SURFACE WATER DATA

LAKE MEREDITH SALINITY CONTROL PROJECT

Prepared for

CANADIAN RIVER MUNICIPAL WATER AUTHORITY

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EXECUTIVE SUMMARY

The Canadian River Municipal Water Authority (CRMWA) is interested in developing a project to control the brine which flows into the Canadian River below Ute Lake, New Mexico, and which degrades water quality in Lake Meredith, Texas. To properly plan and assess such a project, it is important to understand surface water flow and salinity conditions in the entire river reach between the two lakes. This notebook compiles available information on the Canadian River in that reach. A separate notebook presents details on ground-water conditions specific to the area where brine inflow is greatest.

Most of the information comes from studies of the brine problem conducted by or for the U.S. Bureau of Reclamation (USBR), but information also is obtained from reports prepared by or for CRMWA, and reports prepared by or for the New Mexico State Engineer Office. In addition, we have accessed the extensive data base collected by the U.S. Geological Survey; have prepared new tables which compile data from all the major stream surveys conducted between Ute Reservoir and Lake Meredith; and have reproduced key data tables and figures from the previous publications.

Although the data on river conditions are substantial, the previously published reports contain some potentially significant errors and the published analyses don't fully characterize all the key points which must be considered in deciding how best to control the brine. Indeed, the USBR reports repeatedly state that significant uncertainties must be resolved before a successful salinity control program could be implemented.

A particular problem is the lack of good quantitative analyses which show relationships between streamflow and salinity, and which interpret these relationships in terms of probable brine sources. To help solve the problem, we recommended and CRMWA supported a new stream survey from Ute Reservoir to Lake Meredith, and new modeling of water quality conditions at the New Mexico State Line. This notebook contains the results of both work elements.

Based on the available information, the new analyses, and our judgment, we believe that the evidence supports the following concepts.

Streamflows

- Canadian River streamflows from New Mexico include the following sources: spills and seepage from Ute Reservoir; brine inflow which occurs near Logan; runoff and return flows from Revuelto Creek; and other inflows of ground water and runoff.

- Streamflows have been substantially reduced since Ute Reservoir was built. However, construction of Ute explains only part of the change. Other important factors include climatic conditions (we are in a dry cycle with reduced natural runoff) and land use practices (for example, farm ponds and irrigation pumping both hold water back from reaching the river).

- Safe yield of Lake Meredith is substantially less than envisioned when the reservoir was being planned. Conditions will improve by a relatively small amount, if litigation on the Canadian River Compact leads to greater releases and spills from Ute.

Logan brine

- Stream surveys demonstrate that brine inflow occurs throughout the first six miles below Ute Dam; this reach is termed the "Logan area". Since Ute Dam was constructed, the inflow of brine in the Logan area is steadier and possibly larger than it was before.

- The project reports estimated the rate of brine inflow at 0.6 cfs, but our studies suggest the rate is closer to 0.8 cfs and, since Ute Reservoir was enlarged, it may have increased to around 1 cfs. The brine is dominantly sodium chloride. Contrary to some Project reports, it contains relatively little sulfate.

- In the mid-1980's, the brine added at least 15,000 tons/year to the chloride load of the Canadian River, which is about half the total load reaching Lake Meredith. Some 25,000 tons/year were measured in the Logan area in the 1992 stream survey; it is not known if this was simply a high reading or instead it reflects an increase in brine inflow since Ute was enlarged.

- While significant brine flow occurs in the first four miles or so below Ute Dam, the major discharge zone under present conditions occurs between miles 4 and 6, in a straight south-to-north reach of the river which occurs just east of Logan.

Downstream of Logan

- Downstream of Logan, conditions are much more variable than in the Logan area, and it is difficult to sort out the various processes which add salt to or remove salt from the streamflow.

- Our modeling of the available data demonstrates that a brine inflow zone occurs between Revuelto Creek and the State Line. Unlike the brine inflow at Logan, this downstream inflow is not steady, but appears to be most prominant in winter. On average, it is much smaller than the Logan brine inflow; it contributes slightly more than 10% of the total chloride load which is measured at the State Line.

