAPTER 4 - OTHER WATER QUALITY RELATED ISSUES

Lake Powell Sediment

The USGS is involved with a study of the Colorado and San Juan river inflow sediment in Lake Powell. This study will try and determine the history of any contaminants which may have been deposited in Lake Powell from the inflow waters. The Utah USGS office contracted with a drilling company to have a barge mounted drill rig drill and recover sediment columns in the inflow deltas down to bedrock. The USGS will analyze the sediment cores for presence of heavy metals or other contaminants which may be found in the sediment core profile. This study will be used to determine any movement or accumulation of contaminants from upper basin activities, primarily from mining or gas and oil drilling, throughout the Lake Powell sediment deposition timeline.

Dreissenid Mussels in the Upper Colorado River Basin

The dreissenid (quagga) mussels have become well established throughout Lake Powell. As the water level of the reservoir has dropped the mussels have become more visible on the walls, rocks and beaches. With the quagga mussel population as robust as it is, boats on the water for less than ½ day have been found to have mussels attached.

The issue with the quagga is now not how to keep them out of Lake Powell but how to keep them from being transported out of Lake Powell into other bodies of water upstream of Lake Powell on the Colorado River or other water bodies within the basin. Throughout the boating season at some inspection stations, during pre-launch inspection, boats have been found with quagga mussels in northern Utah (Willard Bay, Hyrum Reservoir) after leaving Lake Powell. These boats were decontaminated or quarantined prior to being allowed to launch.

Agreements have been established with state partners to help with the inspection, interdiction and decontamination of boats prior to their launching, to try and stop any movement of mussels into new waters in the Colorado River basin or other river basins such as the Columbia River basin. The state of Utah is working to make sure boats leaving Lake Powell are dewatered and decontaminated prior to launching at other waters (cleaned, drained and dried). As of this report, no new waters in the Upper Colorado River basin (above Lake Powell) have been found to contain quagga or zebra mussels.

REFERENCES CITED

Amrhein, C. and M.A. Anderson. 2005. Geochemistry of the Salton Sea and Agricultural Evaporation Basins. International Salinity Forum Conference, April 25-28, 2005. Riverside, CA.

Anderson, J.C., and A.P. Kleinman. 1978. *Salinity Management Options for the Colorado River.* Water Resources Series Planning Report No. P-78-003, Utah Water Resources Laboratory, Logan, Utah.

Bolke, E.L. and K.M. Waddell. 1975. Chemical Quality and Temperature of Water in Flaming Gorge Reservoir, Wyoming and Utah, and the Effect of the Reservoir on the Green River. Geological Survey Water-Supply Paper 2039-A. US Government Printing Office, Washington DC.

Bolke, E.L. 1979. Dissolved-Oxygen Depletion and Other Effects of Storing Water in Flaming Gorge Reservoir, Wyoming and Utah. Geological Survey Water-Supply Paper 2058. US Government Printing Office, Washington DC.

Bureau of Reclamation. 1999. Salinity management study final report: Long term strategy & recommended action plan. Metropolitan Water District of Southern California.

Bureau of Reclamation. 2012. *Upper Colorado River Basin Consumptive Uses and Losses Report 2006-2010*. Upper Colorado Regional Office, Salt Lake City, Utah.

Bureau of Reclamation. 2012. *Colorado River Basin Water Supply and Demand Study. Technical Report C – Water Demand Assessment.* Lower Colorado Regional Office, Boulder City, NV.

Bureau of Reclamation, Bureau of Land Management, Environmental Protection Agency, U.S. Department of Agriculture, U.S. Fish and Wildlife Service and U.S. Geological Survey. 2012. *Colorado River Basin Salinity Control Program Federal Accomplishments Report for Fiscal Year 2012*. Upper Colorado Regional Office, Salt Lake City, UT.

Bull, R.J. and F.C. Kopfler. 1991. Health Effects of Disinfectants and Disinfection By-products. AWWA Research Foundation and American Water Works Association.

Butler, D.L., 2001. Effects of Piping Irrigation Laterals on Selenium and Salt Loads, Montros Arroyo Basin, Western Colorado. U.S. Geological Survey Water Resources Investigations Report 01-4204, 14p.

Butler, D.L. 1996. Trend Analysis of Selected Water-Quality Data Associated with Salinity-Control Projects in the Grand Valley. In the Lower Gunnison River basin, and at Meeker Dome, Western Colorado. Water Resources Investigation Rep. No. 95–4274, United States Geological Survey, Denver.

Cohen, M.I. June 2011. *Municipal Deliveries of Colorado River Basin Water.* Pacific Institute, Oakland, CA.

Holdren, G.C. and A. Montano. 2002. Chemical and Physical Limnology of the Salton Sea, California – 1999. Technical Memorandum No. 8220-03-02, U.S. Department of the Interior, Bureau of Reclamation, Denver, CO.

Iorns, W.V., C.H. Hembree, and G.L. Oakland. 1965. *Water Resources of the Upper Colorado River Basin - Technical Report.* U.S. Geological Survey, Professional Paper 441.

Kleinman, A.P., and B.F. Brown. December 1980. *Colorado River Salinity, Economic Impacts on Agricultural, Municipal, and Industrial Users.* Bureau of Reclamation, Engineering and Research Center, Colorado River Water Quality Office, Denver, Colorado.

Kurtzweil P. 1995. Scouting for sodium and other nutrients important to blood pressure. Washington, DC: U.S. Food and Drug Administration, FDA Consumer.

Laronne, J.B. 1977. *Dissolution Potential of Surficial Mancos Shale and Alluvium.* Unpublished Ph.D. dissertation, Department of Earth Resources, Colorado State University.

Liebermann, T.D., Middelburg, R.F., Irvine, S.A. 1987. User's Manual for Estimation of Dissolved-Solids Concentrations and Loads in Surface Water. U.S. Geological Survey, Water Resources Investigations Report 86-4124.

Liebermann, T.D., and B.D. Nordlund. 1986. Estimates of Dissolved Solid and Major Constituents for 70 Streamflow-Gaging Stations in the Upper Colorado River Basin. U.S. Geological Survey draft report.

Lohman, L.C., et al. 1988. *Economic Impacts of Salinity of the Colorado River.* Bureau of Reclamation, Denver, Colorado.

McWhorter, D.B., J.W. Rowe, et al. 1979. *Surface and Subsurface Water Quality Hydrology in Surface Mined Watersheds, Part I.* Text Interagency Energy/Environment R&D Program Report, EPA-600/7-79-193.

Midgley JP, Matthew AG, Greenwood CMT, Logan AG. 1996. Effect of reduced dietary sodium on blood pressure. A meta-analysis of randomized controlled trials. JAMA 275:1590-1597.

Mueller, D.K., and L.L. Osen. 1988. *Estimation of Natural Dissolved-Solids Discharge in the Upper Colorado River Basin, Western United States.* U.S. Geological Survey, Water Resources Investigation Report 87-4069.

Mueller, D.K., and T.D. Liebermann. 1988. *Extension of Streamflow and Dissolved Solids Records at Selected Sites in the Colorado River Basin: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming, 1940-83.* U.S. Geological Survey, Water Resources Investigations Report 87-4203.

Parker, R.S., and J.M. Norris. 1983. *Simulated Effects of Anticipated Coal Mining on Dissolved Solids in Selected Tributaries of the Yampa River, Northwestern Colorado.* U.S. Geological Survey, Water Resources Investigation Report 83-4084, Lakewood, Colorado.

Ponce, S.L. 1975. *Examination of a Non-Point Source Loading Function for the Mancos Shale Wildlands of the Price River Basin, Utah.* Ph.D. Thesis, Utah State University, Logan, Utah.

Prairie, J., Rajagopalan, B., Fulp, T., and Zagona, E., (2005). "Statistical Nonparametric Model for Natural Salt Estimation." Journal of Environmental Engineering, 131(1), 130-138.

Riley, J.P., et al. 1982. *Potential of Water and Salt Yields from Surface Runoff on Public Lands in the Price River Basin*. Water Resources Planning Series UWRL/P-82/01, Utah Water Research Laboratory, Logan, Utah, 94 pp.

Reclamation. 1982. Grand Valley Salt Pickup Calculations. Colorado River Basin Salinity Control Project, Colorado. U.S. Bureau of Reclamation. Grand Junction, Colorado. June 1982.

Riley, J.P., et al. 1982. *Salt Uptake in Natural Channels Traversing Mancos Shales in the Price River Basin, Utah*. Water Resources Planning Series UWRL/P-82/02, Utah Water Research Laboratory, Logan, Utah, 194 pp.

Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, Obarzanek E, Conlin PR, Miller ER III, Simons-Morton DG, Karanja N, Lin PH. 2001. Effects on blood pressure of reduced dietary sodium and the dietary approaches to stop hypertension (DASH) diet. New England Journal of Medicine 344(1):53-55.

Schumm, S.A., and D.I. Gregory. 1986. Diffuse-Source Salinity: Mancos Shale Terrain. U.S. Department of the Interior, Bureau of Land Management, Technical Note No. 373, Denver Service Center, Denver, Colorado.

Sowers, JR, Lester M. 2000. Hypertension, hormones and aging. Lab Clin Med 135:379-386.

Stephens, D.W., B. Waddell, L. Peltz, J. Miller. 1992. Detailed Study of Selenium and Selected Elements in Water, Bottom Sediment, and Biota Associated with Irrigation Drainage, in the Middle Green River Basin, Utah, 1988 – 1990. USGS Water-Resources Investigations Report 92-4084.

Svetkey LP, Sacks FM, Obarzanek E, Vollmer WM, Appel LJ, Karanja N, Harsha D, Bray GA, Aickin M, Proschan M, Windhauser MM, Swain JF, McCarron PB, Rhodes DG, Laws RL. 1999. The DASH diet, sodium intake and blood pressure trial (DASH-Sodium): rationale and design. J Am Diet Assoc 99:S96-S104.

Taubes, G. 1998. The (political) science of salt. Science 281:898-907.

Treuman, D. 1995. Land Retirement – Alternative for salinity control. Bureau of Reclamation.

Uintex Corp. 1982. A Study of Runoff and Water Quality Associated with the Wildlands of the Price River Basin, Utah. Bureau of Land Management Contract No. YA553-CT1-1064.

U.S. Department of Agriculture (USDA). 1976. Grand Valley Salinity Study, Investigation of Sediment and Salt Yields in Diffuse Areas. Soil Conservation Service, Memorandum, March 5, 1976. Mesa County, Colorado.

U.S. Department of Agriculture (USDA). 2000. Nutrition and your health: Dietary guidelines for Americans, 5th ed. Home and Garden bulletin No. 232. U.S. Department of Health and Human Services, Washington, DC.

U.S. Department of the Interior. 1984. Status Report, Bureau of Land Management, Technical Note No. 364, Denver Service Center, Denver, Colorado.

U.S. Department of the Interior. 1985. Draft Environmental Impact Statement, James Creek Coal, Preference Right Lease Application. Bureau of Land Management, Craig District, Colorado.

U.S. Department of the Interior. 1990. Colorado River Damage Estimate Program. Bureau of Reclamation, Chief, Analysis, Contracts, and Lands Division, Denver Office, Memorandum, October 25, 1990, Denver, Colorado.

U.S. Environmental Protection Agency (EPA). 1971. The Mineral Quality Problem in the Colorado River Basin, Summary Report*,* EPA Regions VIII and IX.

U.S. Environmental Protection Agency (EPA). 1999. Health effects from exposure to sulfate in drinking water workshop. Office of Water. Washington, DC. EPA 815-R-99-002.

U.S. Geological Survey (USGS). 2012. Salt Load 2012 Update for the 20 Stations. USGS, Water Science Center, Western Colorado Office, Grand Junction, CO.

Vaill, J.E., and Butler, D.L. (1999). "Streamflow and Dissolved-Solids Trends, Through 1996, in the Colorado River basin Upstream from Lake Powell- Colorado, Utah, Wyoming." Water Resources Investigation Rep. No. 99-4097, United States Geological Survey, Denver.

GENERAL REFERENCES

Agricultural Research Service. 1982. *Minimizing Salt in Return Flow through Irrigation Management.* Report No. PUB-744; EPA-600/2-82-073, 181 pp.

Battelle Pacific Northwest Labs. 1982. *Western Oil-Shale Development: A Technological Assessment. Vol. 6: Oil-Shale Development in the Piceance Creek Basin and Potential Water- Quality Changes.* Department of Energy, Report No. PNL-3830-VO2.6, 22 pp.

Bentley, R.G., K.O. Eggleston, and E.B. Janes. 1980. *Salinity Status Report, 1978-79, Control of Salinity from Point Sources Yielding Groundwater Discharge and from Diffuse Surface Runoff in the Upper Colorado River Basin.* Report No. BLM-YA-TR-80-01, Bureau of Land Management, Denver Service Center, Denver, Colorado, 37 pp.

Bowles, D.S., et al. 1982. *Salt Loading from Efflorescence and Suspended Sediments in the Price River Basin.* Water Resources Planning Series UWRL/P-82/05, Utah Water Research Laboratory, Logan, Utah, 142 pp.

Brenniman, G.R. 1981. *Relationship Between High Sodium Levels in Municipally Softened Drinking Water and Elevated Blood Pressures.* Water Resources Center, Illinois University, Research Report 158, NTIS PB81-212615, 27 pp.

Bulke, E.L., and K.M. Waddell. 1975. *Chemical Quality and Temperature of Water in Flaming Gorge Reservoir, Wyoming and Utah, and the Effect of the Reservoir on the Green River.* U.S. Geological Survey, Water Supply Paper 2039-A.

Burdge, Irelan. 1971. *Salinity of Surface Water in the Lower Colorado River, Salton Sea Area.* U.S. Geological Survey, Professional Paper 486-E.

Bureau of Land Management. 1978. *The Effects of Surface Disturbance on the Salinity of Public Lands in the Upper Colorado River Basin, 1977 Status Report.* U.S. Department of the Interior, Denver Service Center, Denver, Colorado, 208 pp.

Bureau of Reclamation. 1981. *Saline Water Use and Disposal Opportunities: Colorado River Water Quality Improvement Program.* Special Report, Bureau of Reclamation, Denver, Colorado, 167 pp.

Bureau of Reclamation. 1981. *Water Assessment for the Lower Colorado River Region, Emerging Energy Technology Development.* Bureau of Reclamation, Boulder City, Nevada, 170 pp.

Bureau of Reclamation. 2012. *Upper Colorado River Basin Consumptive Uses and Losses Report 2006- 2010.* Upper Colorado Region, Salt Lake City, Utah.

Bureau of Reclamation. 1984. *Development, Verification, and Use of Methods to Model Chemical and Thermal Processes for Lakes Powell and Mead.* Engineering and Research Center, Colorado River Water Quality Office, Denver, Colorado.

Bureau of Reclamation. May 1985. *Colorado River Simulation System Documentation System Overview.* USBR Engineering and Research Center, Denver, Colorado.

Bureau of Reclamation. 1986. *Etiwanda Ion-Exchange Pilot-Plant Testing. Denver, Colorado.* CH_2M Hill. 1982. Salinity Investigation of the Price-San Rafael River Unit, Colorado River Water Quality Improvement Program. Bureau of Reclamation, Contract No. 1-07-40-51637, Utah Projects Office, Provo, Utah.

Cissell, Jeffery A., V. Dean Adams, Joel E. Fletcher, Daniel S. Filip, and Dennis B. George. 1982. *Water Requirements and Pollutant Potential in the Gasification of Carbonaceous Shales*. Report Nos. UWRL/Q-82/04; W83-02211; OWRT-A-043-UT(1), Utah Water Research Laboratory, Logan, Utah, 68 pp.

Colorado River Basin Salinity Control Forum. 2011. *2011 Review. Water Quality Standards for Salinity Colorado River System.*

Colorado Water Resources Research Institute. 1981. *A Five Year Plan for Water Research in Colorado.* Office of Water Research and Technology, Report No. W82-05531, 133 pp.

Cowan, Michael S., R. Wayne Cheney, and Jeffrey C. Addiego. 1981. *Colorado River Simulation System: An Executive Summary*. Bureau of Reclamation, Engineering and Research Center, Denver, Colorado, 19 pp.

Dean, A.V. and Lamarra, V.A. (editors). 1981. *Aquatic Resources Management of the Colorado River Ecosystem (Proceedings of the Symposium).* Ann Arbor Science Publication, Ann Arbor, Michigan, 697 pp.

DeLon, L.L. 1982. *Water Quality of Streams and Springs, Green River Basin, Wyoming.* U.S. Geological Survey, Water Resources Investigations Report 82-4008.

Eisenhauer, R.J. 1983. *Characterization of Glenwood Springs and Dotsero Springs Water.* Bureau of Reclamation, Engineering and Research Center, Report No. 83-10, Denver, Colorado, 58 pp.

Eisenhauer, R.J. 1986. *Characterization of Glenwood Springs and Dotsero Springs Source Aquifers.* Bureau of Reclamation, REC-ERC-86-1, Denver, Colorado.

Eisenhauer, R.J. 1987. *Characteristics of Big Sandy River Drainage Basin Water and of Salty Aquifer Water.* Bureau of Reclamation, REC-ERC-87-2, Denver, Colorado.

Evans, R.G., W.R. Walker, and G.V. Skogerboe. 1982. *Defining Cost-Effective Salinity Control Programs.* Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, vol. 108, No. 4, pp. 265-272.

French, Richard H. (Ed.). 1984. *Salinity in Watercourses and Reservoirs.* Proceedings of the 1983 International Symposium on State-of-the-Art Control of Salinity, July 13-15, 1983, Salt Lake City, Utah, Butterworth Publishers, Stoneham, Massachusetts.

Gloss, S., and D.E. Kidd. *Application of the Nutrient Loading Concept and Effects of Nutrient Perturbations on Phytoplankton Productivity.* Lake Powell Research Project, Bulletin No. 59.

Green, S.L. 1981. Water Resources Investigations of the U.S. Geological Survey in Wyoming, Fiscal Year 1980. U.S. Geological Survey, Open-File Report 81-201, 118 pp.

Haselhoff, Donald A. 1983. *Water for Las Vegas Metropolitan Area*, Journal of Environmental Engineering, vol. 109, No. 3, pp. 700-715.

Holburt, M.B. 1982. *Colorado River Water Allocation*. Water Supply and Management, vol. 6, No. 1-2, pp. 63-73.

Howells, L., et al. 1987. *Base of Moderately Saline Groundwater in the Uinta Basin, Utah*. U.S. Geological Survey, Open-File Report 87-397.

Hyatt, M.L., J.P. Riley, M.L. McKee, and E.K. Israelson. 1970. *Computer Simulation of the Hydrologic-Salinity Flow System Within the Upper Colorado River Basin*. PRWG54-1. Utah Water Research Laboratory, Utah State University, Logan, Utah, 255 pp.

Israelsen, C. E., et al. 1980. *Use of Saline Water in Energy Development*. Water Resources Planning Series UWRL/P-80/04, Utah Water Research Laboratory, Logan, Utah, 128 pp.

Jackson, W.L., R.G. Bentley, and S. Fisher. 1984. *Results of BLM Studies on Public Lands in the Upper Colorado River Basin*. BLM Technical Note YA-PT-84-008-4340, Bureau of Land Management, Denver Service Center, Denver, Colorado.

Johnson, D.H., C.M. Leboeuf, and D. Waddington. 1981. *Solar Pond-Driven Distillation and Power Production System*. Solar Energy Research Institute, Report No. SERI/TR-631-1248, Department of Energy, Golden, Colorado, 24 pp.

Johnson, R.K., and S.A. Schumm. 1982. *Geomorphic and Lithologic Controls of Diffuse-Source Salinity, Grand Valley, Western Colorado*. National Technical Information Service, PB82-256587, 99 pp.

Kidd, D.E., E. Hansmann, and S. Gloss. *Trophic Status Investigations at Lake Powell Reservoir*. Lake Powell Research Project Bulletin No. 60.

Koch, R.W., T.G. Sanders, and H.S. Morel-Seytoux. 1982. *Regional Detection of Change in Water Quality Variables*. Water Resources Bulletin, vol. 18, No. 5, pp. 815-821.

Laronne, J.B., and S.A. Schumm. l977. *Evaluation of the Storage of Diffuse Sources of Salinity in the Upper Colorado River Basin*. Environmental Resources Center, Colorado State University, Completion Report Series No. 79, 111 pp.

Laughlin, J.K. 1984. *Appraisal Study of Saline Water Use Equipment for Power Plant Cooling*. Bureau of Reclamation, Denver, Colorado.

Laughlin, J.K. 1985. *Final Report - Study of Saline Water Use at Jim Bridger Power Plant*. Bureau of Reclamation, Denver, Colorado.

Laughlin, J.K. 1986. *Final Report - Study of Saline Water Use at Harry Allen Generating Station*. Bureau of Reclamation, Denver, Colorado.

Laughlin, J.K. 1987. *Final Report - Study of Saline Water Use at the Etiwanda Generating Station*. Bureau of Reclamation, Denver, Colorado.

Law, J.P., Jr., and A.G. Hornsby. 1982. *The Colorado River Salinity Problem*. Water Supply and Management, vol. 6, No. 1-2, pp. 87-104.

Liebermann, T.D., et al. 1987. *User's Manual for Estimation of Dissolved-Solids Concentrations and Loads in Surface Water*. U.S. Geological Survey, Water Resources Investigations Report 86-4124.

Liebermann, T.D., D.K. Mueller, J.E. Kircher, A.F. Choquette, and R.A. Bell. 1986. *Characteristics and Trends of Dissolved Solids in the Upper Colorado River Basin, Arizona, Colorado, New Mexico, Utah, and Wyoming.* U.S. Geological Survey, Open-File Report 87-568.

Lindskov, K.L., and B.A. Kimball. *Quantity and Quality of Streamflow in Southeastern Uinta Basin, Utah and Colorado.* U.S. Geological Survey, Water Supply Paper 2224.

Martin, R.G., and R.H. Stroud. 1973. *Influence of Reservoir Discharge Location on Water Quality, Biology, and Sport Fisheries of Reservoirs and Tailwaters, 1968-71.* U.S. Army Corps of Engineers, Waterway Experiment Station, Contract No. DACW31-67-C-0083.

Mayer, L.M. 1977. *The Effect of Lake Powell on Dissolved Silica Cycling in the Colorado River.* Lake Powell Research Project Bulletin No. 42.

Maynard, D.P., and Caputo, R. 1982. *Assessment of Saline Water Use in Coal Transport and Multipurpose Systems.* Jet Propulsion Laboratory, Report No. JPL-D-425, Pasadena, California, Bureau of Reclamation, Engineering and Research Center, Denver, Colorado, 156 pp.

Merritt, D. and Johnson, N. 1977. *Advective Circulation in Lake Powell, Utah-Arizona.* Lake Powell Research Project Bulletin No. 61, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California, 72 pp.

Miffin, M.D. 1983. *Reuse Versus Return Flows: Considerations for Selecting a Water Supply Strategy.* University of Nevada, Desert Research Institute, Reno, Nevada.

Miller, J.B., D.L. Wegner, and D.R. Bruemmer. 1980. *Salinity and Phosphorus Routing Through the Colorado River/Reservoir System.* Bureau of Reclamation, Salt Lake City, Utah.

Moody, C.D., and D.K. Mueller. 1984. *Water Quality of the Colorado System: Historical Trends in Concentration, Load, and Mass Fraction of Inorganic Solutes.* Bureau of Reclamation, Report No. EC-ERC-84-9.

Mueller, D.K., and L.L. Osen. 1988. *Estimation of Natural Dissolved Solids Discharge in the Upper Colorado River Basin, Western United States.* U.S. Geological Survey, Water Resources Investigations Report 87-4069.

Mundorff, J.C. 1972. *Reconnaissance of Chemical Quality of Surface Water and Fluvial Sediment in the Price River Basin, Utah.* Utah Department of Natural Resources Technical Publication 39.

Mundorff, J.C., and K.R. Thompson. 1980. *Reconnaissance of the Quality of Surface Water in the San Rafael River Basin, Utah.* U.S. Geological Survey, Open-File Report 80-574.

Narayanan, R., and D.R. Franklin. 1982. *An Evaluation of Water Conservancy Techniques in the Upper Colorado River Basin.* Water Resources Planning Series UWRL/P-82/07, Utah Water Research Laboratory, Logan, Utah.

Paulson, L.J. 1981. *Nutrient Management with Hydroelectric Dams on the Colorado River System.* Technical Report No. 8, Lake Mead Limnological Research Center, University of Nevada, Las Vegas, Nevada, 39 pp.

Paulson, L.J., and J.R. Baker. 1981. *The Effects of Impoundments on Salinity in the Colorado River: Proceedings of the Symposium on the Aquatic Resources Management of the Colorado River Ecosystem, November 16-19, 1981, Las Vegas, Nevada.* Ann Arbor Science, Ann Arbor, Michigan.

Paulson, L.J., and J.R. Baker. 1983. *The Limnology in Reservoirs on the Colorado River.* Technical Report No. 11, Lake Mead Limnological Research Center, University of Nevada, Las Vegas, Nevada.

Paulson, L.J., J.R. Baker, and J.E. Deacon. 1980. *The Limnological Status of Lake Mead and Lake Mohave Under Present and Future Powerplant Operation of Hoover Dam.* Technical Report No. 1, Lake Mead Limnological Research Center, University of Nevada, Las Vegas, Nevada.

Prentki, R.T., L.J. Paulson, and J.R. Baker. 1981. *Chemical and Biological Structure of Lake Mead Sediments.* Technical Report No. 6, Lake Mead Limnological Research Center, University of Nevada, Las Vegas, Nevada, 89 pp.

Rittmaster, R.L., and D.K. Mueller. 1985. *Solute Loading Sources in the Dirty Devil River Basin, Utah.* Bureau of Reclamation, REC-ERC-85-5, Denver, Colorado.

Robson, S.G., and G.J. Saulnier, Jr. 1981. *Hydrogeochemistry and Simulated Solute Transport, Piceance Basin, Northwestern Colorado.* U.S. Geological Survey, Professional Paper 1196, 65 pp.

Sandberg, G.W., and L.G. Sutlz. 1985. *Reconnaissance of the Quality of Surface Water in the Upper Virgin River Basin, Utah, Arizona, and Nevada, 1981-82.* Utah Department of Natural Resources, Technical Publication No. 83.

Schumm, S.A., and D.I. Gregory. 1986. *Diffuse-Source Salinity: Mancos Shale Terrain.* U.S. Department of the Interior, Bureau of Land Management, Technical Note 373, Denver Service Center, Denver, Colorado.

Seiler, R.L., and R.L. Baskin. 1987. *Hydrology of Alkali Creek and Castle Valley Ridge Coal-Lease Tracts, Central Utah, and Potential Effects of Coal Mining.* U.S. Geological Survey, Water Resources Investigations Report 87-4186.

Shacklette, H.T., and J.G. Boerngen. 1984. *Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States.* U.S. Geological Survey, Professional Paper 1270.

Shen, H.W., et al. 1981. *Role of Sediment in Non-Point Source Salt Loading Within the Upper Colorado River Basin.* Colorado Water Resources Research Institute Completion Report No. 107, 213 pp.

Skogerboe, G.V., and G.E. Radosevich. 1982. *Future Water Development Policies.* Water Supply and Management, vol. 6, No. 1-2, pp. 221-232.

Skogerboe, G.V., W.R. Walker, and R.G. Evans. 1982. *Salinity Control Measures for Grand Valley.* Water Supply and Management, vol. 6, No. 1-2, pp. 129-167.

Trueman, D.P. 1998. *Colorado River Basin Salinity Control Program, 1998 Review.* Proceedings of the Shared Rivers Conference, U.S. Committee on Irrigation and Drainage, Park City, Utah.

U.S. Department of the Interior. 1984. *Aquatrain Corridor Study Report.* Bureau of Reclamation, Denver, Colorado.

U.S. Environmental Protection Agency. l971. *The Mineral Quality Problem in the Colorado River Basin*. Summary Report. Regions VIII and IX, 65 pp.

Warner, J.W., and F.J. Heimes. 1979. A Preliminary Evaluation of Groundwater Contributions to Salinity of Streams in the Upper Colorado Basin in Colorado and Adjacent Parts of Wyoming and Utah. U.S. Geological Survey, Denver, Colorado, contract to Bureau of Land Management.

Water Resources Council. 1981. *Synthetic Fuels Development in the Upper Colorado Region: Section 13(a) Water Assessment Report*. Technical Report, 138 pp.

Whittig, L.D., et al. 1983. *Salinity Investigations in West Salt Creek, Colorado*. California Water Resources Center Completion Report, University of California, Davis, California, 161 pp.

Yahnke, J. 1982. *Fryingpan River and Rued Reservoir Water Quality Studies*. Part I, Bureau of Reclamation, Working Paper, Engineering and Research Center, Denver, Colorado.

APPENDIX A

SALINITY MONITORING STATION INFORMATION

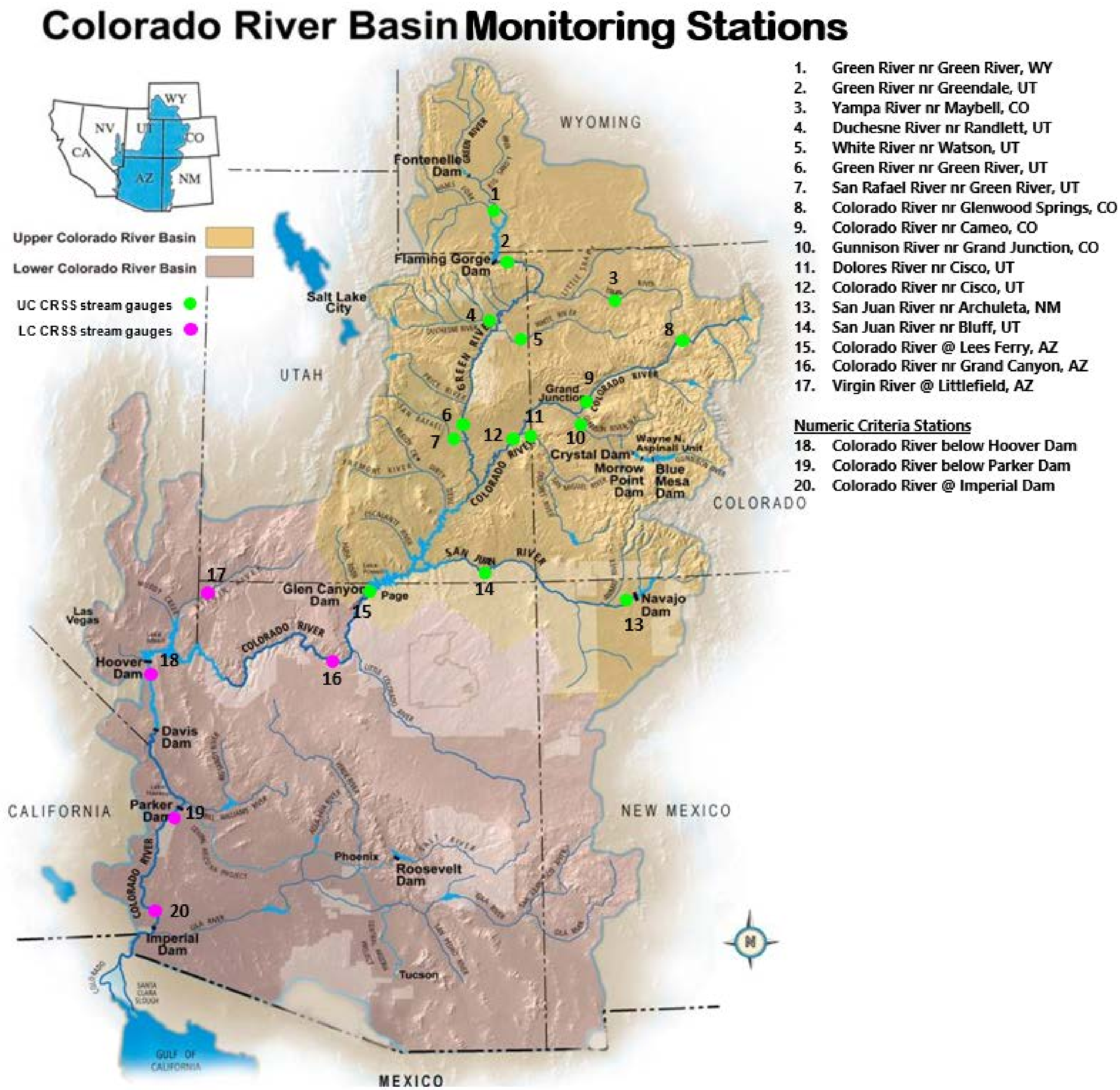


Figure A1 - Colorado River Basin 20 Stream Gage Locations

Table A1 - Characteristics of the 20 Salinity Streamflow-gaging Stations in the Colorado River Basin

[Latitude and Longitude datum: NAD83; Elevation datum: NGVD29.]

U.S. Geological Survey streamflow-gaging station number	U.S. Geological Survey streamflow-gaging station name	Site short name	Latitude, in decimal degrees	Longitude, in decimal degrees	Elevation, in feet above sea level	Drainage area, in square miles
09217000	Green River near Green River WY	GRWY	39.5589	-107.2909	5,760	4,556
09234500	Green River near Greendale, UT	GDALE	39.2391	-108.2662	4,814	7,986
09251000	Yampa River near Maybell, CO	YAMPA	38.9833	-108.4506	4,628	7,923
09302000	Duchesne River near Randlett, UT	DUCH	38.7972	-109.1951	4,165	4,580
09306500	White River near Watson, UT	WHITE	38.8105	-109.2934	4,090	24,100
09315000	Green River at Green River, UT	GRUT	41.5164	-109.4490	6,060	14,000
09328500	San Rafael River near Green River, UT	SANRAF	40.9083	-109.4229	5,594	19,350
09071750	Colorado River above Glenwood Springs, CO	GLEN	40.5027	-108.0334	5,900	3,383
09095500	Colorado River near Cameo, CO	CAMEO	40.2103	-109.7814	4,756	3,790
09152500	Gunnison River near Grand Junction, CO	GUNN	39.9789	-109.1787	4,947	4,020
09180000	Dolores River near Cisco, UT	DOLOR	38.9861	-110.1512	4,040	44,850
09180500	Colorado River near Cisco, UT	CISCO	38.8583	-110.3701	4,190	1,628
09355500	San Juan River near Archuleta, NM	ARCH	36.8019	-107.6986	5,653	3,260
09379500	San Juan River near Bluff, UT	BLUFF	37.1469	-109.8648	4,048	23,000
09380000	Colorado River at Lees Ferry, AZ	LEES	36.8647	-111.5882	3,106	111,800
09402500	Colorado River near Grand Canyon, AZ	GRCAN	36.1014	-112.0863	2,419	141,600
09415000	Virgin River at Littlefield, AZ	VIRGIN	36.8916	-113.9244	1,764	5,090
09421500	Colorado River below Hoover Dam, AZ-NV	HOOVER	36.0153	-114.7386	675	171,700
09427520	Colorado River below Parker Dam, AZ-CA	PARKER	34.2956	-114.1402	301	182,700
09429490	Colorado River above Imperial Dam, AZ-CA	IMPER	32.8837	-114.4674	183	188,500

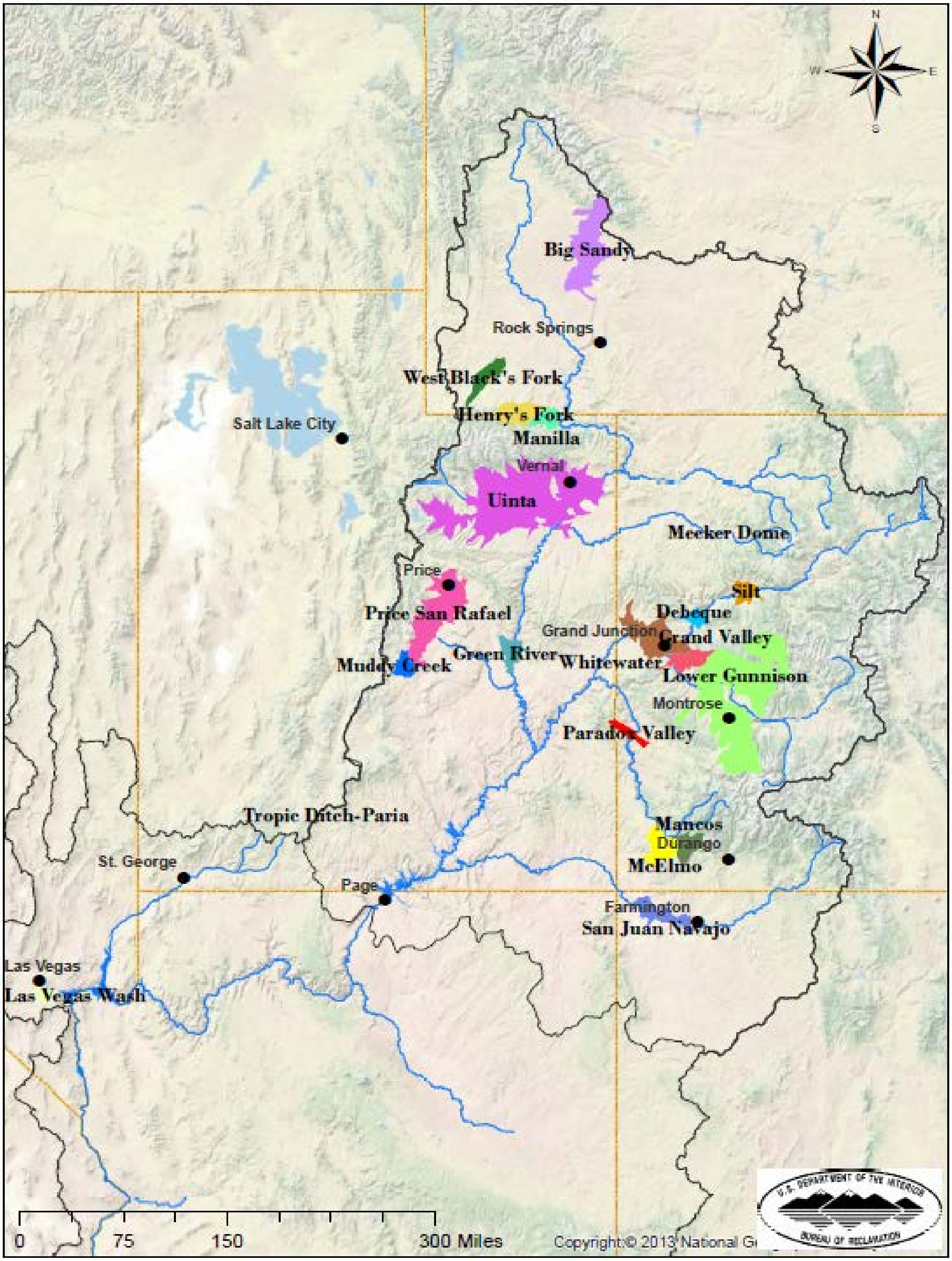


Figure A2 – Salinity Project Locations

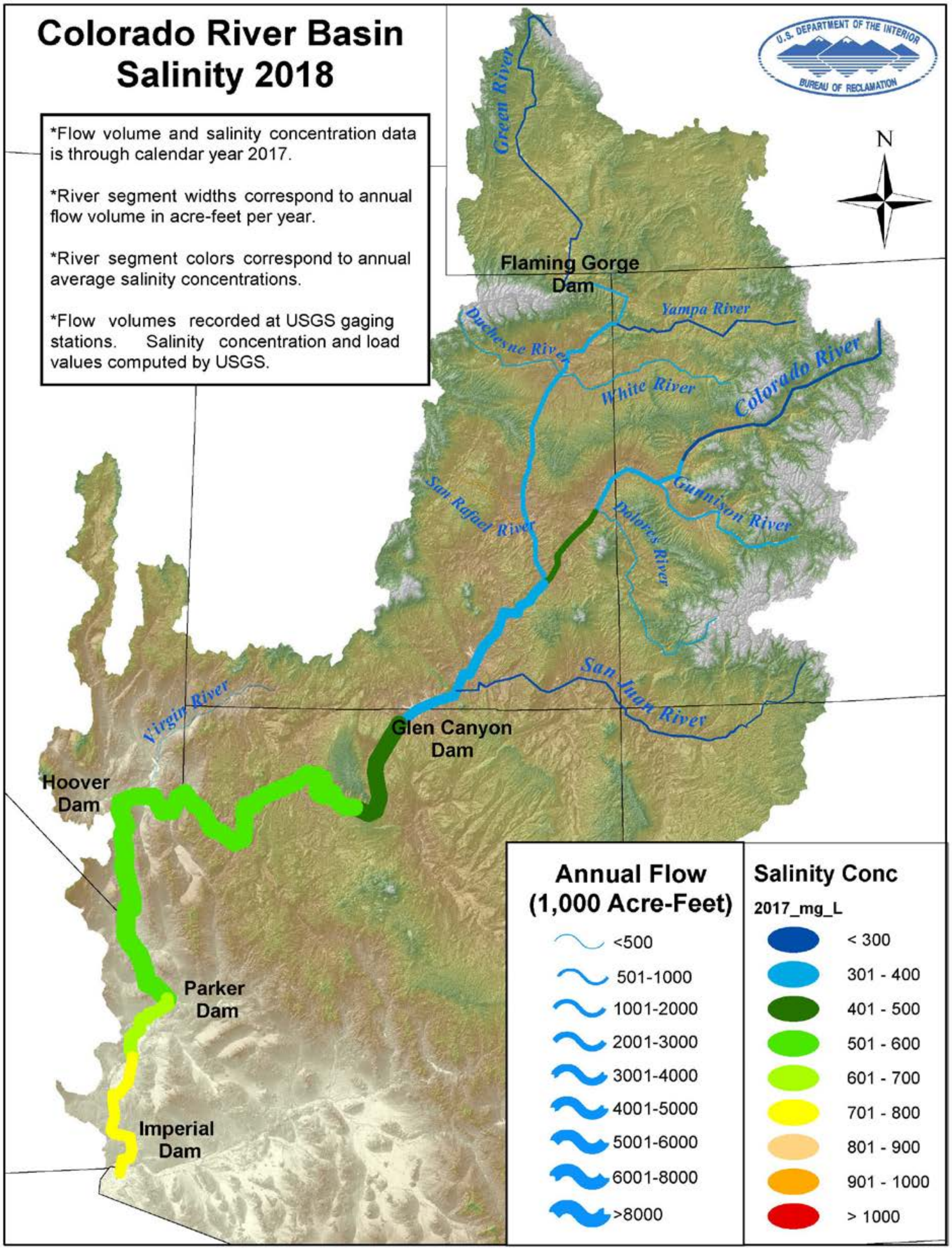


Figure A3 - Colorado River Flow and Salinity

APPENDIX B

SALT LOAD 2018 UPDATE FOR THE 20 STATIONS

(Updates calendar years 2014 through 2017)