- Most sulfates which reach Lake Meredith originate downstream of the Logan area. Sources in Texas probably account for much of the sulfate load and also contribute some of the chloride.

- One significant salt source in Lake Meredith was substantially reduced in the late 1970's when the City of Amarillo ceased discharging effluent to East Amarillo Creek on a regular basis. This effect has not been recognized in previous studies.

- A major complexity impacts the analysis of Lake Meredith salinity problems, because at least some of the salt which reaches the Canadian River in New Mexico does not reach Lake Meredith directly. Instead, salt probably is deposited in channel sediments during low flow periods and is flushed to the reservoir during major runoff events.

- The timing of deposition-flushing cycles is not well understood, and the possibility exists that some of the New Mexico salt is lost permanently through discharge to deep ground water, and is replaced in the Canadian River by salt sources which are located in Texas.

- Models used in USBR reports to calculate the effects of Logan brine on Lake Meredith appear to be invalid. New models have not yet been developed. Effective models must account for the storage-flushing process.

- A rough approximation of the salt budget for Lake Meredith indicates that Logan brine may account for 50% of the chloride reaching the reservoir. For planning purposes, a conservative estimate of the benefits of a brine control project is needed. The benefits of a project in the Logan area are estimated to be about a 25% reduction in chloride loadings to Lake Meredith.

1. INTRODUCTION

The Canadian River Municipal Water Authority (CRMWA) has contracted with Parkhill, Smith and Cooper Inc., and Lee Wilson and Associates Inc., to assist in implementation of the Lake Meredith Salinity Control Project. The Project objective is to reduce salinity in Lake Meredith, located NNE of Amarillo, Texas. The project method is to intercept and dispose of flow from a brine aquifer located near Logan, New Mexico.

The primary mechanism by which salt is delivered to Lake Meredith is surface flow in the Canadian River. This notebook contains readily available information on surface water conditions along the mainstem of the Canadian from Lake Meredith upstream to (and in some cases beyond) Logan. In addition to a brief text summary of the information, selected data summaries and extracts are provided in the tabbed sections of the notebook. The Project area is shown in **TAB 1**. Published documents from which information was extracted are listed in **TAB 2**. Another notebook will provide information related to Logan area ground water.

The notebook was prepared for several reasons: first, to compile and organize data and interpretations from many different sources, so that in the future it will be easier to find and use the information; second, to allow the contractors to become more familiar with the Project; third to identify some obvious limitations and problems in the available data; and fourth to recommend and (in some cases) complete additional studies to gather and/or evaluate data.

In general, the available information provides valuable insights regarding salinity problems at Lake Meredith and the brine aquifer near Logan. Coupled with information presented in the ground-water notebook, CRMWA now has information which is pointing to a relatively specific concept for a brine control project. However, the assessments provided in this notebook show that there is not a simple relationship between salt inflow from the brine aquifer and salt inflow to Lake Meredith; and that control of brine in the Logan area, while useful in reducing salinity in the reservoir, probably would have less benefits than estimated in previous studies.

2. BASIC DATA

The surface-water data available in the Project area fall into three categories:

- U.S. Geological Survey gaging station records, which provide routine monitoring of streamflow, water quality and reservoir contents;
- special stream surveys and other studies which aim to address salinity issues in the Project area; and
- other data, such as those which are part of conventional federal or state water-quality studies.

2.1 U.S. Geological Survey Gaging Station Records

The USGS WATSTORE data base contains routine streamflow and reservoir records for the entire nation. We asked USGS to retrieve all WATSTORE records for the Project area (extending upstream to Conchas Reservoir). The result was a massive computer printout and six separate computer-readable files. These data currently reside in the Santa Fe and/or Albuquerque offices of Lee Wilson and Associates. Note that this retrieval obtained flow data only from stations with daily records, not those where only periodic peak flow is reported.