STATION CLASSIFICATIONS

U.S. Geological Survey
Colorado Water Science Center
Western Colorado Office

August 01, 2018

INTRODUCTION

Methodology

Three Statistical Analyses System (SAS) computer programs, FLAGIT, DVCOND, and SLOAD are used to estimate dissolved-solids concentrations and loads from existing data. The program FLAGIT retrieves data from the daily-values (DV) file and water-quality file (QW) of the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) (Hutchinson, 1975), examines the data, deletes incomplete observations, and flags possible errors in the remaining observations. FLAGIT also produces the data base used by the programs DVCOND and SLOAD. The program DVCOND fills in missing values in the daily specific-conductance record by linear interpolation. DVCOND needs to be used only when the flow at a streamflow-gaging station is extensively regulated.

The program SLOAD derives regression relations from water-quality data, modeling dissolved solids and six major ions as functions of specific conductance and discharge (Q). SLOAD then applies these relations to the daily specific conductance and discharge data and computes daily loads of dissolved solids and the other six major ions. The computed daily loads are summed by month and by year. Monthly and annual dissolved-solids and major ion concentrations are computed from the monthly and annual loads and streamflow. Monthly, annual, and seasonal concentrations and loads, in addition to regression statistics, are printed and saved on SAS data sets. Separate versions of SLOAD enable annual summation either by water year (WY) or calendar year (CY) (Lieberman and others, 1987).

The computerized method can be used for streamflow-gaging stations that have a complete record of DV Q and periodic QW analyses. The reliability of the estimate is considerably increased if DV specific conductance (SC) also is available. Water-quality analysis that includes total dissolved solids (TDS) with major ion analysis (also referred to as sum of constituents or SOC/SUM; herein referred to as SOC) is preferred over residue on evaporation at 180 degrees Celsius (ROE). SOC enables SLOAD calculations of the 8 major constituents normally present in natural streams: Calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), silica (Si), chloride (Cl^{-}), sulfate (SO_4^{2-}), and carbon, expressed as carbonate equivalent (Liebermann and others, 1987).

Classification Criteria

The 20 stations are classified A, B, or C, according to the quantity and quality of available data for the salt-load computations. Optimal data collection at each station includes daily mean streamflow, daily mean SC, and at least 6 water quality samples per WY which include TDS. SC may be monitored continuously with an instrument (daily mean) or sampled once per day by an observer (instantaneous). Continuous monitoring for daily mean SC by instrument is the preferred method.

Types of Specific Conductivity

Specific Conductivity at the sites is classified into several types:

- Daily – mean daily SC collected by instrumentation. To be considered "daily", the record may have up to 60 missing days of SC per water year which are spread out in small groups over the year.

- Intermittent – mean daily SC which has more than 60 missing days per water year spread out over the water year.
- Seasonal – mean daily SC has been continuously shut off during the winter (November through March typically), with more than 60 missing days.
- Instantaneous – single SC values which have been manually collected by an observer. Usually spaced several days apart and may be missing during winter months.

CLASS A

For Class A, adequate data must be available for salt-load computation using SLOAD. Site data includes:

- 6 or more QW samples per WY which include some type of TDS (ROE, SOC, or Calculated). SLOAD automatically discards QW records without any type of TDS.
- Daily Q (SLOAD allows no days with missing Q).
- Mean daily SC from instrumentation. The SC record must be "daily" and must have no more than *60 total days of missing values for the WY*.

CLASS B

Salt-load computation is possible using SLOAD, but limited data availability could be contributing to error in salt load estimate. Even though the site has daily Q and daily SC, if there are fewer than 6 QW observations, the site will be Class B. Site data includes:

- There are fewer than 6 QW samples per WY which include some type of TDS.
- Daily Q (SLOAD allows no days with missing Q). Missing Q values may be interpolated from surrounding values.
- SC may be mean daily (with up to 60 missing days), seasonal, intermittent (more than 60 missing days), instantaneous from observers, or non-existent.

CLASS C

Inadequate data exists for SLOAD salt-load computation. Site data includes:

- Some QW records may exist, but none have TDS, hence they are not usable.
- SC may or may not exist but is not used.
- Salt concentration and load are calculated from regression analysis of old data (Q and TDS).

Improvements and Declines in Class

The classification is shown by year for each site in the tables. This is helpful to see the trend in classifications.

A judgment call must be made for the final year classification. The final year has incomplete data, and the data have not been finalized by USGS. The final year classification will be shown as "provisional" if the criteria for the class are being met as of the cutoff date for the data. For example, if enough QW records exist to suggest that 6 observations will be made by the end of the WY, and if daily SC is being recorded, then A (provisional) will be given. The pattern of QW observations for the previous years is taken to project the QW for the final year. The final year will not be shown as provisional if no daily SC is being recorded, (the class is clearly B), or, if no QW records are available, (the class is clearly C).

#1 GRWY - STATION 09217000 Green River near Green River, WY

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	12	11	12	9	4 (thru 5-31)
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Seasonal (132 missing)	Seasonal (142 missing)	Seasonal (166 missing)	Seasonal (141 missing)	Seasonal (156 missing)
ROE TDS samples	12	11	12	9	4
SOC TDS samples	12	11	12	9	4
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	Missing SC>60/year	Missing SC>60/year	Missing SC>60/year	Missing SC>60/year	Missing SC>60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#2 GDALE - STATION 09234500, Green River near Greendale, UT

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	9	10	11	8	5 (thru 5-31)
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (10 missing)	Daily (22 missing)	Daily (3 missing)	Daily (17 missing)	Daily (3 missing)
ROE TDS samples	9	10	11	8	5
SOC TDS samples	8	10	11	8	5
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#3 YAMPA – STATION 09251000, Yampa River near Maybell, CO

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	6	6	5	6	2
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (25 missing)	Daily (17 missing)	Daily (6 missing)	Daily (11 missing)	Daily (26 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	6	6	5	6	2
Class by Year	**A**	**A**	**B**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year; 5 QW samples	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#4 DUCH – STATION 09302000, Duchesne River near Randlett, UT

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	9	9	11	8	5
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (20 missing)	Daily (13 missing)	Daily (13 missing)	Daily (4 missing)	Daily (5 missing)
ROE TDS samples	9	9	11	8	5
SOC TDS samples	9	9	11	8	5
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#5 WHITE – STATION 09306500, White River near Watson, Utah

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	9	9	10	8	5
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	9	9	10	8	5
SOC TDS samples	9	9	10	8	5
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC	No SC	No SC	No SC	No SC

Operation is by USGS for daily Q and periodic QW.

#6 GRUT – STATION 09315000, Green River at Green River, UT

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	8	8	8	9	4
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	9	8	8	9	4
SOC TDS samples	9	8	8	9	4
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC	No SC	No SC	No SC	No SC

Operation is by USGS for daily Q and periodic QW.

#7 SANRAF – STATION 09328500, San Rafael River near Green River, UT

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	8	7	10	8	6
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	Intermittent (186 missing)	Intermittent (82 missing)	Intermittent (3 missing)
ROE TDS samples	8	7	10	8	6
SOC TDS samples	8	7	10	8	6
Class by Year	**B**	**B**	**B**	**B**	**A (provisional)**
Classify Notes	No SC	No SC	Missing SC>60/year	Missing SC>60/year	Missing SC<60/year

Operation is by USGS for daily Q and periodic QW.

#8 GLEN – STATION 09071750, Colorado River above Glenwood Springs, CO

This station has an SC monitor but no stream gage. Flow is computed as the difference between station 09085100 (Colorado River below Glenwood Springs, CO) and station 09085000 (Roaring Fork River at Glenwood Springs, CO).

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	6	6	6	6	3
Daily Q	Estimated (0 missing)	Estimated (0 missing)	Estimated (0 missing)	Estimated (0 missing)	Estimated (0 missing)
SC	Daily (2 missing)	Daily (17 missing)	Daily (46 missing)	Daily (4 missing)	Daily (0 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	6	6	6	6	3
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for estimated Q, daily SC and periodic QW.

#9 CAMEO - STATION 09095500, Colorado River near Cameo, CO

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	5	5	5	5	2
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (5 missing)	Daily (53 missing)	Daily (0 missing)	Daily (0 missing)	Daily (12 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	5	5	5	5	2
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	QW observations < 6	QW observations < 6	QW observations < 6	QW observations < 6	QW observations < 6

Operation is by USGS for daily Q, daily SC, and periodic QW.

#10 GUNN - STATION 09152500, Gunnison River near Grand Junction, CO

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	9	9	10	9	5
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (9 missing)	Daily (16 missing)	Daily (0 missing)	Daily (1 missing)	Daily (3 missing)
ROE TDS samples	0	0	0	0	0
SOC TDS samples	9	9	10	9	**5**
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#11 DOLOR - STATION 09180000, Dolores River near Cisco, UT

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	9	8	8	9	5
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (10 missing)	Daily (14 missing)	Daily (21 missing)	Daily (17 missing)	Daily (0 missing)
ROE TDS samples	9	8	8	9	5
SOC TDS samples	9	8	8	9	5
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#12 CISCO - STATION 09180500, Colorado River near Cisco, UT

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	9	8	7	8	4
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (36 missing)	Daily (12 missing)	Daily (1 missing)	Daily (0 missing)	Daily (4 missing)
ROE TDS samples	9	8	7	8	4
SOC TDS samples	9	8	7	8	4
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#13 ARCH - STATION 09355500, San Juan River near Archuleta, NM

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	3	3	3	3	1
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	3	3	3	3	1
SOC TDS samples	3	3	3	3	1
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC	No SC	No SC	No SC	No SC

Operation is by USGS for daily Q and periodic QW.

#14 BLUFF - STATION 09379500, San Juan River near Bluff, UT

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	8	9	9	9	5
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (18 missing)	Daily (16 missing)	Daily (38 missing)	Daily (15 missing)	Daily (4 missing)
ROE TDS samples	8	9	9	9	5
SOC TDS samples	8	9	9	9	5
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#15 LEES - STATION 09380000, Colorado River at Lees Ferry, AZ

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	13	14	14	14	10
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (0 missing)	Daily (0 missing)	Daily (14 missing)	Daily (0 missing)	Daily (0 missing)
ROE TDS samples	13	14	14	14	10
SOC TDS samples	13	14	14	14	10
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year	Missing SC<60/year

Operation is by USGS for daily Q, daily SC, and periodic QW.

#16 GRCAN - STATION 09402500, Colorado River near Grand Canyon, AZ

Daily Q only. Salt loads are computed with a special version of SLOAD by using the load at station 09380000 (Colorado River at Lees Ferry, AZ) and the flow difference between the 2 stations.

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	None	None	None	None	None
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	0	0	0	0	0
SOC TDS samples	0	0	0	0	0
Class by Year	**C**	**C**	**C**	**C**	**C (provisional)**
Classify Notes	No SC or QW	No SC or QW	No SC or QW	No SC or QW	No SC or QW

Operation is by USGS for daily Q.

#17 VIRGIN - STATION 09415000, Virgin River at Littlefield, AZ

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	3	5	4	4	2
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	None	None	None	None	None
ROE TDS samples	3	5	4	4	2
SOC TDS samples	3	5	4	4	2
Class by Year	**B**	**B**	**B**	**B**	**B (provisional)**
Classify Notes	No SC, TDS samples < 6	No SC, TDS samples < 6	No SC, TDS samples < 6	No SC, TDS samples < 6	No SC, TDS samples < 6

Operation is by USGS for daily Q and periodic QW.

#18 HOOVER – STATION 09421500, Colorado River below Hoover Dam, AZ-NV

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	17	17	17	23	17
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)
ROE TDS samples	17	17	17	23	17
SOC TDS samples	17	17	17	23	17
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Includes BOR data	Includes BOR data	Includes BOR data	Includes BOR data	Includes BOR data

Operation is by USGS for daily Q and periodic QW and by BOR for daily SC and periodic QW.

#19 PARKER - STATION 09427520, Colorado River below Parker Dam, AZ-CA

Daily SC data provided by BOR was available for the first time for the 2014 update.

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	31	24	25	25	16
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
ROE TDS samples	31	24	25	25	16
SOC TDS samples	31	24	25	25	16
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Includes BOR data	Includes BOR data	Includes BOR data	Includes BOR data	Includes BOR data

Operation is by USGS for daily Q and periodic QW and by BOR for daily SC and periodic QW.

#20 IMPER - STATION 09429490, Colorado River above Imperial Dam, AZ-CA

Water Year	2014	2015	2016	2017	2018 (thru 5-31)
QW Observations	25	25	27	25	18
Daily Q	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)	Yes (0 missing)
SC	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)	Daily (0 missing)
ROE TDS samples	25	25	27	25	18
SOC TDS samples	25	25	27	25	18
Class by Year	**A**	**A**	**A**	**A**	**A (provisional)**
Classify Notes	Includes BOR data	Includes BOR data	Includes BOR data	Includes BOR data	Includes BOR data

Operation is by USGS for daily Q and quarterly QW, and by BOR for daily SC and additional periodic QW.

References

Liebermann, T.D., Middelburg, R.F., Irvine, S.A. 1987. User's Manual for Estimation of Dissolved-Solids Concentrations and Loads in Surface Water. U.S. Geological Survey, Water Resources Investigations Report 86-4124.

APPENDIX C

REGRESSION STATISTICS FOR 2018 SLOAD

(Updates CY 2014-2017)

1. STATION 09217000 (GRWY) Green River near Green River, WY

STATION 09217000 Green River near Green River, UT UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	35	0.0	0.0
2	2015	35	0.0	0.0
3	2016	32	0.0	0.0
4	2017	25	0.0	0.0
5	2018	25	0.0	0.0

STATION 09217000 Green River near Green River, UT UPDATE 2016
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	35	0.90090	0.14178	0.82508	0.84031	32	0.99719	0.02524	-7.3900	1.00802	1.15650
2	Calcium	35	0.01188	0.14056	4.05750	-0.03030	32	0.81250	0.06397	-3.3654	0.12527	1.03953
3	Magnesium	35	0.15893	0.13013	3.56406	-0.11119	32	0.86438	0.05473	-3.4415	0.03336	0.98408
4	Chloride	35	0.27432	0.21962	3.28360	-0.26542	32	0.90875	0.08218	-8.7492	-0.02261	1.69758
5	Sulfate	35	0.36952	0.23855	6.93830	-0.35898	32	0.94495	0.07446	-6.4996	-0.08611	1.89369
6	Carbonate	35	0.04861	0.09520	4.80720	-0.04230	32	0.68098	0.05676	0.3084	0.05196	0.63002
7	Sodium +K	35	0.56417	0.17106	6.02711	-0.38257	32	0.89056	0.09099	-2.4195	-0.21831	1.20004

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	35	0.90090	0.14178	0.82508	0.84031	32	0.99719	0.02524	-7.3900	1.00802	1.15650
2	Calcium	35	0.01188	0.14056	4.05750	-0.03030	32	0.81250	0.06397	-3.3654	0.12527	1.03953
3	Magnesium	35	0.15893	0.13013	3.56406	-0.11119	32	0.86438	0.05473	-3.4415	0.03336	0.98408
4	Chloride	35	0.27432	0.21962	3.28360	-0.26542	32	0.90875	0.08218	-8.7492	-0.02261	1.69758
5	Sulfate	35	0.36952	0.23855	6.93830	-0.35898	32	0.94495	0.07446	-6.4996	-0.08611	1.89369
6	Carbonate	35	0.04861	0.09520	4.80720	-0.04230	32	0.68098	0.05676	0.3084	0.05196	0.63002
7	Sodium +K	35	0.56417	0.17106	6.02711	-0.38257	32	0.89056	0.09099	-2.4195	-0.21831	1.20004

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	35	0.90090	0.14178	0.82508	0.84031	32	0.99719	0.02524	-7.3900	1.00802	1.15650
2	Calcium	35	0.01188	0.14056	4.05750	-0.03030	32	0.81250	0.06397	-3.3654	0.12527	1.03953
3	Magnesium	35	0.15893	0.13013	3.56406	-0.11119	32	0.86438	0.05473	-3.4415	0.03336	0.98408
4	Chloride	35	0.27432	0.21962	3.28360	-0.26542	32	0.90875	0.08218	-8.7492	-0.02261	1.69758
5	Sulfate	35	0.36952	0.23855	6.93830	-0.35898	32	0.94495	0.07446	-6.4996	-0.08611	1.89369
6	Carbonate	35	0.04861	0.09520	4.80720	-0.04230	32	0.68098	0.05676	0.3084	0.05196	0.63002
7	Sodium +K	35	0.56417	0.17106	6.02711	-0.38257	32	0.89056	0.09099	-2.4195	-0.21831	1.20004

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	35	0.90090	0.14178	0.82508	0.84031	32	0.99719	0.02524	-7.3900	1.00802	1.15650
2	Calcium	35	0.01188	0.14056	4.05750	-0.03030	32	0.81250	0.06397	-3.3654	0.12527	1.03953
3	Magnesium	35	0.15893	0.13013	3.56406	-0.11119	32	0.86438	0.05473	-3.4415	0.03336	0.98408
4	Chloride	35	0.27432	0.21962	3.28360	-0.26542	32	0.90875	0.08218	-8.7492	-0.02261	1.69758
5	Sulfate	35	0.36952	0.23855	6.93830	-0.35898	32	0.94495	0.07446	-6.4996	-0.08611	1.89369
6	Carbonate	35	0.04861	0.09520	4.80720	-0.04230	32	0.68098	0.05676	0.3084	0.05196	0.63002
7	Sodium +K	35	0.56417	0.17106	6.02711	-0.38257	32	0.89056	0.09099	-2.4195	-0.21831	1.20004

2. STATION 09234500 (GDALE) Green River Near Greendale, UT

STATION 09234500 Green River near Greendale, Utah, UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	30	3.3	0.0
2	2015	30	3.3	0.0
3	2016	29	0.0	3.4
4	2017	24	0.0	8.3
5	2018	24	0.0	8.3

STATION 09234500 Green River near Greendale, Utah, UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	30	0.99018	0.064658	0.20349	0.97292	30	0.99877	0.023303	-7.17496	0.98936	1.13730
2	Calcium	29	0.06134	0.048313	4.17858	-0.01855	29	0.68401	0.028566	-0.55902	-0.00940	0.73201
3	Magnesium	29	0.04761	0.063466	3.18594	-0.02131	29	0.85953	0.024838	-3.86919	-0.00769	1.09010
4	Chloride	29	0.01756	0.083928	2.82191	-0.01685	29	0.69129	0.047943	-5.54597	-0.00069	1.29293
5	Sulfate	29	0.07058	0.097163	5.22697	-0.04021	29	0.82642	0.042790	-5.32248	-0.01984	1.63001
6	Carbonate	29	0.02324	0.047395	4.62311	-0.01098	29	0.41360	0.037422	1.01573	-0.00401	0.55738
7	Sodium +K	29	0.02965	0.088072	3.97000	-0.02312	29	0.82402	0.038221	-5.62409	-0.00460	1.48240

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	30	0.99018	0.064658	0.20349	0.97292	30	0.99877	0.023303	-7.17496	0.98936	1.13730
9	Calcium	29	0.06134	0.048313	4.17858	-0.01855	29	0.68401	0.028566	-0.55902	-0.00940	0.73201
10	Magnesium	29	0.04761	0.063466	3.18594	-0.02131	29	0.85953	0.024838	-3.86919	-0.00769	1.09010
11	Chloride	29	0.01756	0.083928	2.82191	-0.01685	29	0.69129	0.047943	-5.54597	-0.00069	1.29293
12	Sulfate	29	0.07058	0.097163	5.22697	-0.04021	29	0.82642	0.042790	-5.32248	-0.01984	1.63001
13	Carbonate	29	0.02324	0.047395	4.62311	-0.01098	29	0.41360	0.037422	1.01573	-0.00401	0.55738
14	Sodium +K	29	0.02965	0.088072	3.97000	-0.02312	29	0.82402	0.038221	-5.62409	-0.00460	1.48240

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	29	0.99286	0.062313	0.01999	0.99559	29	0.99920	0.021194	-7.38605	0.99302	1.16554
16	Calcium	29	0.01522	0.057132	4.10771	-0.00962	29	0.68006	0.033185	-1.81091	-0.01167	0.93145
17	Magnesium	29	0.00921	0.064697	3.08030	-0.00846	29	0.84737	0.025877	-4.42229	-0.01105	1.18074
18	Chloride	29	0.02768	0.087013	2.54816	0.01990	29	0.52236	0.062148	-5.27704	0.01719	1.23151
19	Sulfate	29	0.01676	0.088775	5.01253	-0.01571	29	0.74799	0.045800	-4.64007	-0.01905	1.51910
20	Carbonate	29	0.00386	0.050689	4.51167	0.00428	29	0.49448	0.036798	0.02646	0.00272	0.70587
21	Sodium +K	29	0.00955	0.082282	3.69880	0.01095	29	0.74866	0.042239	-5.26305	0.00785	1.41039

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	24	0.99446	0.054418	-0.09270	1.00783	24	0.99906	0.022951	-6.88120	0.99643	1.08195
23	Calcium	24	0.00764	0.058461	4.07951	-0.00709	24	0.70983	0.032356	-2.65332	-0.01841	1.07308
24	Magnesium	24	0.00184	0.057172	3.02102	-0.00339	24	0.69204	0.032504	-3.48792	-0.01433	1.03740
25	Chloride	24	0.13918	0.075054	2.37704	0.04173	24	0.29139	0.069699	-1.94390	0.03447	0.68867
26	Sulfate	24	0.00963	0.077769	4.76590	0.01060	24	0.69096	0.044465	-4.06551	-0.00424	1.40755
27	Carbonate	24	0.00606	0.048324	4.50891	0.00522	24	0.52166	0.034313	-0.25634	-0.00279	0.75949
28	Sodium +K	24	0.05773	0.068160	3.57438	0.02333	24	0.72543	0.037659	-4.28106	0.01013	1.25200

3. STATION 09251000 (YAMPA) Yampa River near Maybell, CO

STATION 09251000 Yampa River near Maybell, CO UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	17	0.0	0.0
2	2015	17	0.0	0.0
3	2016	17	0.0	0.0
4	2017	13	0.0	0.0
5	2018	13	0.0	0.0

STATION 09251000 Yampa River near Maybell, Colorado SLOAD UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	17	0.85273	0.42187	1.37608	0.72639	17	0.99968	0.02034	-7.31670	1.03431	1.11546
2	Calcium	17	0.41251	0.33686	4.88705	-0.20198	17	0.97837	0.06690	-1.93248	0.03959	0.87508
3	Magnesium	17	0.42777	0.47250	4.73184	-0.29231	17	0.99752	0.03217	-4.99353	0.05218	1.24796
4	Chloride	17	0.80048	0.41210	6.02110	-0.59064	17	0.98807	0.10429	-2.22162	-0.29866	1.05771
5	Sulfate	17	0.36958	0.61368	6.55477	-0.33621	17	0.99482	0.05758	-6.05186	0.11035	1.61768
6	Carbonate	17	0.61135	0.26535	5.75078	-0.23813	17	0.95759	0.09073	0.58459	-0.05513	0.66293
7	Sodium +K	17	0.55673	0.50200	5.94146	-0.40255	17	0.98767	0.08668	-4.26844	-0.04089	1.31014

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	17	0.85273	0.42187	1.37608	0.72639	17	0.99968	0.02034	-7.31670	1.03431	1.11546
9	Calcium	17	0.41251	0.33686	4.88705	-0.20198	17	0.97837	0.06690	-1.93248	0.03959	0.87508
10	Magnesium	17	0.42777	0.47250	4.73184	-0.29231	17	0.99752	0.03217	-4.99353	0.05218	1.24796
11	Chloride	17	0.80048	0.41210	6.02110	-0.59064	17	0.98807	0.10429	-2.22162	-0.29866	1.05771
12	Sulfate	17	0.36958	0.61368	6.55477	-0.33621	17	0.99482	0.05758	-6.05186	0.11035	1.61768
13	Carbonate	17	0.61135	0.26535	5.75078	-0.23813	17	0.95759	0.09073	0.58459	-0.05513	0.66293
14	Sodium +K	17	0.55673	0.50200	5.94146	-0.40255	17	0.98767	0.08668	-4.26844	-0.04089	1.31014

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	17	0.84367	0.46813	1.06824	0.76136	17	0.99933	0.03171	-7.37065	1.03861	1.11984
16	Calcium	17	0.30023	0.39026	4.67296	-0.17896	17	0.97793	0.07174	-2.26522	0.04898	0.92070
17	Magnesium	17	0.30912	0.53667	4.36523	-0.25132	17	0.99672	0.03825	-5.30711	0.06645	1.28352
18	Chloride	17	0.76663	0.42970	5.68518	-0.54525	17	0.97396	0.14858	-1.63172	-0.30487	0.97095
19	Sulfate	17	0.26556	0.67367	6.08786	-0.28360	17	0.99604	0.05120	-6.04966	0.11516	1.61065
20	Carbonate	17	0.47200	0.33123	5.57479	-0.21925	17	0.95707	0.09777	-0.16060	-0.03082	0.76109
21	Sodium +K	17	0.49964	0.50622	5.55388	-0.35415	17	0.97713	0.11203	-3.37982	-0.06065	1.18551

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	13	0.80513	0.53840	0.98834	0.77923	13	0.99923	0.03547	-7.40305	1.04143	1.12090
23	Calcium	13	0.23785	0.45014	4.67730	-0.17905	13	0.99322	0.04452	-2.32108	0.03962	0.93482
24	Magnesium	13	0.21118	0.61654	4.24058	-0.22715	13	0.99677	0.04137	-5.36805	0.07309	1.28350
25	Chloride	13	0.70144	0.47170	5.57539	-0.51481	13	0.97561	0.14141	-1.48367	-0.29424	0.94293
26	Sulfate	13	0.16614	0.76689	5.89070	-0.24374	13	0.99618	0.05447	-6.05811	0.12962	1.59609
27	Carbonate	13	0.39623	0.38476	5.59419	-0.22194	13	0.96934	0.09094	-0.25994	-0.03901	0.78198
28	Sodium +K	13	0.39126	0.56694	5.44019	-0.32364	13	0.98433	0.09540	-3.29891	-0.05057	1.16735

4. STATION 09302000 (DUCH) Duchesne River near Randlett, UT

STATION 09302000 Duchesne River near Randlett, UT UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	29	0.0	0.0
2	2015	29	0.0	0.0
3	2016	28	0.0	3.6
4	2017	24	0.0	8.3
5	2018	24	0.0	8.3

STATION 09302000 Duchesne River near Randlett, UT UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	29	0.81469	0.23702	2.90052	0.55003	29	0.99745	0.02832	-6.97198	1.00094	1.09254
2	Calcium	29	0.63885	0.21614	5.95152	-0.31816	29	0.93555	0.09305	-2.26506	0.05712	0.90929
3	Magnesium	29	0.70063	0.24891	5.90590	-0.42144	29	0.97145	0.07833	-4.02354	0.03207	1.09884
4	Chloride	29	0.79488	0.26114	6.51281	-0.56894	29	0.98576	0.07011	-4.05285	-0.08638	1.16925
5	Sulfate	29	0.72998	0.29603	8.35441	-0.53869	29	0.98923	0.06025	-3.81126	0.01695	1.34631
6	Carbonate	29	0.68453	0.18750	6.46326	-0.30568	29	0.85864	0.12790	0.62091	-0.03884	0.64654
7	Sodium +K	29	0.76079	0.27571	7.36594	-0.54418	29	0.97860	0.08404	-3.66811	-0.04022	1.22108

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-475square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	29	0.81469	0.23702	2.90052	0.55003	29	0.99745	0.02832	-6.97198	1.00094	1.09254
9	Calcium	29	0.63885	0.21614	5.95152	-0.31816	29	0.93555	0.09305	-2.26506	0.05712	0.90929
10	Magnesium	29	0.70063	0.24891	5.90590	-0.42144	29	0.97145	0.07833	-4.02354	0.03207	1.09884
11	Chloride	29	0.79488	0.26114	6.51281	-0.56894	29	0.98576	0.07011	-4.05285	-0.08638	1.16925
12	Sulfate	29	0.72998	0.29603	8.35441	-0.53869	29	0.98923	0.06025	-3.81126	0.01695	1.34631
13	Carbonate	29	0.68453	0.18750	6.46326	-0.30568	29	0.85864	0.12790	0.62091	-0.03884	0.64654
14	Sodium +K	29	0.76079	0.27571	7.36594	-0.54418	29	0.97860	0.08404	-3.66811	-0.04022	1.22108

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	28	0.82187	0.27984	3.00855	0.53212	28	0.99867	0.02463	-6.73161	0.98800	1.06784
16	Calcium	28	0.75666	0.22734	6.17051	-0.35489	28	0.96719	0.08513	-1.21714	-0.00911	0.80993
17	Magnesium	28	0.73849	0.30302	6.10026	-0.45078	28	0.98877	0.06403	-4.25649	0.03396	1.13544
18	Chloride	28	0.77913	0.34727	6.57448	-0.57740	28	0.98930	0.07796	-5.26047	-0.02348	1.29749
19	Sulfate	28	0.76838	0.35132	8.49674	-0.56647	28	0.99160	0.06824	-3.55252	-0.00251	1.32099
20	Carbonate	28	0.72679	0.22244	6.58681	-0.32117	28	0.91381	0.12741	0.15725	-0.02024	0.70489
21	Sodium +K	28	0.77990	0.33696	7.44641	-0.5152	28	0.98641	0.08539	-3.95676	-0.02781	1.25016

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	24	0.83670	0.27489	2.97979	0.53720	24	0.99852	0.02674	-6.77104	0.99290	1.06914
23	Calcium	24	0.75467	0.23175	6.16243	-0.35093	24	0.96378	0.09114	-1.46174	0.00538	0.83596
24	Magnesium	24	0.74571	0.30712	6.13155	-0.45406	24	0.99248	0.05405	-4.64900	0.04976	1.18204
25	Chloride	24	0.79262	0.34587	6.61876	-0.58377	24	0.98659	0.09001	-5.30058	-0.02673	1.30691
26	Sulfate	24	0.78484	0.33980	8.45260	-0.56029	24	0.99156	0.06890	-3.41565	-0.00564	1.30131
27	Carbonate	24	0.72321	0.23222	6.62162	-0.32407	24	0.93685	0.11353	-0.64803	0.01567	0.79709
28	Sodium +K	24	0.79653	0.32183	7.35984	-0.54975	24	0.98955	0.07466	-3.80947	-0.02776	1.22467

5. STATION 09306500 (WHITE) White River near Watson, UT

STATION 09306500 White River near Watson, UT SLOAD UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	28	0.0	0.0
2	2015	28	0.0	0.0
3	2016	27	0.0	3.7
4	2017	23	0.0	8.7
5	2018	23	0.0	8.7

STATION 09306500 White River near Watson, UT UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	28	0.90228	0.14533	2.13766	0.66872	27	0.99669	0.02779	-7.0458	1.00335	1.10589
2	Calcium	28	0.75153	0.08941	5.65867	-0.23548	27	0.89309	0.05997	1.4165	-0.07945	0.50901
3	Magnesium	28	0.65853	0.15291	5.10288	-0.32158	27	0.94086	0.06595	-3.8578	0.00438	1.07978
4	Chloride	28	0.69835	0.28045	6.35179	-0.64620	27	0.96506	0.09886	-10.6354	-0.02805	2.04670
5	Sulfate	28	0.72432	0.20790	8.14266	-0.51032	27	0.97044	0.07063	-4.5124	-0.05055	1.52569
6	Carbonate	28	0.49037	0.11376	5.68907	-0.16899	27	0.77478	0.07749	0.2521	0.03027	0.65326
7	Sodium +K	28	0.57320	0.28479	6.75812	-0.49978	27	0.92493	0.12382	-9.9025	0.10624	2.00767

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	28	0.90228	0.14533	2.13766	0.66872	27	0.99669	0.02779	-7.0458	1.00335	1.10589
9	Calcium	28	0.75153	0.08941	5.65867	-0.23548	27	0.89309	0.05997	1.4165	-0.07945	0.50901
10	Magnesium	28	0.65853	0.15291	5.10288	-0.32158	27	0.94086	0.06595	-3.8578	0.00438	1.07978
11	Chloride	28	0.69835	0.28045	6.35179	-0.64620	27	0.96506	0.09886	-10.6354	-0.02805	2.04670
12	Sulfate	28	0.72432	0.20790	8.14266	-0.51032	27	0.97044	0.07063	-4.5124	-0.05055	1.52569
13	Carbonate	28	0.49037	0.11376	5.68907	-0.16899	27	0.77478	0.07749	0.2521	0.03027	0.65326
14	Sodium +K	28	0.57320	0.28479	6.75812	-0.49978	27	0.92493	0.12382	-9.9025	0.10624	2.00767

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	27	0.86353	0.16621	2.01725	0.68819	26	0.99720	0.02477	-6.9735	1.00330	1.09451
16	Calcium	27	0.49404	0.11956	5.38730	-0.19447	26	0.83868	0.06868	0.0706	-0.00589	0.64449
17	Magnesium	27	0.60184	0.15702	5.10372	-0.31777	26	0.95237	0.05644	-2.9596	-0.03645	0.98318
18	Chloride	27	0.63930	0.29673	6.41028	-0.65027	26	0.97057	0.08800	-9.1560	-0.10661	1.89734
19	Sulfate	27	0.61620	0.23537	8.02120	-0.49091	26	0.97677	0.06015	-4.4644	-0.05506	1.52210
20	Carbonate	27	0.46345	0.10683	5.66378	-0.16343	26	0.91410	0.04382	0.3471	0.02411	0.64577
21	Sodium +K	27	0.48931	0.31919	6.85859	-0.51428	26	0.92634	0.12592	-9.3088	0.05053	1.97041

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	23	0.84572	0.17539	1.98308	0.69136	22	0.99836	0.01898	-7.0415	1.00083	1.10691
23	Calcium	23	0.50761	0.12519	5.50725	-0.21401	22	0.84884	0.07138	0.2034	-0.03046	0.64838
24	Magnesium	23	0.53565	0.16908	5.00413	-0.30574	22	0.93943	0.06398	-3.1762	-0.02603	1.00442
25	Chloride	23	0.57788	0.31728	6.26928	-0.62502	22	0.95913	0.10356	-9.3736	-0.09103	1.92186
26	Sulfate	23	0.57654	0.24954	7.99955	-0.49022	22	0.98463	0.04984	-4.7077	-0.05606	1.56069
27	Carbonate	23	0.43110	0.11006	5.63179	-0.16131	22	0.91910	0.04271	0.4329	0.01824	0.63603
28	Sodium +K	23	0.43115	0.33982	6.71504	-0.49810	22	0.93374	0.12144	-9.8517	0.06880	2.03356

6. STATION 09315000 (GRUT) Green River at Green River, UT

STATION 09315000 Green River at Green River, UT UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	24	0.0	0.0
2	2015	24	0.0	0.0
3	2016	25	0.0	0.0
4	2017	21	0.0	0.0
5	2018	21	0.0	0.0

STATION 09315000 Green River at Green River, UT UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	24	0.88040	0.17029	2.49107	0.71044	23	0.99459	0.03701	-7.16332	1.01700	1.09972
2	Calcium	24	0.39976	0.15623	5.63577	-0.19605	23	0.73748	0.10830	-1.23903	0.02356	0.78122
3	Magnesium	24	0.52757	0.18297	5.51944	-0.29732	23	0.68171	0.15743	-0.47315	-0.10796	0.68393
4	Chloride	24	0.64458	0.21950	6.67609	-0.45454	23	0.89073	0.12727	-4.06765	-0.11099	1.22038
5	Sulfate	24	0.46030	0.24465	7.90047	-0.34743	23	0.95573	0.07348	-5.68688	0.08405	1.54767
6	Carbonate	24	0.59646	0.12920	6.55446	-0.24153	23	0.77763	0.10053	1.59546	-0.08486	0.56601
7	Sodium +K	24	0.53315	0.21962	7.01035	-0.36089	23	0.92671	0.09125	-4.72585	0.01251	1.33580

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	24	0.88040	0.17029	2.49107	0.71044	23	0.99459	0.03701	-7.16332	1.01700	1.09972
9	Calcium	24	0.39976	0.15623	5.63577	-0.19605	23	0.73748	0.10830	-1.23903	0.02356	0.78122
10	Magnesium	24	0.52757	0.18297	5.51944	-0.29732	23	0.68171	0.15743	-0.47315	-0.10796	0.68393
11	Chloride	24	0.64458	0.21950	6.67609	-0.45454	23	0.89073	0.12727	-4.06765	-0.11099	1.22038
12	Sulfate	24	0.46030	0.24465	7.90047	-0.34743	23	0.95573	0.07348	-5.68688	0.08405	1.54767
13	Carbonate	24	0.59646	0.12920	6.55446	-0.24153	23	0.77763	0.10053	1.59546	-0.08486	0.56601
14	Sodium +K	24	0.53315	0.21962	7.01035	-0.36089	23	0.92671	0.09125	-4.72585	0.01251	1.33580

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	25	0.92225	0.15233	2.63180	0.69743	24	0.99563	0.03632	-6.92268	1.00217	1.08152
16	Calcium	25	0.58113	0.14133	5.88032	-0.22130	24	0.82227	0.09625	-1.08809	0.00155	0.78792
17	Magnesium	25	0.63523	0.16700	5.55110	-0.29297	24	0.83234	0.11842	-2.23782	-0.04572	0.88339
18	Chloride	25	0.76270	0.18982	6.71534	-0.45239	24	0.90481	0.12519	-2.88752	-0.14491	1.08526
19	Sulfate	25	0.61432	0.22183	8.13222	-0.37217	24	0.95796	0.07663	-5.43578	0.06142	1.53460
20	Carbonate	25	0.63767	0.12970	6.49703	-0.22873	24	0.81558	0.09677	0.74714	-0.04637	0.65237
21	Sodium +K	25	0.72973	0.17763	7.25591	-0.38800	24	0.94723	0.08199	-3.03354	-0.05961	1.16440