TAB 3 provides an index to the data provided by USGS. The index includes two pages which summarize discharge records and one page which summarizes water-quality records. It is apparent that studies of long-term flow and quality conditions will rely heavily on two mainstem gages - one at Logan (flow only) and one north of Amarillo. Additional records of value are available for Ute Reservoir and Lake Meredith, for the (now inoperative) mainstem stations at the State Line and Tascosa, and for the key tributaries, Revuelto Creek and Punta del Agua. [As recommended in a prior draft of this report, CRMWA has arranged with USGS to partially reactivate the State Line gage and to collect water-quality data at Logan. Results of the monitoring should be incorporated into subsequent editions of the notebook.]

The simplest way to learn more about any given record - such as details about location, data quality, etc. - is to look at the station descriptions which are published in the USGS annual data reports. **TAB 4** is a photo-copy of the station descriptions which are most important to the Project.

When the Project was being studied and planned, it was no simple matter to perform statistical and graphical analyses on a massive data base such as that compiled by USGS. Today's hardware and software make these data much more accessible to analysis. In our judgment, analysis of the USGS data is a high priority, because it has a significant potential to improve the understanding of salt loading to Lake Meredith, and to assess the value of the Project as now planned.

A major component of our work has been to organize the USGS data into formats which will make it easy to perform flow and salinity evaluations. We also have begun some of those evaluations, in order to illustrate the potential significance of the results. This effort utilized a large portion of the total budget for the initial data survey. The formatting work is described in **TAB 5** and is summarized below.

- Six relatively simple FORTRAN programs were written to access and process the data. These programs can reformat the data into tables; count the number of data points of a given type; determine the parameters measured at a station; and generate histograms and cumulative frequency diagrams.

- The programs were used to generate 25 FORTRAN data files (readable as LOTUS worksheets) which in effect are tables. Included are tables which contain daily discharge records for various gages and time periods, tables which list both discharge and water-quality records, and tables which provide overview information, such as a list of all parameter codes in the water quality data base.

- The programs also were used to generate 41 separate FORTRAN data files (readable as LOTUS worksheets), each of which contains all the concentration and related discharge data for one particular major ion at one particular gaging station.

- There are 27 tables listing the number of major constituent analyses, one for each of the available water quality stations from Bell Ranch Canal, NM to Meredith Lake, TX. We have included these tables in **TAB 5**, as they provide the best simple overview of the data base.

- One LOTUS worksheet provides an organized list of parameter codes; and two are templates for chloride load calculations and discharge frequency calculations respectively. The parameter codes are included in **TAB 5**, as they are an essential reference for anyone who wants to access the basic data.

- There are 41 LOTUS worksheets containing double-mass curves and regression data for determining constituent concentrations as functions of discharge. These are manipulations of the ion-discharge data files identified above.

Over time, the USGS data can be extracted and interpreted as needed to address Project issues. Any data extracts (without significant interpretation) which are appropriate for this notebook can be put into **TAB 6**. In this draft, **TAB 6** includes a representative data extract, a worksheet of the flow, chloride and sulfate data for the Amarillo gage, which is the monitoring point most useful for evaluation of Lake Meredith. The worksheet includes data calculations for the double-mass curves, and selected curves are included in **TAB 6**, along with representative results from regression analyses.

2.2 Stream Surveys, 1969-84

Most of the significant stream surveys were performed in the periods 1969-73 and 1983-84. We have compiled these surveys into a series of LOTUS-123 worksheets, using a format which will make comparisons of results easier than has been possible in the past. The hard-copy outputs of the worksheets are included in the notebook as follows.

- **TAB 7** contains the key data from TWQB (1970). These data primarily indicate spatial trends in water quantity and quality along the Canadian River in the winter of 1969-70. High chlorides were observed immediately below Ute Dam, but also near the State Line. Reduced salt concentrations were observed in Texas. Overall, stream discharge rates were relatively high and indicative of conditions other than baseflow.

- **TAB 8** contains the key data from an unpublished survey of the Canadian River from Lake Meredith up to Ute Reservoir, conducted by CRMWA in early 1973, and referred to as the Ashby Lewis survey. Chlorides increased rapidly below Ute Reservoir and reached 4750 mg/l before being diluted by inflows from Revuelto Creek.