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	21	0.92797	0.14332	2.76927	0.68039	20	0.99637	0.03235	-6.96207	1.00146	1.08803
23	Calcium	21	0.74307	0.10380	5.97457	-0.23348	20	0.96629	0.03967	-0.82076	-0.00865	0.75885
24	Magnesium	21	0.68479	0.15577	5.65930	-0.30366	20	0.94822	0.06672	-4.17241	0.02016	1.10007
25	Chloride	21	0.84654	0.15595	7.02176	-0.48444	20	0.97587	0.06512	-2.76675	-0.16288	1.09646
26	Sulfate	21	0.70838	0.19134	8.29650	-0.39443	20	0.97938	0.05373	-4.62961	0.03299	1.44384
27	Carbonate	21	0.72634	0.10918	6.56929	-0.23527	20	0.95890	0.04472	-0.28214	-0.01040	0.76777
28	Sodium +K	21	0.78304	0.16850	7.54830	-0.42339	20	0.98309	0.04961	-3.74527	-0.05037	1.26210

7. STATION 09328500, San Rafael River near Green River, UT

STATION 09328500 San Rafael River near Green River, UT UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	25	0.0	0.0
2	2015	25	0.0	0.0
3	2016	25	0.0	0.0
4	2017	24	0.0	0.0
5	2018	24	0.0	0.0

STATION 09328500 San Rafael River near Green River, UT UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	25	0.92541	0.38508	2.24679	0.80043	25	0.99809	0.06305	-6.10748	1.00147	0.98963
2	Calcium	25	0.09693	0.61583	5.76349	-0.11907	25	0.79186	0.30230	-6.10993	0.16666	1.40650
3	Magnesium	25	0.49304	0.54755	5.61903	-0.31866	25	0.91221	0.23297	-5.32401	-0.05532	1.29629
4	Chloride	25	0.67221	0.61330	5.51777	-0.51829	25	0.87520	0.38693	-5.08979	-0.26303	1.25655
5	Sulfate	25	0.27213	0.65504	7.66644	-0.23636	25	0.95083	0.17408	-6.23569	0.09818	1.64682
6	Carbonate	25	0.60551	0.30918	5.69765	-0.22605	25	0.63539	0.30393	3.82757	-0.18105	0.22153
7	Sodium +K	25	0.64542	0.50688	6.72019	-0.40357	25	0.72190	0.45899	1.54608	-0.27906	0.61292

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	25	0.92541	0.38508	2.24679	0.80043	25	0.99809	0.06305	-6.10748	1.00147	0.98963
9	Calcium	25	0.09693	0.61583	5.76349	-0.11907	25	0.79186	0.30230	-6.10993	0.16666	1.40650
10	Magnesium	25	0.49304	0.54755	5.61903	-0.31866	25	0.91221	0.23297	-5.32401	-0.05532	1.29629
11	Chloride	25	0.67221	0.61330	5.51777	-0.51829	25	0.87520	0.38693	-5.08979	-0.26303	1.25655
12	Sulfate	25	0.27213	0.65504	7.66644	-0.23636	25	0.95083	0.17408	-6.23569	0.09818	1.64682
13	Carbonate	25	0.60551	0.30918	5.69765	-0.22605	25	0.63539	0.30393	3.82757	-0.18105	0.22153
14	Sodium +K	25	0.64542	0.50688	6.72019	-0.40357	25	0.72190	0.45899	1.54608	-0.27906	0.61292

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	25	0.88349	0.39621	2.44127	0.73747	25	0.99629	0.07234	-6.11360	0.98936	0.99364
16	Calcium	25	0.27684	0.56018	6.06789	-0.23428	25	0.82968	0.27797	-4.68019	0.08218	1.24838
17	Magnesium	25	0.42113	0.55419	5.69956	-0.31950	25	0.94386	0.17646	-5.85693	0.02076	1.34227
18	Chloride	25	0.60572	0.59096	5.53809	-0.49510	25	0.89484	0.31205	-5.56691	-0.16813	1.28983
19	Sulfate	25	0.37695	0.64616	7.97441	-0.33972	25	0.95739	0.17279	-5.71156	0.06324	1.58961
20	Carbonate	25	0.37107	0.30089	5.56643	-0.15622	25	0.50407	0.27319	2.53012	-0.06682	0.35266
21	Sodium +K	25	0.56505	0.49783	6.75699	-0.38354	25	0.77635	0.36500	-0.85740	-0.15934	0.88440

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	24	0.87423	0.41475	2.44757	0.73569	24	0.99583	0.07727	-6.18139	0.99152	1.00052
23	Calcium	24	0.25798	0.57560	6.03354	-0.22834	24	0.83425	0.27844	-4.69946	0.08986	1.24448
24	Magnesium	24	0.40962	0.57785	5.72538	-0.32383	24	0.94322	0.18342	-5.89853	0.02079	1.34778
25	Chloride	24	0.59585	0.60430	5.53344	-0.49366	24	0.88896	0.32420	-5.35572	-0.17083	1.26259
26	Sulfate	24	0.36682	0.66737	7.98007	-0.34175	24	0.95840	0.17508	-5.66907	0.06291	1.58261
27	Carbonate	24	0.36349	0.31211	5.58176	-0.15868	24	0.51235	0.27961	2.38809	-0.06400	0.37030
28	Sodium +K	24	0.56041	0.51317	6.79962	-0.38982	24	0.77916	0.37228	-0.85999	-0.16274	0.88813

8. STATION 09071750 (GLEN) Colorado River above Glenwood Springs CO

STATION 09071750 Colorado River above Glenwood Springs, CO UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	18	0.0	0.0
2	2015	18	0.0	0.0
3	2016	18	0.0	0.0
4	2017	15	0.0	0.0
5	2018	15	0.0	0.0

STATION 09071750 Colorado River above Glenwood Springs, CO UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	18	0.96621	0.08280	3.2838	0.53406	18	0.99852	0.017909	-8.9139	1.12854	1.23474
2	Calcium	18	0.90402	0.08135	6.0811	-0.30114	18	0.98700	0.030919	-5.3143	0.25423	1.15353
3	Magnesium	18	0.81070	0.12393	4.5599	-0.30934	18	0.93445	0.075320	-10.5353	0.42634	1.52804
4	Chloride	18	0.99143	0.07149	11.0997	-0.92732	18	0.99183	0.072079	8.7632	-0.81345	0.23651
5	Sulfate	18	0.88860	0.12155	7.2965	-0.41409	18	0.95977	0.075446	-7.3399	0.29924	1.48160
6	Carbonate	18	0.75446	0.09690	5.5320	-0.20487	18	0.89749	0.064661	-5.6094	0.33812	1.12781
7	Sodium +K	18	0.97775	0.09511	9.5529	-0.76049	18	0.98817	0.071625	-0.2532	-0.28257	0.99264

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	18	0.96621	0.08280	3.2838	0.53406	18	0.99852	0.017909	-8.9139	1.12854	1.23474
9	Calcium	18	0.90402	0.08135	6.0811	-0.30114	18	0.98700	0.030919	-5.3143	0.25423	1.15353
10	Magnesium	18	0.81070	0.12393	4.5599	-0.30934	18	0.93445	0.075320	-10.5353	0.42634	1.52804
11	Chloride	18	0.99143	0.07149	11.0997	-0.92732	18	0.99183	0.072079	8.7632	-0.81345	0.23651
12	Sulfate	18	0.88860	0.12155	7.2965	-0.41409	18	0.95977	0.075446	-7.3399	0.29924	1.48160
13	Carbonate	18	0.75446	0.09690	5.5320	-0.20487	18	0.89749	0.064661	-5.6094	0.33812	1.12781
14	Sodium +K	18	0.97775	0.09511	9.5529	-0.76049	18	0.98817	0.071625	-0.2532	-0.28257	0.99264

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	18	0.93959	0.07692	3.6830	0.48348	18	0.99635	0.019533	-8.0117	1.07975	1.14918
16	Calcium	18	0.88729	0.07757	6.4403	-0.34691	18	0.98639	0.027843	-4.9691	0.23481	1.12115
17	Magnesium	18	0.74397	0.12956	4.9015	-0.35200	18	0.89216	0.086842	-10.5591	0.43628	1.51924
18	Chloride	18	0.98982	0.05936	11.1722	-0.93274	18	0.99177	0.055112	7.0944	-0.72482	0.40071
19	Sulfate	18	0.90268	0.09783	7.7707	-0.47486	18	0.96094	0.064012	-4.1019	0.13047	1.16666
20	Carbonate	18	0.60204	0.10546	5.5681	-0.20674	18	0.79138	0.078861	-5.8417	0.37501	1.12119
21	Sodium +K	18	0.97164	0.08464	9.8038	-0.78962	18	0.98684	0.059544	0.0842	-0.29405	0.95510

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	15	0.94922	0.06192	4.0012	0.43935	15	0.99489	0.020436	-7.3846	1.04270	1.09275
23	Calcium	15	0.92937	0.06397	6.6836	-0.38084	15	0.98143	0.034145	-3.9651	0.18345	1.02200
24	Magnesium	15	0.84214	0.10612	5.2690	-0.40225	15	0.89672	0.089337	-6.8306	0.23892	1.16125
25	Chloride	15	0.98693	0.06457	11.0871	-0.92093	15	0.99346	0.047527	2.2345	-0.45182	0.84962
26	Sulfate	15	0.93998	0.07730	7.9485	-0.50208	15	0.96742	0.059280	-2.1864	0.03498	0.97269
27	Carbonate	15	0.71207	0.09778	5.8929	-0.25236	15	0.82077	0.080293	-5.7567	0.36496	1.11805
28	Sodium +K	15	0.98008	0.07165	10.0607	-0.82490	15	0.99164	0.048317	-0.5222	-0.26410	1.01568

9. STATION 09095500 (CAMEO) Colorado River near Cameo, CO

STATION 09095500 Colorado River near Cameo, CO UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	15	0.0	0.0
2	2015	15	0.0	0.0
3	2016	15	0.0	0.0
4	2017	12	0.0	0.0
5	2018	12	0.0	0.0

STATION 09095500 Colorado River near Cameo, CO UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	15	0.98321	0.04796	4.8284	0.41934	15	0.99582	0.024915	-6.77533	1.01938	1.02185
2	Calcium	15	0.98515	0.03718	6.8108	-0.34602	15	0.98992	0.031878	0.92564	-0.04169	0.51826
3	Magnesium	15	0.95500	0.08061	5.9643	-0.42432	15	0.95912	0.079973	-0.84497	-0.07220	0.59964
4	Chloride	15	0.98990	0.08458	12.3632	-0.95658	15	0.99245	0.076115	0.49550	-0.34288	1.04510
5	Sulfate	15	0.97630	0.07477	8.9056	-0.54831	15	0.98608	0.059644	-4.50532	0.14519	1.18100
6	Carbonate	15	0.90654	0.06871	6.2079	-0.24450	15	0.91927	0.066465	-0.87302	0.12166	0.62356
7	Sodium +K	15	0.99147	0.06852	11.1917	-0.84405	15	0.99358	0.061858	1.66845	-0.35159	0.83864

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	15	0.98321	0.04796	4.8284	0.41934	15	0.99582	0.024915	-6.77533	1.01938	1.02185
9	Calcium	15	0.98515	0.03718	6.8108	-0.34602	15	0.98992	0.031878	0.92564	-0.04169	0.51826
10	Magnesium	15	0.95500	0.08061	5.9643	-0.42432	15	0.95912	0.079973	-0.84497	-0.07220	0.59964
11	Chloride	15	0.98990	0.08458	12.3632	-0.95658	15	0.99245	0.076115	0.49550	-0.34288	1.04510
12	Sulfate	15	0.97630	0.07477	8.9056	-0.54831	15	0.98608	0.059644	-4.50532	0.14519	1.18100
13	Carbonate	15	0.90654	0.06871	6.2079	-0.24450	15	0.91927	0.066465	-0.87302	0.12166	0.62356
14	Sodium +K	15	0.99147	0.06852	11.1917	-0.84405	15	0.99358	0.061858	1.66845	-0.35159	0.83864

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	15	0.96647	0.06107	5.0376	0.39301	15	0.99495	0.024657	-7.01266	1.02792	1.04721
16	Calcium	15	0.96122	0.06029	6.9184	-0.35983	15	0.98990	0.032027	-4.18115	0.22499	0.96460
17	Magnesium	15	0.92825	0.09944	5.9960	-0.42875	15	0.94864	0.087570	-5.35175	0.16915	0.98617
18	Chloride	15	0.98932	0.08652	12.7047	-0.99814	15	0.99404	0.067258	0.38652	-0.34911	1.07050
19	Sulfate	15	0.97547	0.08087	9.3903	-0.61134	15	0.99266	0.046050	-5.10282	0.15228	1.25951
20	Carbonate	15	0.89566	0.07471	6.3491	-0.26239	15	0.90408	0.074558	1.80612	-0.02302	0.39480
21	Sodium +K	15	0.98716	0.08488	11.5802	-0.89199	15	0.99449	0.057876	-2.14909	-0.16862	1.19313

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	12	0.96973	0.05311	5.2695	0.36532	12	0.99825	0.013448	-6.18190	0.98064	0.97859
23	Calcium	12	0.95904	0.06415	7.0578	-0.37724	12	0.99171	0.030430	-5.66604	0.30645	1.08733
24	Magnesium	12	0.93054	0.10153	6.1774	-0.45162	12	0.95056	0.090289	-5.92914	0.19890	1.03458
25	Chloride	12	0.98764	0.09190	12.7249	-0.99833	12	0.99361	0.069668	-1.45822	-0.23623	1.21204
26	Sulfate	12	0.97421	0.08499	9.5702	-0.63476	12	0.99434	0.041969	-7.10768	0.26139	1.42523
27	Carbonate	12	0.90125	0.07480	6.4544	-0.27464	12	0.90402	0.077736	3.67201	-0.12513	0.23777
28	Sodium +K	12	0.98552	0.09119	11.7671	-0.91439	12	0.99359	0.063964	-3.35372	-0.10190	1.29217

10. STATION 09152500 (GUNN) Gunnison River near Grand Junction, CO

STATION 09152500 Gunnison River near Grand Junction, Co UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	28	0.0	0.0
2	2015	28	0.0	0.0
3	2016	28	0.0	0.0
4	2017	24	0.0	0.0
5	2018	24	0.0	0.0

STATION 09152500 Gunnison River near Grand Junction, Co UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	28	0.67698	0.19886	4.3309	0.46927	28	0.99771	0.017093	-7.15272	1.00997	1.11865
2	Calcium	28	0.63147	0.21774	7.9778	-0.46460	28	0.97412	0.058849	-4.18991	0.10831	1.18528
3	Magnesium	28	0.79174	0.18481	7.7070	-0.58739	28	0.97803	0.061220	-2.42285	-0.11043	0.98678
4	Chloride	28	0.87980	0.13701	6.4062	-0.60421	28	0.96444	0.075991	-0.25684	-0.29048	0.64906
5	Sulfate	28	0.72953	0.24647	10.5021	-0.65981	28	0.99022	0.047796	-3.52092	0.00047	1.36602
6	Carbonate	28	0.68153	0.13482	6.8332	-0.32148	28	0.94394	0.057684	-0.25888	0.01245	0.69086
7	Sodium +K	28	0.82942	0.17990	8.6674	-0.64663	28	0.97155	0.074920	-0.84948	-0.19853	0.92707

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	28	0.67698	0.19886	4.3309	0.46927	28	0.99771	0.017093	-7.15272	1.00997	1.11865
9	Calcium	28	0.63147	0.21774	7.9778	-0.46460	28	0.97412	0.058849	-4.18991	0.10831	1.18528
10	Magnesium	28	0.79174	0.18481	7.7070	-0.58739	28	0.97803	0.061220	-2.42285	-0.11043	0.98678
11	Chloride	28	0.87980	0.13701	6.4062	-0.60421	28	0.96444	0.075991	-0.25684	-0.29048	0.64906
12	Sulfate	28	0.72953	0.24647	10.5021	-0.65981	28	0.99022	0.047796	-3.52092	0.00047	1.36602
13	Carbonate	28	0.68153	0.13482	6.8332	-0.32148	28	0.94394	0.057684	-0.25888	0.01245	0.69086
14	Sodium +K	28	0.82942	0.17990	8.6674	-0.64663	28	0.97155	0.074920	-0.84948	-0.19853	0.92707

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	28	0.55832	0.18531	4.8643	0.39584	28	0.99464	0.020822	-7.12029	1.00569	1.11826
16	Calcium	28	0.67112	0.19598	8.4667	-0.53191	28	0.96670	0.063598	-3.62294	0.08328	1.12806
17	Magnesium	28	0.79352	0.17720	8.2426	-0.65999	28	0.96854	0.070538	-2.37277	-0.11981	0.99050
18	Chloride	28	0.90834	0.10998	6.7802	-0.65777	28	0.95639	0.077364	1.59921	-0.39413	0.48343
19	Sulfate	28	0.74549	0.23371	11.2309	-0.75995	28	0.99360	0.037780	-3.78410	0.00410	1.40102
20	Carbonate	28	0.68138	0.12262	6.9670	-0.34068	28	0.94037	0.054096	-0.22645	0.02536	0.67121
21	Sodium +K	28	0.83930	0.16763	9.2615	-0.72783	28	0.96683	0.077668	-0.45503	-0.23340	0.90663

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	24	0.50964	0.19216	4.7412	0.40994	24	0.99423	0.021341	-7.27348	1.01409	1.13108
23	Calcium	24	0.55957	0.21527	8.2614	-0.50774	24	0.96373	0.063224	-4.70846	0.14444	1.22100
24	Magnesium	24	0.75095	0.17735	8.1175	-0.64441	24	0.96727	0.065804	-2.27803	-0.12168	0.97866
25	Chloride	24	0.90406	0.10701	7.0017	-0.68735	24	0.94679	0.081566	2.51011	-0.46149	0.42285
26	Sulfate	24	0.67770	0.23943	10.9607	-0.72650	24	0.99259	0.037150	-3.92420	0.02197	1.40129
27	Carbonate	24	0.66779	0.11767	7.0120	-0.34911	24	0.94405	0.049426	0.26293	-0.00973	0.63537
28	Sodium +K	24	0.78801	0.17695	9.1460	-0.71387	24	0.95943	0.079232	-0.86149	-0.21065	0.94213

11. STATION 09180000 (DOLOR) Dolores River near Cisco, UT

STATION 09180000 Dolores River near Cisco, UT UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	25	0.0	0.0
2	2015	25	0.0	0.0
3	2016	25	0.0	0.0
4	2017	22	0.0	0.0
5	2018	22	0.0	0.0

STATION 09180000 Dolores River near Cisco, UT SLOAD UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	25	0.58485	0.28502	3.9499	0.38360	25	0.97891	0.06569	-6.16375	0.98079	0.98199
2	Calcium	25	0.62006	0.28358	6.7597	-0.41078	25	0.69767	0.25864	2.09159	-0.13515	0.45325
3	Magnesium	25	0.80454	0.23083	6.1363	-0.53104	25	0.92941	0.14183	-0.58370	-0.13424	0.65248
4	Chloride	25	0.67148	0.62642	10.1741	-1.01551	25	0.79376	0.50749	-3.74516	-0.19362	1.35150
5	Sulfate	25	0.68750	0.39872	9.0510	-0.67061	25	0.75873	0.35822	2.11774	-0.26122	0.67318
6	Carbonate	25	0.61003	0.14636	5.5333	-0.20757	25	0.73765	0.12274	2.48401	-0.02751	0.29607
7	Sodium +K	25	0.72343	0.46249	9.1490	-0.84818	25	0.91417	0.26343	-4.83988	-0.02218	1.35825