- **TAB 9** is a copy of a 1975 stream survey performed by USBR. The survey was cited in USBR (1979) along with other data, but none of the actual field records are in that report. This survey sheet was provided to us by CRMWA; the additional records may be available from USBR files in Oklahoma City and should be added to the notebook if they are obtained.

- **TAB 10** compiles the key data from three stream surveys conducted by HGC (1984). The data show a pronounced salinization of the river in the first two miles below Ute Dam, and at various additional points farther downstream. Generally the data demonstrate very close relationships between specific conductance, TDS and chlorides. Figure 37 is HGC's own plot of the data and is included in **TAB 10**.

- **TAB 11** compiles monthly water-quality data collected from May 1983 through August 1984 by USBR (1984). Data sites include Ute Reservoir (lake, toe drains, outlet works), four sites along the mainstem Canadian River (miles 1.6, 2.2, 5.4 and 9.9), and one site on Revuelto Creek. These data provide the most useful time-series of water-quality conditions that may be impacted by brine inflow below Ute Dam. An additional value of these data is that contemporary sampling was conducted for ground water at the same sites (see ground-water notebook); and estimates of streamflow accompany the water-quality results. We prepared a chart at the end of the Tab to show chloride loading variations among sites and over time.

- **TAB 12** pulls together narrative and numeric information contained in Attachment B of USBR (1984), from a stream survey conducted in May, 1983. USBR notes data problems including some samples where the ionic balance indicated errors; data points which were outliers (i.e. far outside normal ranges); data points where total dissolved solids and conductance did not follow normally observed relationships. Similar problems are evident in most of the other data sets, although they are not always noted in the source reports. In addition, except for the USBR report, there generally is a lack of detail regarding sampling conditions, which makes it difficult (for example) to determine exactly why salinity at a given location may differ from one sample to another.

2.3 Data from CRMWA and other Sources

Additional data sources include CRMWA and Federal, State and local water resource and environmental agencies.

CRMWA. The Authority is directly or indirectly responsible for an extensive data base related to Lake Meredith and the Canadian River. Files we have identified are as follows.

- Water quality data (monthly chlorides from three lake locations) and water supply data (monthly diversions and estimated inflow and net evaporation) are maintained on a salt balance worksheet. The worksheet is provided here as **TAB 13**; graphs which plot some of the data also are provided. Note that the chloride data show somewhat higher levels at the upper end of the reservoir.

- Additional data have been collected from upstream areas on an irregular basis. For example, at times when Lake Meredith receives significant runoff, samples often are collected at various upstream locations in order to determine levels of chlorides (and some other constituents) and to determine possible locations of salt influx to the river. We have compiled some of these data into **TAB 14**. Additional records should be added as they are obtained.

- CRMWA conducted a new stream survey in 1992. **TAB 15** provides data from that survey, including a spreadsheet developed by the Authority, and graphs and tables prepared by the Texas Bureau of Economic Geology. Additional records from periodic resurveys should be added as they are obtained.

- CRMWA provides quarterly samples to the State of Texas for analysis of numerous parameters. **TAB 16** is reserved for these data.

- We expect that additional data related to Meredith water may be available from Safe Drinking Water Act records maintained by the State, Authority and/or member cities. **TAB 17** is reserved for these data, and any other miscellaneous records which CRMWA may wish to add to this notebook.

Federal/State/Local Agencies. Additional data are available in many reports, especially intensive surveys of lakes and streams conducted by EPA and/or State water-quality agencies. Reports cited in Section 3 are McCarley (1975), Kirkpatrick (1976), EPA (1977), Dutton (1978), Ottmers (1986), Smolka (1988), Potter and Davis (1989), and TWC (1990). At this time, we have not reviewed all the EPA and State data. Those records we have reviewed appear to be of limited value to a salinity study when compared to the much more extensive USGS data base; the records would be of substantial value to any CRMWA studies of eutrophication or sanitation.

At this time the data have not been entered into worksheets. As studies progress, it may become useful to computerize some of the the data; or, perhaps simply to xerox and include key tables in this notebook for ready reference. We have reserved **TAB 18** for any such worksheets or photocopies that may be compiled by or for CRMWA.

TAB 19 provides data related to the quantity of effluent discharged to East Amarillo Creek by the City of Amarillo.

Finally, our experience in this work is that new sources of information often turn up. An example is data recently obtained from the Corps of Engineers regarding Conchas Lake, which indicate that in 1991 there has been a small (<10 gpm) salt leak to the reservoir (chloride = 2250 mg/l, sulfate 1880 mg/l) from an artesian well. We determined this leak was too small to justify inclusion of the data in the notebook. However, reflecting the basic concept that any data compilation for the Canadian basin will expand over time, and this notebook is an evolving document, **TAB 20** is reserved for additional worksheets or information extracts.

3. LITERATURE SUMMARY

The bibliography provided in **TAB 2** was developed through review of documents provided by CRMWA, and by cross-checking libraries such as those in our office and at the New Mexico Interstate Stream Commission; we have not done a detailed check of State libraries in Texas. Many studies were identified but not reviewed in detail because of their relatively early date or limited relevance; these are not listed on the bibliography.

In this notebook, we abstract the listed references and, where appropriate, provide indexes to and/or hard copies of key data and interpretations. We are actively pursuing additional documents, especially water-quality surveys published by the State of Texas, and may expand **TAB 2** and this Section 3 before completing the notebook. To a limited extent, our interpretations or critiques of the information are provided here in Section 3; however, most such interpretations are presented in Section 4.

Note that in the abstracts, some salinity data are expressed in milligrams per liter (concentration), while others are in tons per year (load). A rough conversion factor is that the concentration in mg/l can be multiplied by the flow in cubic feet per second to give the loading in tons per year. (The exact relationship is 984 tons per year for a 1 cfs flow containing 1000 mg/l.)

3.1 Studies Which Helped Define the Problem

The basic salinity problems at Lake Meredith, and/or the potential role of salts from the Logan area, were defined in TWQB (1970); MJA (1972); USBR (1979) and EHA (1982).

TWQB (1970). This report presents a small number of salinity measurements made on the mainstem Canadian River and some tributaries in the winter of 1969-70 (see **TAB 7**). These showed 9 cfs of seepage and springflow below Ute Dam, with 7,236 mg/l average total dissolved solids and a $Cl:SO_4$ ratio of nearly 7:1. The highest chloride values were observed immediately below Ute Dam. On an annualized basis, the total salt loading from the Logan area would exceed 60,000 tons per year, indicating that the reach of the Canadian River immediately below Ute Reservoir is a major source of salinity problems at Lake Meredith.

Loads on Punta de Agua and Reveulto Creek combined to equal about 5,000 tons/year and at Reveulto in particular were dominated by sulfate. East Amarillo Creek contributed 14 cfs and 20,000 tons per year with a $Cl:SO_4$ ratio of about 1:1; most of this flow and salt was caused by wastewater discharges by the City of Amarillo.

Our initial comments on the report follow:

- the data do not include all major ions and do not appear to have undergone quality assurance tests, e.g. unusual chloride-conductance relationships are reported without comment;

- subsequent studies have not shown such high salinity at such (relatively) high flows;

- the Amarillo effluent went substantially off-line in 1977 (John Williams, personal communication). Reduced quantities of effluent are still discharged at some times, though the water may not reach the Canadian mainstem.

MJA (1972). This brief report summarizes USGS gaging station records in the Project area. The data indicate that the dominant cause of salinity in Lake Meredith probably is ground water seepage from Permian rocks, most of which enters the Canadian River near Logan. The report does not contain any basic data and it does not give a clear indication as to exactly what data were used to create the graphs which are presented.

USBR (1979). The appraisal-level report on the Project presents the results of several investigations, mostly directed at subsurface conditions (see separate notebook). There is some historical discussion about Lake Meredith (including data on the capacity of different pools). Table 1 in the report is the salinity forecast from the 1960 USBR study of the reservoir; the lake was predicted to have an average TDS of 950 mg/l and a maximum of 1838.