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	25	0.58485	0.28502	3.9499	0.38360	25	0.97891	0.06569	-6.16375	0.98079	0.98199
9	Calcium	25	0.62006	0.28358	6.7597	-0.41078	25	0.69767	0.25864	2.09159	-0.13515	0.45325
10	Magnesium	25	0.80454	0.23083	6.1363	-0.53104	25	0.92941	0.14183	-0.58370	-0.13424	0.65248
11	Chloride	25	0.67148	0.62642	10.1741	-1.01551	25	0.79376	0.50749	-3.74516	-0.19362	1.35150
12	Sulfate	25	0.68750	0.39872	9.0510	-0.67061	25	0.75873	0.35822	2.11774	-0.26122	0.67318
13	Carbonate	25	0.61003	0.14636	5.5333	-0.20757	25	0.73765	0.12274	2.48401	-0.02751	0.29607
14	Sodium +K	25	0.72343	0.46249	9.1490	-0.84818	25	0.91417	0.26343	-4.83988	-0.02218	1.35825

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	25	0.71169	0.30176	3.7347	0.42929	25	0.99091	0.05479	-5.82893	0.96337	0.94392
16	Calcium	25	0.72162	0.22850	6.2737	-0.33311	25	0.78967	0.20308	2.63541	-0.12993	0.35909
17	Magnesium	25	0.88089	0.20150	5.9527	-0.49615	25	0.95579	0.12551	0.80691	-0.20879	0.50788
18	Chloride	25	0.79572	0.59125	10.6708	-1.05659	25	0.94286	0.31972	-5.48929	-0.15413	1.59498
19	Sulfate	25	0.80320	0.31257	8.3996	-0.57177	25	0.84703	0.28177	3.64897	-0.30647	0.46888
20	Carbonate	25	0.71084	0.12878	5.4178	-0.18283	25	0.87835	0.08541	2.26128	-0.00655	0.31155
21	Sodium +K	25	0.79458	0.48719	9.4332	-0.86759	25	0.96418	0.20801	-4.82308	-0.07145	1.40707

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	22	0.68665	0.30081	4.1537	0.37361	22	0.98764	0.06128	-5.63725	0.95617	0.92081
23	Calcium	22	0.71809	0.24241	6.2289	-0.32462	22	0.76277	0.22815	3.02410	-0.13393	0.30141
24	Magnesium	22	0.90050	0.20100	6.0412	-0.50733	22	0.96068	0.12963	0.84978	-0.19845	0.48823
25	Chloride	22	0.86646	0.54690	11.5199	-1.16882	22	0.95868	0.31210	-3.57382	-0.27074	1.41952
26	Sulfate	22	0.79663	0.33366	8.2722	-0.55408	22	0.82184	0.32041	4.37062	-0.32194	0.36694
27	Carbonate	22	0.74262	0.13095	5.4509	-0.18663	22	0.88975	0.08793	2.16290	0.00901	0.30923
28	Sodium +K	22	0.86056	0.46839	10.2464	-0.97629	22	0.97380	0.20831	-3.77153	-0.14222	1.31834

12. STATION 09180500 (CISCO) Colorado River near Cisco, UT

STATION 09180500 Colorado River near Cisco, UT UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	24	0.0	0.0
2	2015	24	0.0	0.0
3	2016	23	0.0	0.0
4	2017	19	0.0	0.0
5	2018	19	0.0	0.0

STATION 09180500 Colorado River near Cisco, UT UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	24	0.68705	0.18507	5.5049	0.40612	24	0.98739	0.03802	-6.57190	0.99693	1.03232
2	Calcium	24	0.61579	0.22870	8.0742	-0.42881	24	0.89734	0.12100	-4.96670	0.20917	1.11473
3	Magnesium	24	0.85032	0.15880	7.9364	-0.56056	24	0.97481	0.06668	-1.71022	-0.08863	0.82460
4	Chloride	24	0.94077	0.16459	12.6204	-0.97152	24	0.96992	0.12005	4.92878	-0.59524	0.65748
5	Sulfate	24	0.69649	0.28755	10.8582	-0.64514	24	0.96042	0.10629	-7.00314	0.22866	1.52679
6	Carbonate	24	0.85367	0.08418	6.9900	-0.30115	24	0.93552	0.05720	2.79602	-0.09597	0.35850
7	Sodium +K	24	0.92240	0.16516	11.5847	-0.84334	24	0.98193	0.08158	1.94865	-0.37194	0.82369

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	24	0.68705	0.18507	5.5049	0.40612	24	0.98739	0.03802	-6.57190	0.99693	1.03232
9	Calcium	24	0.61579	0.22870	8.0742	-0.42881	24	0.89734	0.12100	-4.96670	0.20917	1.11473
10	Magnesium	24	0.85032	0.15880	7.9364	-0.56056	24	0.97481	0.06668	-1.71022	-0.08863	0.82460
11	Chloride	24	0.94077	0.16459	12.6204	-0.97152	24	0.96992	0.12005	4.92878	-0.59524	0.65748
12	Sulfate	24	0.69649	0.28755	10.8582	-0.64514	24	0.96042	0.10629	-7.00314	0.22866	1.52679
13	Carbonate	24	0.85367	0.08418	6.9900	-0.30115	24	0.93552	0.05720	2.79602	-0.09597	0.35850
14	Sodium +K	24	0.92240	0.16516	11.5847	-0.84334	24	0.98193	0.08158	1.94865	-0.37194	0.82369

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	23	0.71616	0.14398	5.6890	0.38309	23	0.98645	0.03224	-6.08856	0.97264	0.99073
16	Calcium	23	0.65063	0.18984	8.1073	-0.43394	23	0.85491	0.12536	-4.06069	0.17515	1.02357
17	Magnesium	23	0.85718	0.13939	8.0418	-0.57201	23	0.97245	0.06274	-2.45522	-0.04656	0.88301
18	Chloride	23	0.92148	0.17603	12.9555	-1.01013	23	0.94982	0.14420	4.09147	-0.56642	0.74564
19	Sulfate	23	0.76301	0.22847	11.1743	-0.68666	23	0.94324	0.11457	-5.52656	0.14933	1.40488
20	Carbonate	23	0.81487	0.08079	6.8475	-0.28390	23	0.91636	0.05564	1.83355	-0.03292	0.42177
21	Sodium +K	23	0.92829	0.14458	11.8147	-0.87132	23	0.97683	0.08421	1.84386	-0.37221	0.83875

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	19	0.68998	0.14016	5.8043	0.36825	19	0.98313	0.03370	-6.57242	1.00055	1.02639
23	Calcium	19	0.63675	0.19043	8.1790	-0.44402	19	0.86784	0.11840	-5.61361	0.26062	1.14382
24	Magnesium	19	0.84245	0.14109	8.0606	-0.57458	19	0.96472	0.06882	-3.22640	0.00205	0.93602
25	Chloride	19	0.92555	0.16969	13.3252	-1.05366	19	0.94793	0.14628	4.87715	-0.62207	0.70059
26	Sulfate	19	0.75390	0.22865	11.3105	-0.70480	19	0.93282	0.12314	-6.39390	0.19969	1.46821
27	Carbonate	19	0.82730	0.07068	6.7414	-0.27242	19	0.90793	0.05319	2.35588	-0.04837	0.36369
28	Sodium +K	19	0.93178	0.13677	11.9498	-0.89017	19	0.97497	0.08540	2.06745	-0.38530	0.81953

13. STATION 09355500 (ARCH) San Juan River near Archuleta, NM

STATION 09355500 San Juan River near Archuleta, NM UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	9	0.0	0.0
2	2015	9	0.0	0.0
3	2016	9	0.0	0.0
4	2017	7	0.0	0.0
5	2018	7	0.0	0.0

STATION 09355500 San Juan River near Archuleta, NM UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	9	0.99624	0.05132	-0.46214	0.93899	9	0.99843	0.035811	-4.24506	0.97495	0.64132
2	Calcium	9	0.39386	0.05779	3.74939	-0.05235	9	0.57841	0.052058	0.67043	-0.02308	0.52198
3	Magnesium	9	0.28778	0.05564	1.91482	-0.03974	9	0.75329	0.035368	-2.42813	0.00155	0.73626
4	Chloride	9	0.40990	0.05669	1.43173	-0.05309	9	0.62429	0.048860	-1.86764	-0.02173	0.55934
5	Sulfate	9	0.61285	0.10115	4.64336	-0.14301	9	0.87514	0.062046	-3.39545	-0.06659	1.36282
6	Carbonate	9	0.41615	0.02567	4.07913	-0.02435	9	0.77732	0.017123	2.12974	-0.00582	0.33048
7	Sodium +K	9	0.46817	0.06541	3.22279	-0.06897	9	0.67777	0.054996	-0.74219	-0.03127	0.67218

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	9	0.99624	0.05132	-0.46214	0.93899	9	0.99843	0.035811	-4.24506	0.97495	0.64132
9	Calcium	9	0.39386	0.05779	3.74939	-0.05235	9	0.57841	0.052058	0.67043	-0.02308	0.52198
10	Magnesium	9	0.28778	0.05564	1.91482	-0.03974	9	0.75329	0.035368	-2.42813	0.00155	0.73626
11	Chloride	9	0.40990	0.05669	1.43173	-0.05309	9	0.62429	0.048860	-1.86764	-0.02173	0.55934
12	Sulfate	9	0.61285	0.10115	4.64336	-0.14301	9	0.87514	0.062046	-3.39545	-0.06659	1.36282
13	Carbonate	9	0.41615	0.02567	4.07913	-0.02435	9	0.77732	0.017123	2.12974	-0.00582	0.33048
14	Sodium +K	9	0.46817	0.06541	3.22279	-0.06897	9	0.67777	0.054996	-0.74219	-0.03127	0.67218

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	9	0.99796	0.04821	-0.67581	0.96698	9	0.99877	0.040493	-4.08376	0.97662	0.60738
16	Calcium	9	0.24440	0.05620	3.56649	-0.02895	9	0.35464	0.056105	1.15325	-0.02212	0.43010
17	Magnesium	9	0.11293	0.03985	1.71276	-0.01288	9	0.50978	0.032002	-1.28382	-0.00440	0.53406
18	Chloride	9	0.16847	0.05892	1.21792	-0.02402	9	0.44001	0.052226	-2.56697	-0.01331	0.67456
19	Sulfate	9	0.51734	0.08473	4.18718	-0.07945	9	0.80295	0.058478	-3.13987	-0.05872	1.30585
20	Carbonate	9	0.19843	0.03061	3.98509	-0.01379	9	0.36031	0.029535	2.43876	-0.00942	0.27559
21	Sodium +K	9	0.20261	0.07757	2.95443	-0.03541	9	0.36470	0.074785	-0.97688	-0.02429	0.70065

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	7	0.99943	0.02981	-0.79674	0.98168	7	0.99956	0.029222	-2.82892	0.98086	0.37162
23	Calcium	7	0.29237	0.03970	3.49795	-0.02000	7	0.40246	0.040783	1.27980	-0.02089	0.40563
24	Magnesium	7	0.08332	0.04144	1.68964	-0.00979	7	0.46672	0.035337	5.48628	-0.00827	-0.69428
25	Chloride	7	0.07429	0.03084	1.07663	-0.00685	7	0.19395	0.032171	-0.49407	-0.00748	0.28723
26	Sulfate	7	0.67998	0.04979	4.00555	-0.05688	7	0.72100	0.051973	1.48028	-0.05789	0.46179
27	Carbonate	7	0.00227	0.03273	3.87901	-0.00122	7	0.42836	0.027697	0.84901	-0.00243	0.55409
28	Sodium +K	7	0.17632	0.04364	2.78754	-0.01583	7	0.17817	0.048739	2.49452	-0.01594	0.05358

14. STATION 09379500 (BLUFF) San Juan River near Bluff, UT

STATION 09379500 San Juan River near Bluff, UT UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	26	0.0	0.0
2	2015	26	0.0	0.0
3	2016	27	0.0	0.0
4	2017	23	0.0	0.0
5	2018	23	0.0	0.0

STATION 09379500 San Juan River near Bluff, UT UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	26	0.80010	0.28282	2.16184	0.70799	26	0.99808	0.02833	-6.81560	0.99617	1.07551
2	Calcium	26	0.55246	0.21098	6.28568	-0.29331	26	0.84598	0.12643	0.83576	-0.11837	0.65291
3	Magnesium	26	0.48126	0.31817	5.30336	-0.38348	26	0.66258	0.26213	-0.69677	-0.19087	0.71882
4	Chloride	26	0.67240	0.26403	5.93997	-0.47332	26	0.92585	0.12832	-1.46766	-0.23553	0.88744
5	Sulfate	26	0.38075	0.38281	7.82374	-0.37560	26	0.98857	0.05313	-4.27347	0.01272	1.44926
6	Carbonate	26	0.63076	0.11551	5.63335	-0.18892	26	0.84534	0.07637	2.82449	-0.09875	0.33650
7	Sodium +K	26	0.16290	0.46466	5.73349	-0.25649	26	0.86894	0.18781	-7.87799	0.18044	1.63067

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	26	0.80010	0.28282	2.16184	0.70799	26	0.99808	0.02833	-6.81560	0.99617	1.07551
9	Calcium	26	0.55246	0.21098	6.28568	-0.29331	26	0.84598	0.12643	0.83576	-0.11837	0.65291
10	Magnesium	26	0.48126	0.31817	5.30336	-0.38348	26	0.66258	0.26213	-0.69677	-0.19087	0.71882
11	Chloride	26	0.67240	0.26403	5.93997	-0.47332	26	0.92585	0.12832	-1.46766	-0.23553	0.88744
12	Sulfate	26	0.38075	0.38281	7.82374	-0.37560	26	0.98857	0.05313	-4.27347	0.01272	1.44926
13	Carbonate	26	0.63076	0.11551	5.63335	-0.18892	26	0.84534	0.07637	2.82449	-0.09875	0.33650
14	Sodium +K	26	0.16290	0.46466	5.73349	-0.25649	26	0.86894	0.18781	-7.87799	0.18044	1.63067

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	27	0.84051	0.23374	2.73349	0.62446	27	0.99686	0.03348	-6.82577	0.99994	1.07284
16	Calcium	27	0.70539	0.18177	6.52981	-0.32733	27	0.90899	0.10311	0.28829	-0.08216	0.70049
17	Magnesium	27	0.63599	0.27699	5.67834	-0.42609	27	0.84413	0.18499	-2.97301	-0.08627	0.97095
18	Chloride	27	0.74888	0.27823	6.55334	-0.55916	27	0.97625	0.08732	-4.38233	-0.12961	1.22732
19	Sulfate	27	0.64546	0.31550	8.64443	-0.49542	27	0.98357	0.06931	-4.08203	0.00447	1.42830
20	Carbonate	27	0.73415	0.10305	5.70979	-0.19930	27	0.88910	0.06793	2.46010	-0.07165	0.36471
21	Sodium +K	27	0.46081	0.40859	6.96097	-0.43960	27	0.88251	0.19467	-7.96461	0.14667	1.67511

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	23	0.83291	0.25456	2.62432	0.63840	23	0.99741	0.03247	-6.75977	0.99997	1.06124
23	Calcium	23	0.64221	0.20322	6.37168	-0.30582	23	0.89650	0.11200	0.00655	-0.06058	0.71982
24	Magnesium	23	0.68576	0.26552	5.82133	-0.44058	23	0.89288	0.15885	-2.18741	-0.13201	0.90570
25	Chloride	23	0.71574	0.30256	6.40282	-0.53928	23	0.97440	0.09303	-4.32005	-0.12614	1.21264
26	Sulfate	23	0.62060	0.33871	8.56989	-0.48659	23	0.98691	0.06446	-3.79527	-0.01017	1.39836
27	Carbonate	23	0.69223	0.11011	5.60705	-0.18548	23	0.89128	0.06706	2.31721	-0.05873	0.37204
28	Sodium +K	23	0.44253	0.43121	6.85994	-0.43155	23	0.91321	0.17434	-7.86113	0.13564	1.66479

15. STATION 09380000 (LEES) Colorado River at Lees Ferry, AZ

STATION 09380000 Colorado River at Lees Ferry, AZ UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	41	0.0	0.0
2	2015	41	0.0	0.0
3	2016	42	0.0	0.0
4	2017	38	0.0	0.0
5	2018	38	0.0	0.0

STATION 09380000 Colorado River at Lees Ferry, AZ UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	41	0.89736	0.08081	1.17122	0.90843	41	0.99281	0.021666	-6.72912	0.99474	1.06181
2	Calcium	41	0.03466	0.07740	4.77924	-0.05576	41	0.66392	0.046267	-1.55574	0.01345	0.85142
3	Magnesium	41	0.06902	0.07792	3.84824	-0.08066	41	0.80320	0.036292	-3.16611	-0.00403	0.94273
4	Chloride	41	0.10185	0.11739	5.36242	-0.15028	41	0.90698	0.038273	-5.90479	-0.02720	1.51431
5	Sulfate	41	0.06594	0.09521	6.19750	-0.09617	41	0.91652	0.028835	-3.01242	0.00444	1.23781
6	Carbonate	41	0.10476	0.05282	5.07686	-0.06870	41	0.80194	0.025170	0.35148	-0.01707	0.63509
7	Sodium +K	41	0.09085	0.08911	5.26518	-0.10709	41	0.84144	0.037699	-2.94235	-0.01743	1.10309

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	41	0.89736	0.08081	1.17122	0.90843	41	0.99281	0.021666	-6.72912	0.99474	1.06181
9	Calcium	41	0.03466	0.07740	4.77924	-0.05576	41	0.66392	0.046267	-1.55574	0.01345	0.85142
10	Magnesium	41	0.06902	0.07792	3.84824	-0.08066	41	0.80320	0.036292	-3.16611	-0.00403	0.94273
11	Chloride	41	0.10185	0.11739	5.36242	-0.15028	41	0.90698	0.038273	-5.90479	-0.02720	1.51431
12	Sulfate	41	0.06594	0.09521	6.19750	-0.09617	41	0.91652	0.028835	-3.01242	0.00444	1.23781
13	Carbonate	41	0.10476	0.05282	5.07686	-0.06870	41	0.80194	0.025170	0.35148	-0.01707	0.63509
14	Sodium +K	41	0.09085	0.08911	5.26518	-0.10709	41	0.84144	0.037699	-2.94235	-0.01743	1.10309

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	42	0.94726	0.07053	0.12975	1.01396	42	0.99537	0.021159	-6.68346	1.00664	1.03756
16	Calcium	42	0.00843	0.07343	4.00802	0.02297	42	0.58183	0.048292	-1.63931	0.01689	0.86001
17	Magnesium	42	0.01214	0.05910	2.82473	0.02223	42	0.76933	0.028922	-2.40827	0.01660	0.79691
18	Chloride	42	0.00006	0.10550	3.86936	0.00286	42	0.90011	0.033767	-6.25336	-0.00802	1.54155
19	Sulfate	42	0.00833	0.08157	4.99100	0.02536	42	0.88698	0.027889	-2.77497	0.01701	1.18265
20	Carbonate	42	0.00739	0.04599	4.53259	-0.01346	42	0.73618	0.024010	0.54732	-0.01775	0.60690
21	Sodium +K	42	0.00463	0.08345	4.01370	0.01930	42	0.76840	0.040766	-3.37954	0.01135	1.12589

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	38	0.93354	0.06654	0.22699	1.00130	38	0.99520	0.018139	-6.72039	1.02390	1.01882
23	Calcium	38	0.01091	0.07145	3.92282	0.03013	38	0.69922	0.039960	-2.53830	0.05115	0.94751
24	Magnesium	38	0.01095	0.06480	2.76829	0.02738	38	0.54125	0.044761	-2.37564	0.04411	0.75435
25	Chloride	38	0.00184	0.10717	4.03864	-0.01846	38	0.91611	0.031510	-7.08020	0.01770	1.63055
26	Sulfate	38	0.00009	0.07409	5.22310	-0.00281	38	0.88738	0.025218	-2.34294	0.02180	1.10954
27	Carbonate	38	0.01289	0.04426	4.60041	-0.02030	38	0.70355	0.024597	0.58748	-0.00725	0.58849
28	Sodium +K	38	0.00192	0.07873	4.03302	0.01387	38	0.75776	0.039338	-3.39405	0.03803	1.08916