Actual data from 1965-77 are said to indicate a total inflow of sodium, chloride and sulfate which averaged 84,095 tons per year. Details of this calculation are not provided, but the breakout by type of salt is: 27,660 tons/year sodium; 29,525 tons/year chloride; 26,910 tons/year sulfate.

The report describes stream surveys which were conducted during the 1970's, but does not present the survey data. The following information relates to these studies.

- At some time, electrical conductivity meters were used to identify small brine seeps and springs (marked by colorful, saline algae) between Ute Reservoir and Revuelto Creek, but these are too small to indicate any major structural conduit which could be involved in the brine leakage (page 9). The discussion does not indicate who performed the conductivity survey, or when, and no data are presented.

- Studies begun in 1972 included "sampling and testing ... of the riverbed sands combined with an evapotranspiration study ... at various points along the river channel" (page 10). No details are given, but the conclusion was that "the evaporation and flushing process was not a primary source of saline pollution".

- In 1975, electrical conductivity meters were used to map saline concentrations along the river (page 11). Again, no details of this work are provided in the report, but CRMWA was able to locate the map referred to; it is provided in **TAB 9**. It is not known if this survey is the same one reported on page 11 of the report.

USBR (1979) is the basic reference by which benefits of pumping the brine aquifer are calculated. USBR reports that the brine contains 22,000 mg/l chloride and between 8,600 to 9,700 mg/l sulfate. Note that we are not able to verify the high sulfate value. USBR also estimated a brine flow of 0.6 cfs. The basis of the estimate is not presented. However, the report does state that base flow in the river comes mostly from the Ogallala (fresh) and Triassic (fair to poor quality), along with highly mineralized Permian water. Ute Dam has caused an increase in seepage due to reservoir leakage and "possibly to hydraulic loading on the Triassic aquifers" (page 9).

Although the methodology is not stated explicitly, it appears that by combining the flow and salinity data, and by assuming that all brine at Logan reaches Lake Meredith, USBR estimated that the brine aquifer contributes 8,500 tons/year sodium (31% of the calculated average load at Lake Meredith), 13,000 tons/year chloride (44%), and 5,400 tons/year sulfate (20%), for a total of 26,900 tons/year (32%). The report indicates that if one assumes that all this salt inflow would be completely eliminated by pumping the brine aquifer, the reduction of salt inflow to Lake Meredith of 32% would mean that reservoir TDS would gradually stabilize in the range 800-900 mg/l.

An interesting statement at page 20 is: "future studies would attempt to establish proof that salt from the brine aquifer actually reaches Lake Meredith". Among the recommendations at page 32 is: "investigate any other major sources of saline contamination between Ute Reservoir and Lake Meredith".

<u>EHA (1982)</u>. This brief, informal report formulates a salt balance model for Lake Meredith. The model results also are included in Ward (1985). The salt balance model boils down to the principle that inflow salts will be concentrated by a factor equal to inflow divided by non-evaporative outflow. During the drought years 1973-80, discharge-weighted chlorides in inflow water ranged from 110 to 330 mg/l. Based on relatively recent data, EHA estimates the equilibrium chloride concentration in the reservoir would be 442 mg/l; looking at a longer record of higher flows it would be 281 mg/l.

The report notes significant data problems. First, data on lake evaporation are limited or questionable. Second, estimates of chloride loading need to consider low-flow brine salts and high-flow runoff salts separately. Third, selection of the inflow record is critical - if the full historic inflows are used, predictions may be in error. Fourth, evaluations of a salt balance need to involve more than long-term averaging.

3.2 The Key Project Reports

In the period 1983-85, USBR undertook or sponsored detailed field studies and other evaluations of the Project. These studies are reported in HGC (1984), USBR (1984) and USBR (1985), which are the "Key Project Reports" for determining how Lake Meredith salinity might be improved. HGC is abstracted below; the two USBR reports are on pages 3-9 and 3-12 respectively.

HGC (1984). The HGC report is the most extensive interpretation of surface and shallow ground water conditions related to the Project. The report concludes that a major salinity problem is caused by inflows to the Canadian River at 0.5 and 3 miles below Ute Dam, related to upflow from a shallow brine aquifer. This salt may be stored in channel sediments during low flow periods and flushed to Lake Meredith during high flows. Under equilibrium conditions, Lake Meredith chlorides will be about 400 mg/l; sulfates 350 mg/l; and total dissolved solids 1500 mg/l. With control of the brine inflow, these values can be cut by more than half.

Because of the importance of the HGC report, we have abstracted it in considerable detail. The abstract deals only with the surface water components of the study; see the ground water notebook for a similar discussion related to the shallow brine and other aquifers. Unless clearly indicated otherwise, all statements made here are based on statements made i the report, and not our interpretations.

As background, HGC indicates that the very course of the Canadian valley is controlled by the fracturing and solution of salt deposits, with evidence of solution collapse along the river. In New Mexico, the stream is fed by ground water from Triassic rocks at a rate of roughly 0.15 cfs per mile, for a total of 5 cfs between Ute and the State Line (p. 51). A localized inflow of about 1 cfs near Logan (Highway 54 bridge) was observed on several occasions. HGC attributed about 0.6 cfs of the gain to brine inflow, which mixes with fresher Triassic ground water.

The primary analysis of surface water quantity begins on page 56; key graphics and tables include Figures 24 through 29, and Tables 3 through 5, all of which are provided here in **TAB 21**. Some of the key conclusions (including conclusions we draw from the report simply by addition or multiplcation of numbers) are as follows. (Note, Ute Reservoir began impounding water in December, 1963; cfs = cubic feet per second; AFY = acre-feet per year.)

Location	Flow since 1963	Comments
Ute seepage	1 cfs (750 AFY)	Flow is for period of HGC study; mostly at toe drains
Brine inflow	0.6 cfs	No evidence of increase due to construction of Ute Reservoir

Logan gage	Mean = 30 cfs (22,000 AFY)	Includes 28 cfs of spills; flow was 307 cfs before closure of dam
Logan gage	Median = 2 cfs	80 cfs before closure of dam; 2 cfs is dam seepage, baseflow
Revuelto Creek	Mean = 45 cfs (32,500 AFY)	Floods can be quick, intense, and can back up water into mainstem Canadian
Revuelto Creek	Median = 8 cfs	Mostly irrigation return flow (Arch Hurley Conservancy District)
State Line	Mean = 81 cfs (58,500 AFY)	Mostly Logan + Revuelto but correlation is not good for high flows
State Line	Median = 13 cfs	HGC estimates seepage gain between Revuelto and the State Line is about 5 cfs from Triassic rocks
Tascosa	Mean = 168 cfs (over 120,000 AFY)	Gains below State Line due mostly to Punta de Agua
Tascosa	Median = 30 cfs	During some low flow periods, stream losses occur above Tascosa; zero flows can occur even when there is perennial flow upstream. There is little if any baseflow accrual from Triassic rocks in Texas
Amarillo	Mean = 190 cfs (138,000 AFY)	456 cfs before closure Ute Dam; both before and after closure, flows are roughly 150-160 cfs greater than Logan; since 1963, only 30 of 190 cfs of Amarillo flow comes from Logan
Amarillo	Median = 50 cfs	85 cfs (about same as Logan) before closure of Ute dam; flow correlations between Amarillo and Ute dropped after closure; correlation between Amarillo and Tascosa is good due to consistent gain in effluent, baseflow between the stations

In assessing these data, we note that the report contains some errors in the discussion of flow statistics (e.g. the term "correlation coefficient" refers to values which are actually "coefficients of determination"); also inspection of the data makes it evident that with proper stratification of inputs, better correlations will be observed. Also, the period of record and frequency of measurement vary among stations, so that direct comparison of the records is possible only with great care. Finally, note that HGC makes no mention of the reduction in Amarillo effluent inflows reported to occur in 1978.