16. STATION 09402500 (GRCAN) Colorado River Near Grand Canyon, AZ - NO REGRESSION STATS

No QW since late 1980's. Alternate method from Mueller calculates GRCAN load from Lees Ferry load and the flow difference between GRCAN and LEES. See no.15 STATION 09380000 (LEES) Colorado River at Lees Ferry, AZ

COLORADO RIVER NEAR GRAND CANYON-09402500- MONTHLY Q, LOAD, TDS DATA, JAN 2015-DECEMBER 2017

Obs	YEAR	MONTH	WMONTH	GCQ	GCLOAD	MTDS
1	2013	10	Oct	502,480	386,263	565
2	2013	11	Nov	722,946	544,575	554
3	2013	12	Dec	620,002	466,342	553
4	2014	1	Jan	833,863	624,369	551
5	2014	2	Feb	636,307	523,094	605
6	2014	3	Mar	541,119	475,771	647
7	2014	4	Apr	534,573	476,634	656
8	2014	5	May	525,508	457,743	641
9	2014	6	Jun	634,938	527,075	611
10	2014	7	Jul	843,583	669,007	583
11	2014	8	Aug	859,054	677,217	580
12	2014	9	Sep	658,105	519,886	581
13	2014	10	Oct	655,130	504,499	566
14	2014	11	Nov	804,329	617,166	564
15	2014	12	Dec	911,736	645,751	521
16	2015	1	Jan	908,641	606,866	491
17	2015	2	Feb	634,958	482,340	559
18	2015	3	Mar	696,982	556,110	587
19	2015	4	Apr	635,394	509,283	589
20	2015	5	May	737,069	544,454	543
21	2015	6	Jun	826,921	588,320	523
22	2015	7	Jul	1,109,372	751,896	498
23	2015	8	Aug	858,260	598,218	513
24	2015	9	Sep	758,292	533,128	517
25	2015	10	Oct	664,770	469,112	519

26	2015	11	Nov	605,106	431,602	525
27	2015	12	Dec	885,831	582,017	483
28	2016	1	Jan	901,302	580,623	474
29	2016	2	Feb	745,598	528,132	521
30	2016	3	Mar	743,416	569,566	563
31	2016	4	Apr	712,870	564,111	582
32	2016	5	May	741,631	561,109	556
33	2016	6	Jun	835,450	599,846	528
34	2016	7	Jul	988,973	690,004	513
35	2016	8	Aug	956,047	668,179	514
36	2016	9	Sep	742,821	527,732	523
37	2016	10	Oct	638,846	460,327	530
38	2016	11	Nov	782,292	558,465	525
39	2016	12	Dec	949,382	608,553	471
40	2017	1	Jan	945,138	612,042	476
41	2017	2	Feb	782,689	554,330	521
42	2017	3	Mar	793,598	598,246	554
43	2017	4	Apr	669,392	516,334	567
44	2017	5	May	687,560	509,836	545
45	2017	6	Jun	787,053	562,736	526
46	2017	7	Jul	907,055	630,033	511
47	2017	8	Aug	969,733	669,039	507
48	2017	9	Sep	695,514	490,965	519
49	2017	10	Oct	659,772	464,526	518
50	2017	11	Nov	643,507	447,247	511
51	2017	12	Dec	759,482	498,523	483

17. STATION 09415000 (VIRGIN) Virgin River at Littlefield, AZ

STATION 09415000 Virgin River at Littlefield, AZ UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	12	0.0	0.0
2	2015	12	0.0	0.0
3	2016	13	0.0	0.0
4	2017	10	0.0	0.0
5	2018	10	0.0	0.0

STATION 09415000 Virgin River at Littlefield, AZ UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	12	0.92015	0.09488	2.91801	0.75637	8	0.99397	0.025760	-5.51678	0.97353	0.91872
2	Calcium	12	0.69367	0.09301	7.26140	-0.32870	8	0.98680	0.023072	-1.15531	-0.11324	0.91864
3	Magnesium	12	0.79976	0.07262	6.11737	-0.34083	8	0.96011	0.036880	0.96765	-0.21562	0.56554
4	Chloride	12	0.11008	0.12877	6.41765	-0.10636	8	0.79480	0.072883	-3.12191	0.12905	1.04472
5	Sulfate	12	0.69235	0.10630	8.58081	-0.37451	8	0.96074	0.045176	-0.63287	-0.13808	1.00447
6	Carbonate	12	0.19915	0.06360	4.70886	0.07448	8	0.38670	0.062585	3.97279	0.12743	0.05629
7	Sodium +K	12	0.12356	0.12099	6.26189	-0.10669	8	0.94775	0.036013	-4.22724	0.15825	1.14548

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	12	0.92015	0.09488	2.91801	0.75637	8	0.99397	0.025760	-5.51678	0.97353	0.91872
9	Calcium	12	0.69367	0.09301	7.26140	-0.32870	8	0.98680	0.023072	-1.15531	-0.11324	0.91864
10	Magnesium	12	0.79976	0.07262	6.11737	-0.34083	8	0.96011	0.036880	0.96765	-0.21562	0.56554
11	Chloride	12	0.11008	0.12877	6.41765	-0.10636	8	0.79480	0.072883	-3.12191	0.12905	1.04472
12	Sulfate	12	0.69235	0.10630	8.58081	-0.37451	8	0.96074	0.045176	-0.63287	-0.13808	1.00447
13	Carbonate	12	0.19915	0.06360	4.70886	0.07448	8	0.38670	0.062585	3.97279	0.12743	0.05629
14	Sodium +K	12	0.12356	0.12099	6.26189	-0.10669	8	0.94775	0.036013	-4.22724	0.15825	1.14548

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	13	0.91998	0.08563	2.94445	0.75252	9	0.99509	0.018025	-5.34869	0.93601	0.92091
16	Calcium	13	0.65370	0.08735	7.17396	-0.31105	9	0.97632	0.024831	-2.05267	-0.06440	0.99832
17	Magnesium	13	0.76510	0.06596	5.95988	-0.30855	9	0.97612	0.020586	-0.15780	-0.13203	0.65299
18	Chloride	13	0.14787	0.11163	6.51519	-0.12053	9	0.81401	0.061582	-0.46419	-0.04362	0.82373
19	Sulfate	13	0.68714	0.10084	8.64257	-0.38737	9	0.96631	0.037054	-1.13067	-0.15801	1.07719
20	Carbonate	13	0.17698	0.06659	4.68813	0.08004	9	0.29325	0.070879	3.07089	0.16333	0.14791
21	Sodium +K	13	0.14822	0.10878	6.33281	-0.11762	9	0.92331	0.039365	-3.01770	0.05443	1.06032

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	10	0.85476	0.08435	3.11602	0.71281	10	0.97540	0.037108	-5.63107	0.98351	0.92420
23	Calcium	10	0.53942	0.08814	7.26313	-0.33227	10	0.94785	0.031705	-2.18058	-0.04001	0.99781
24	Magnesium	10	0.72837	0.05917	6.10125	-0.33750	10	0.95118	0.026815	0.00432	-0.14881	0.64419
25	Chloride	10	0.31784	0.09752	7.04283	-0.23187	10	0.66156	0.073430	-0.83301	0.01186	0.83215
26	Sulfate	10	0.44401	0.12059	8.53293	-0.37538	10	0.75416	0.085720	-1.71456	-0.05825	1.08273
27	Carbonate	10	0.09048	0.07553	4.66706	0.08299	10	0.11961	0.079447	3.12892	0.13059	0.16252
28	Sodium +K	10	0.37892	0.09915	7.09805	-0.26977	10	0.86550	0.049324	-2.88704	0.03924	1.05501

18. STATION 09421500 (HOOVER) Colorado River below Hoover Dam, AZ-NV

STATION 09421500 Colorado River below Hoover Dam, AZ UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	51	0.0	0.0
2	2015	51	0.0	0.0
3	2016	57	0.0	0.0
4	2017	57	0.0	0.0
5	2018	57	0.0	0.0

STATION 09421500 Colorado River below Hoover Dam, AZ UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	51	0.98189	0.046299	0.52866	0.99493	47	0.99616	0.022004	-7.11968	0.98026	1.13140
2	Calcium	51	0.00816	0.046534	4.45591	-0.01231	47	0.40213	0.036746	-1.06465	-0.02228	0.81567
3	Magnesium	51	0.00510	0.058453	3.35946	-0.01221	47	0.53550	0.040377	-4.60228	-0.02843	1.17883
4	Chloride	51	0.00285	0.075486	4.54198	-0.01179	47	0.73819	0.039907	-7.92036	-0.02968	1.83574
5	Sulfate	51	0.00009	0.051227	5.41967	0.00139	47	0.72156	0.027164	-2.71584	-0.01150	1.19996
6	Carbonate	51	0.00231	0.028329	4.39128	0.00398	47	0.02263	0.029157	3.59366	0.00042	0.12068
7	Sodium +K	51	0.00299	0.075768	4.63897	-0.01210	47	0.68059	0.041009	-6.23662	-0.04312	1.62204

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	51	0.98189	0.046299	0.52866	0.99493	47	0.99616	0.022004	-7.11968	0.98026	1.13140
9	Calcium	51	0.00816	0.046534	4.45591	-0.01231	47	0.40213	0.036746	-1.06465	-0.02228	0.81567
10	Magnesium	51	0.00510	0.058453	3.35946	-0.01221	47	0.53550	0.040377	-4.60228	-0.02843	1.17883
11	Chloride	51	0.00285	0.075486	4.54198	-0.01179	47	0.73819	0.039907	-7.92036	-0.02968	1.83574
12	Sulfate	51	0.00009	0.051227	5.41967	0.00139	47	0.72156	0.027164	-2.71584	-0.01150	1.19996
13	Carbonate	51	0.00231	0.028329	4.39128	0.00398	47	0.02263	0.029157	3.59366	0.00042	0.12068
14	Sodium +K	51	0.00299	0.075768	4.63897	-0.01210	47	0.68059	0.041009	-6.23662	-0.04312	1.62204

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	57	0.99516	0.023607	0.53432	0.99587	53	0.99822	0.014734	-5.49603	0.99493	0.87591
16	Calcium	57	0.01218	0.031358	4.44732	-0.01024	53	0.05964	0.030636	2.05447	-0.01038	0.34707
17	Magnesium	57	0.00744	0.049732	3.36119	-0.01267	53	0.49326	0.035171	-8.70390	-0.01571	1.75387
18	Chloride	57	0.01142	0.034076	4.56770	-0.01077	53	0.44214	0.024337	-3.08587	-0.00618	1.10421
19	Sulfate	57	0.01092	0.027019	5.52748	-0.00835	53	0.51825	0.017123	-0.68406	-0.00735	0.89970
20	Carbonate	57	0.02555	0.031671	4.27909	0.01509	53	0.06030	0.032029	1.90403	0.01290	0.34738
21	Sodium +K	57	0.00039	0.047273	4.52012	0.00274	53	0.40565	0.032747	-4.91038	-0.00686	1.38038

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	57	0.99502	0.023518	0.53243	0.99447	57	0.99826	0.014041	-5.28650	1.00082	0.83724
23	Calcium	57	0.00378	0.037932	4.39870	-0.00699	57	0.20618	0.034172	-0.84839	-0.00126	0.75496
24	Magnesium	57	0.02011	0.048544	3.40022	-0.02080	57	0.56492	0.032645	-7.70825	-0.00867	1.59830
25	Chloride	57	0.00047	0.035657	4.48363	-0.00230	57	0.28582	0.030418	-1.36322	0.00408	0.84125
26	Sulfate	57	0.02117	0.028885	5.55209	-0.01270	57	0.68932	0.016423	-1.77178	-0.00471	1.05377
27	Carbonate	57	0.00703	0.026959	4.34398	0.00678	57	0.00923	0.027178	3.95427	0.00721	0.05607
28	Sodium +K	57	0.00051	0.044757	4.49874	0.00301	57	0.24648	0.039220	-2.31525	0.01045	0.98041

19. STATION 09427520 (PARKER) Colorado River below Parker Dam, AZ-CA

STATION 09427520 Colorado River below Parker Dam, AZ UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	80	0.0	0.0
2	2015	80	0.0	0.0
3	2016	74	0.0	0.0
4	2017	66	0.0	0.0
5	2018	66	0.0	0.0

STATION 09427520 Colorado River below Parker Dam, AZ UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	80	0.98739	0.053035	0.35867	1.01429	80	0.99707	0.025724	-7.39581	0.99371	1.15246
2	Calcium	80	0.08815	0.041093	4.06970	0.02762	80	0.36507	0.034512	0.29093	0.01759	0.56159
3	Magnesium	80	0.01208	0.065851	3.12138	0.01574	80	0.55742	0.044361	-5.04271	-0.00593	1.21333
4	Chloride	80	0.00699	0.086304	4.31864	0.01566	80	0.84279	0.034562	-8.89357	-0.01941	1.96358
5	Sulfate	80	0.00340	0.065987	5.37304	0.00834	80	0.64651	0.039554	-3.47221	-0.01514	1.31457
6	Carbonate	80	0.07260	0.035088	4.19897	0.02122	80	0.10189	0.034753	5.23959	0.02398	-0.15466
7	Sodium +K	80	0.00837	0.074161	4.42260	0.01473	80	0.69744	0.041229	-5.89318	-0.01265	1.53312

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	80	0.98739	0.053035	0.35867	1.01429	80	0.99707	0.025724	-7.39581	0.99371	1.15246
9	Calcium	80	0.08815	0.041093	4.06970	0.02762	80	0.36507	0.034512	0.29093	0.01759	0.56159
10	Magnesium	80	0.01208	0.065851	3.12138	0.01574	80	0.55742	0.044361	-5.04271	-0.00593	1.21333
11	Chloride	80	0.00699	0.086304	4.31864	0.01566	80	0.84279	0.034562	-8.89357	-0.01941	1.96358
12	Sulfate	80	0.00340	0.065987	5.37304	0.00834	80	0.64651	0.039554	-3.47221	-0.01514	1.31457
13	Carbonate	80	0.07260	0.035088	4.19897	0.02122	80	0.10189	0.034753	5.23959	0.02398	-0.15466
14	Sodium +K	80	0.00837	0.074161	4.42260	0.01473	80	0.69744	0.041229	-5.89318	-0.01265	1.53312

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	74	0.99605	0.024465	0.62164	0.98861	74	0.99823	0.016516	-6.45179	0.99630	1.01274
16	Calcium	74	0.00207	0.034019	4.29595	0.00394	74	0.10314	0.032476	0.07721	0.00852	0.60402
17	Magnesium	74	0.05805	0.039227	3.50921	-0.02477	74	0.26286	0.034945	-3.61827	-0.01702	1.02048
18	Chloride	74	0.03870	0.039819	4.70301	-0.02032	74	0.35871	0.032751	-4.24927	-0.01059	1.28175
19	Sulfate	74	0.03006	0.031077	5.60986	-0.01391	74	0.54206	0.021504	-3.18837	-0.00435	1.25969
20	Carbonate	74	0.02150	0.038806	4.24989	0.01463	74	0.02851	0.038938	2.96985	0.01602	0.18327
21	Sodium +K	74	0.01508	0.044388	4.72515	-0.01397	74	0.17765	0.040844	-2.30185	-0.00633	1.00610

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	66	0.99606	0.025099	0.69603	0.97997	66	0.99836	0.016339	-6.16279	0.99362	0.97456
23	Calcium	66	0.00477	0.040132	4.26206	0.00682	66	0.19974	0.036271	-2.09588	0.01947	0.90339
24	Magnesium	66	0.01428	0.050529	3.39406	-0.01492	66	0.50442	0.036111	-9.35924	0.01046	1.81210
25	Chloride	66	0.18240	0.034945	4.89095	-0.04051	66	0.39523	0.030292	-1.49060	-0.02781	0.90675
26	Sulfate	66	0.14203	0.029260	5.74461	-0.02922	66	0.63274	0.019295	-2.17597	-0.01345	1.12543
27	Carbonate	66	0.08588	0.028892	4.17671	0.02173	66	0.08949	0.029063	3.52675	0.02303	0.09235
28	Sodium +K	66	0.02892	0.049004	4.78690	-0.02075	66	0.19519	0.044965	-2.47091	-0.00631	1.03125

20. STATION 09429490 (IMPER) Colorado River above Imperial Dam, AZ-CA

STATION 09429490 Colorado River above Imperial Dam, AZ UPDATE 2018
SUMMARY OF QW OBSERVATIONS, BY 3-YEAR SLIDING GROUP

Obs	WATER YEAR	# OF QW OBSV.	% P70300 SUBST.	% P00060 SUBST.
1	2014	77	0.0	0.0
2	2015	77	0.0	0.0
3	2016	77	0.0	0.0
4	2017	70	0.0	0.0
5	2018	70	0.0	0.0

STATION 09429490 Colorado River above Imperial Dam, AZ UPDATE 2018
REGRESSION STATISTICS, BY 3-YEAR SLIDING GROUPS
REGRESSION #1: VARIABLE = e**A * DISCHARGE**B
REGRESSION #2: VARIABLE = e**C * DISCHARGE**D * COND**E
VARIABLE=(mg/L), except for SALT LOAD (tons/day)
DISCHARGE=(CFS) COND=(uMHOS/cm)

GROUP=2014

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
1	SALT LOAD	77	0.97429	0.035576	1.98240	0.85096	77	0.99612	0.013920	-7.41571	1.01419	1.12887
2	Calcium	77	0.30298	0.034883	5.23552	-0.08937	77	0.57043	0.027569	-0.95965	0.01823	0.74414
3	Magnesium	77	0.48576	0.034312	4.54415	-0.12959	77	0.74703	0.024227	-2.46796	-0.00780	0.84227
4	Chloride	77	0.53912	0.048142	6.49329	-0.20233	77	0.89291	0.023363	-5.60010	0.00771	1.45261
5	Sulfate	77	0.45097	0.041543	6.90475	-0.14631	77	0.82355	0.023710	-2.90719	0.02411	1.17857
6	Carbonate	77	0.24614	0.042612	5.36022	-0.09461	77	0.27378	0.042105	3.02072	-0.05398	0.28101
7	Sodium +K	77	0.39468	0.058292	6.40543	-0.18290	77	0.83098	0.031010	-7.78367	0.06354	1.70434

GROUP=2015

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
8	SALT LOAD	77	0.97429	0.035576	1.98240	0.85096	77	0.99612	0.013920	-7.41571	1.01419	1.12887
9	Calcium	77	0.30298	0.034883	5.23552	-0.08937	77	0.57043	0.027569	-0.95965	0.01823	0.74414
10	Magnesium	77	0.48576	0.034312	4.54415	-0.12959	77	0.74703	0.024227	-2.46796	-0.00780	0.84227
11	Chloride	77	0.53912	0.048142	6.49329	-0.20233	77	0.89291	0.023363	-5.60010	0.00771	1.45261
12	Sulfate	77	0.45097	0.041543	6.90475	-0.14631	77	0.82355	0.023710	-2.90719	0.02411	1.17857
13	Carbonate	77	0.24614	0.042612	5.36022	-0.09461	77	0.27378	0.042105	3.02072	-0.05398	0.28101
14	Sodium +K	77	0.39468	0.058292	6.40543	-0.18290	77	0.83098	0.031010	-7.78367	0.06354	1.70434

GROUP=2016

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
15	SALT LOAD	77	0.97455	0.033905	2.10574	0.83782	77	0.99509	0.014991	-6.44979	0.99010	1.02305
16	Calcium	77	0.23007	0.040680	5.22639	-0.08880	77	0.69286	0.025866	-3.63200	0.06888	1.05926
17	Magnesium	77	0.38509	0.047123	4.70362	-0.14892	77	0.77974	0.028393	-5.89980	0.03982	1.26793
18	Chloride	77	0.64146	0.039156	6.57238	-0.20915	77	0.83675	0.026599	-1.54443	-0.06467	0.97059
19	Sulfate	77	0.58569	0.032159	6.97678	-0.15270	77	0.82656	0.020947	0.08956	-0.03010	0.82356
20	Carbonate	77	0.33994	0.044641	5.63189	-0.12794	77	0.68784	0.030906	-3.47098	0.03409	1.08850
21	Sodium +K	77	0.51145	0.049956	6.60779	-0.20412	77	0.84162	0.028635	-4.92693	0.00120	1.37929

GROUP=2017

Obs	VARIABLE	#1 obsv.	R-square #1	Std. Error	A	B	#2 obsv.	R-square #2	Std. Error	C	D	E
22	SALT LOAD	70	0.97654	0.033167	2.04035	0.84339	70	0.99584	0.014064	-6.74888	0.98939	1.06685
23	Calcium	70	0.27857	0.037045	5.23195	-0.09072	70	0.65557	0.025787	-2.59161	0.03924	0.94963
24	Magnesium	70	0.41587	0.044393	4.66327	-0.14762	70	0.78397	0.027198	-5.63192	0.02340	1.24964
25	Chloride	70	0.60445	0.040920	6.47289	-0.19936	70	0.86419	0.024156	-3.21451	-0.03843	1.17587
26	Sulfate	70	0.58495	0.034324	7.03326	-0.16059	70	0.86835	0.019475	-1.25270	-0.02295	1.00576
27	Carbonate	70	0.29313	0.032227	5.20417	-0.08179	70	0.60205	0.024361	-1.01986	0.02160	0.75548
28	Sodium +K	70	0.57623	0.045474	6.63128	-0.20898	70	0.88320	0.024051	-4.67568	-0.02116	1.37245

APPENDIX D

20 Station Flow and Salt over Time

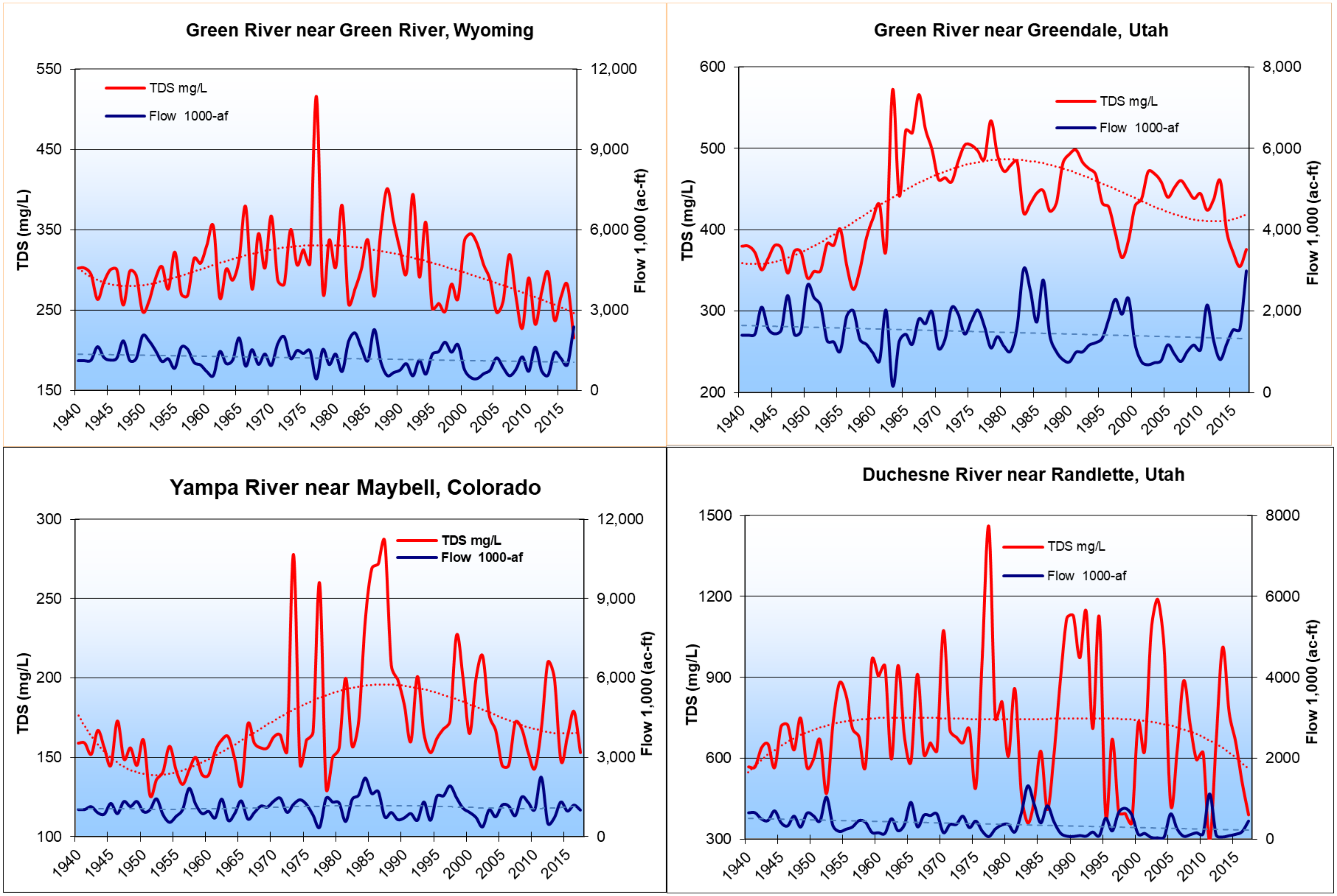


Figure D1 - Flow and TDS over Time for Sites 1-4

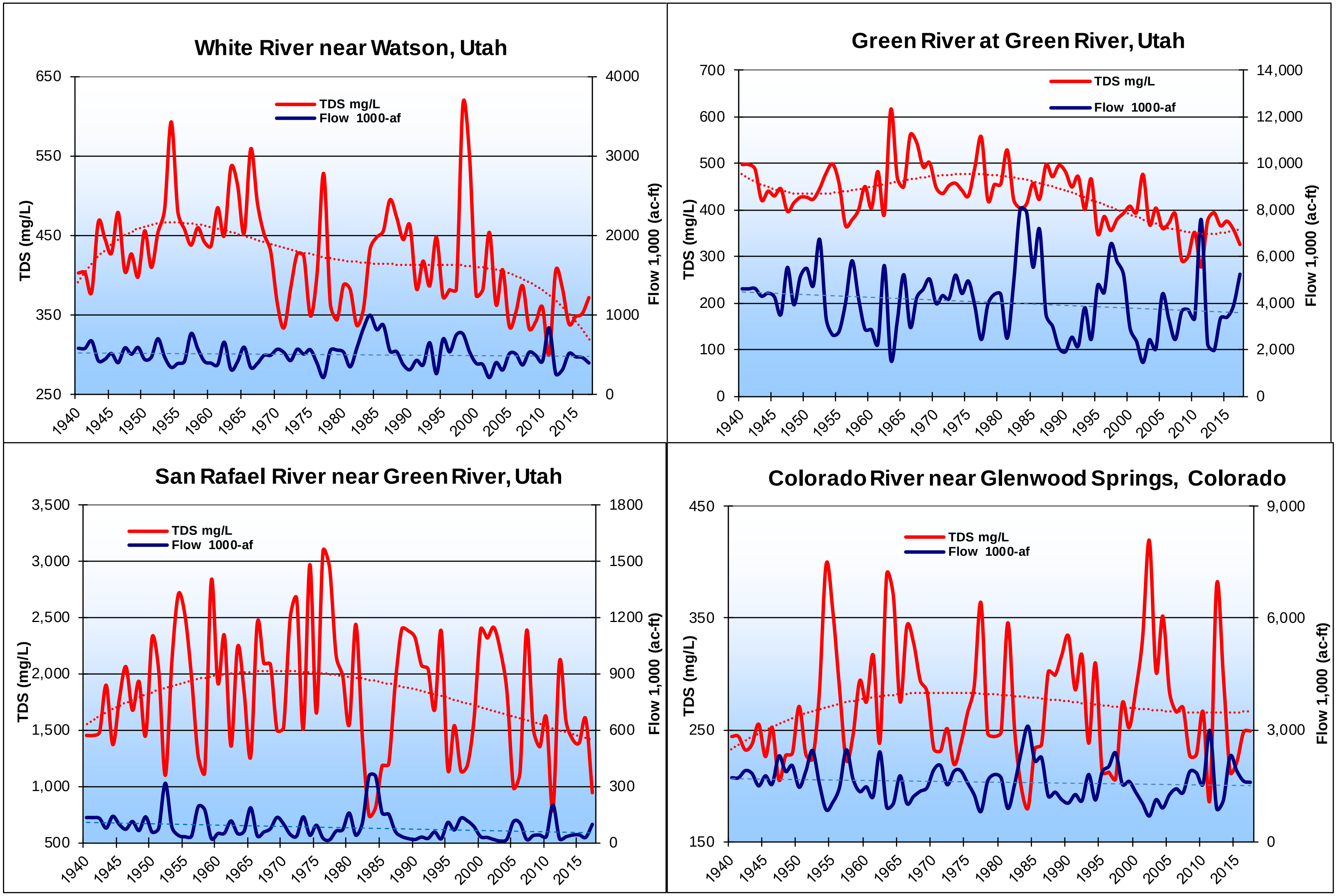


Figure D2 - Flow and TDS over Time for Sites 5-8

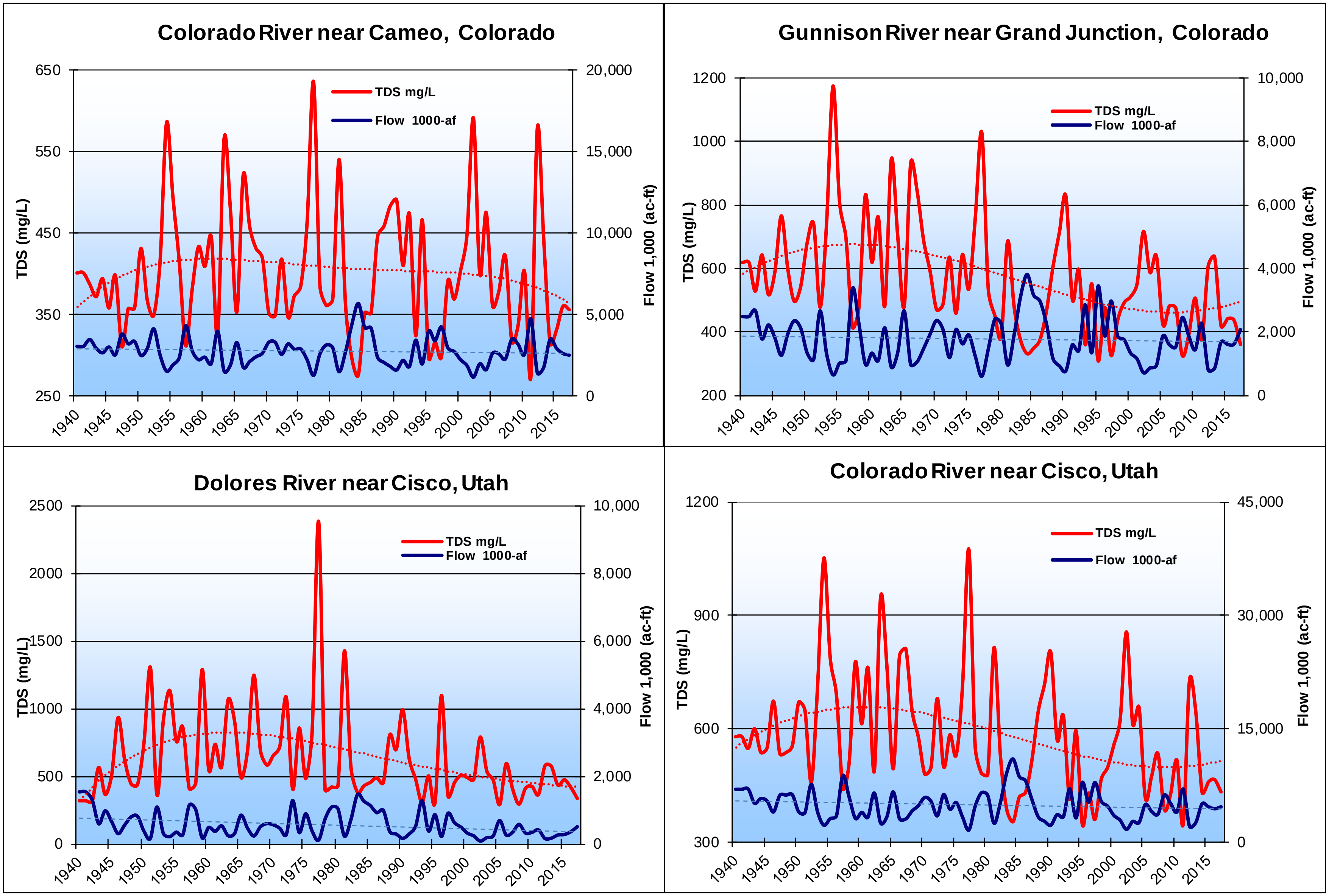


Figure D3 - Flow and TDS over Time for Sites 9-12

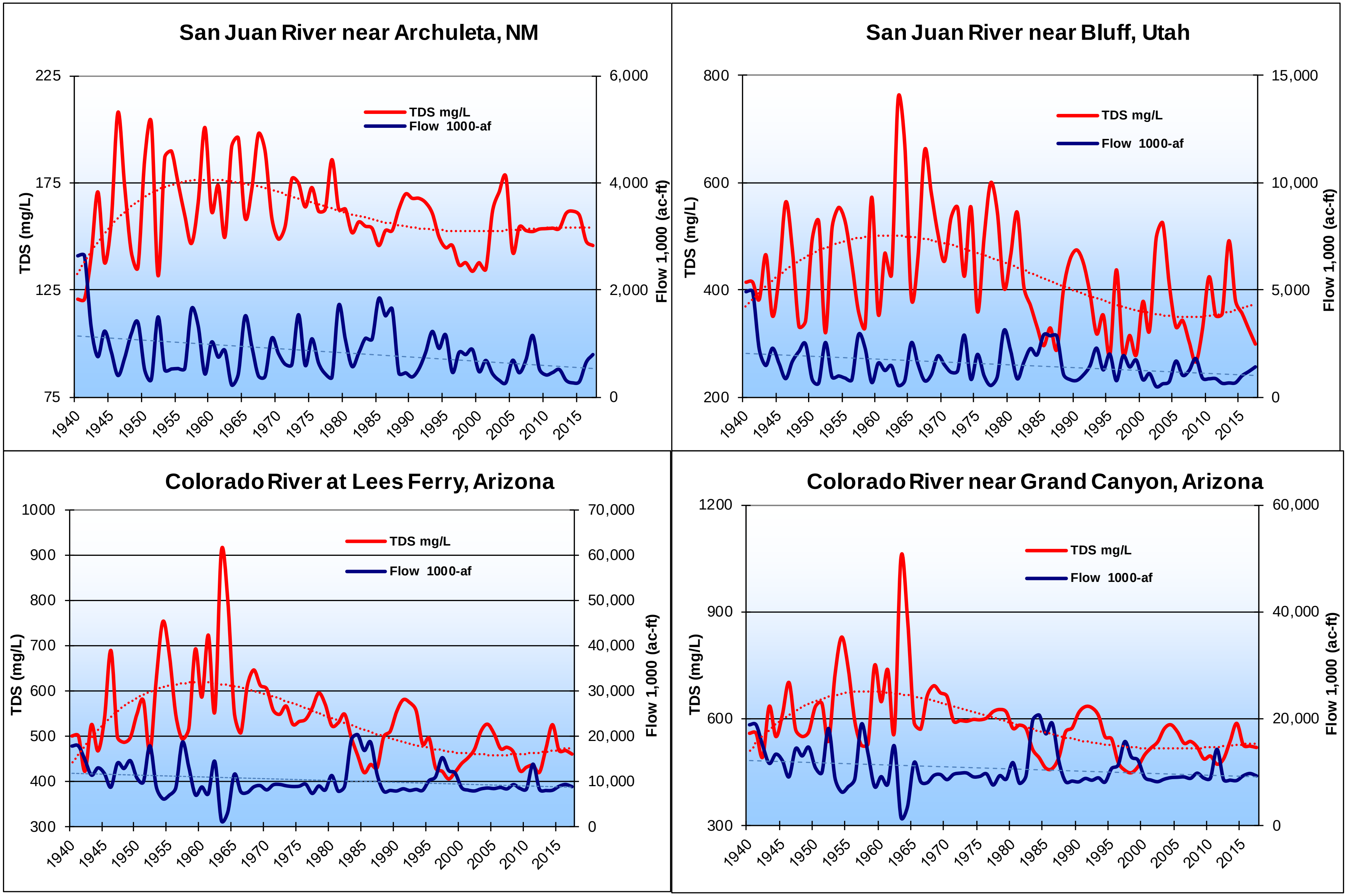


Figure D4 - Flow and TDS over Time for Sites 13-16

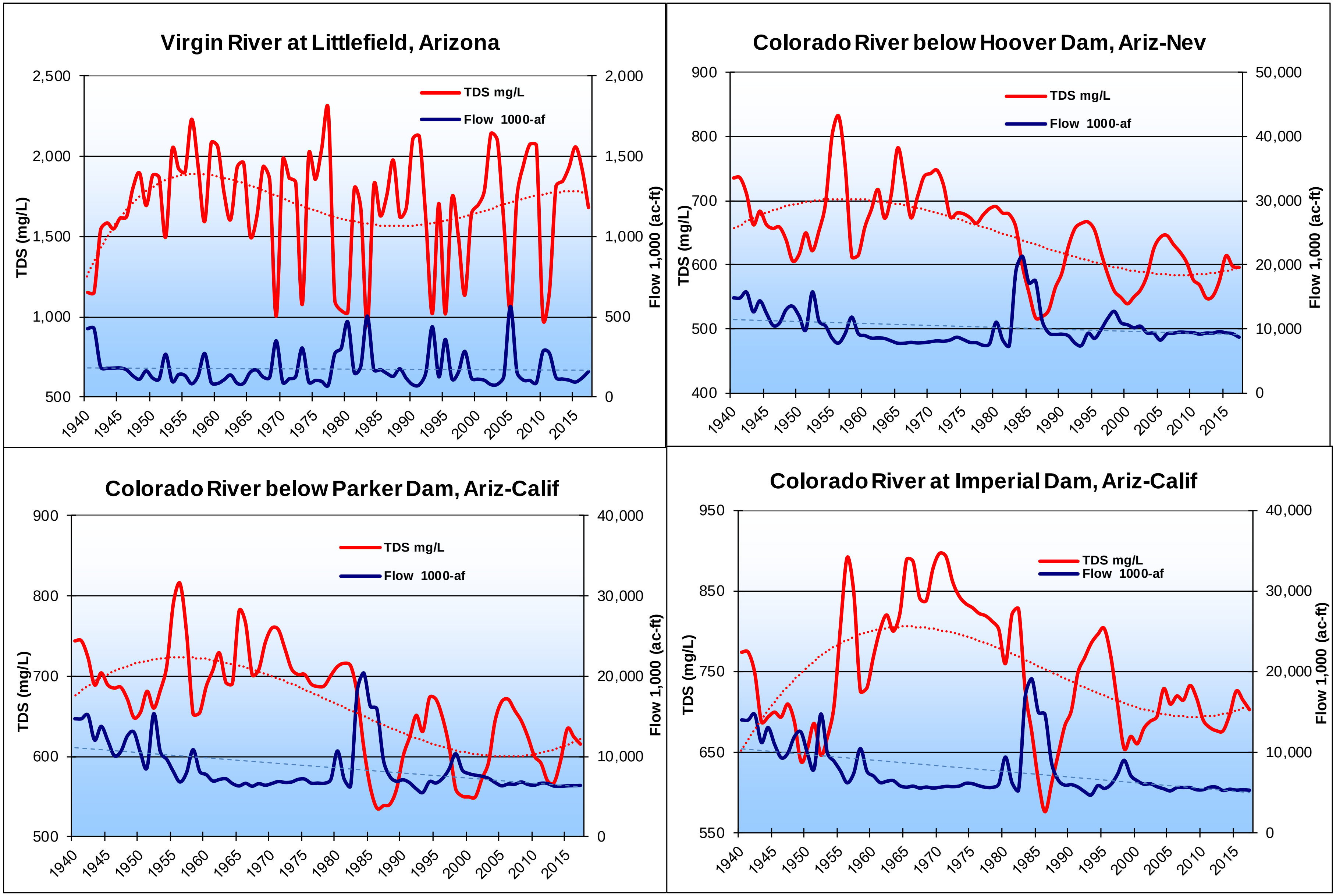


Figure D5 - Flow and TDS over Time for Sites 17-20