The bottom line of the HGC hydrology analysis is that the 190 cfs at Amarillo gage is accounted for as follows:

1% = Ute seepage
15% = Ute spills
4% = Revuelto return flows
20% = Revuelto floods
3% = Ground water inflow, Revuelto - State Line
45% = Punta de Agua & other streams above Tascosa
12% = Tascosa - baseflow, irrigation return flow.

This budget differs from that prior to construction of Ute, when 67% of the average flow of 456 cfs came from above Logan.

The HGC study also considers the quality of surface water. Key tables and graphics include Figure 32, Figures 36 through 46, and Tables 7 and 8, all of which are provided here in **TAB 22**. Figure 36 indicates that salt concentrations clearly drop by the State Line, parallel with a drop in ground-water salinity and stratification. The report does not comment on the fact that there is a marked increase in ground water chlorides at Amarillo, which is not paralleled by an increase in surface water chlorides, although it does say (p. 75) that "there are two sources of brine" shown on the graph; if one source is New Mexico, the second may be Amarillo. We note also that the chloride values plotted on the graph are less than long-term average measurements.

The report contains data from three stream surveys downstream of Ute Reservoir (see **TAB 9**). Flows were similar for all three of the surveys, reaching about 3 cfs near (apparently above) the confluence with Revuelto Creek. Figure 37 is HGC's plot of the data.

- The survey of 10/83 found "rapid increases" in salinity at 0.5 and 3 miles below the dam, with a gradual increase thereafter; by mile 6, TDS was nearly 12000 mg/l and chloride was about 6000 mg/l.

- The survey of 1/84 found a saline pool at mile 0.9, no further salt increases until mile 3, and perhaps another salt influx near mile 5. By mile 5, TDS was nearly 12000 mg/l and chloride was about 6000 mg/l. The survey went 18 miles farther downstream and 9 miles up Revuelto Creek without finding additional highly saline areas. (We note that a poor match exists between some of the conductance and TDS values; for example, the saline pool at mile 0.9 is shown only by anomalous conductance values. These relationships are note discussed in the HGC report.)

- The survey of 2/84 found similar results but numerous brine pools not seen on previous trips. Pools, each with conductance of about 60,000 micromhos, were concentrated at miles 0.8 to 1.1; just downstream of the railway bridge (roughly mile 3.5); and 0.8 miles below the bridge where river turns sharply north (roughly mile 4.2). By mile 6, TDS was about 12000 mg/l and chloride was nearly 6000 mg/l.

The HGC report interprets these data as reflecting brine upflow through the alluvium ... probably in three locations. (We infer these are miles 0.9, 3.5, 4.2.) It is suggested that construction at the railroad bridge may have disturbed channel sediments such that brine is forced to the surface.

Information on salinity elsewhere in the study area is provided by HGC; see especially Table 7 which is included in **TAB 22**. The following is a summary of the information. All water is dominated by sodium chloride unless otherwise noted. (Acronyms and measurement units are: Cl = chloride, in milligrams/liter; SO_4 = sulfate, in milligrams/liter; TDS = total dissolved solids, in milligrams per liter; SC = specific conductance, in micromhos per centimeter; TPY = chloride load, in tons per year.)

Location	Salinity values	Comments
Ute Reservoir	TDS = 565 Cl = <50	Sodium-bicarbonate water; no trend toward increased salinity; no salinity stratification
Toe drains	TDS = 1270	Mix of reservoir seepage and Triassic ground water (p. 87); limited data; TPY = 312
Logan area	TDS up to 12000 Cl up to 6000	See discussion of stream surveys above
Revuelto Ck	Cl = 218 SO_4= 410	Sodium chloride-sulfate water; TPY = 2,775
State Line	Cl = 1728 SO_4= 373	TPY = 27,750 (1969-83)
Tascosa	Cl = 530 SO_4= 290	TPY = 33,000 (1968-77)
Amarillo	Cl = 320 SO_4= 268	TPY = 40,000 (1968-77) TPY = 37,100 since closure of Ute

Our comments made previously regarding data on surface water quantity apply to the quality data also, e.g. there is no consideration of the effects of changes in Amarillo effluent; and the data sets at different locations are not entirely comparable.

The interpretation presented by HGC (p. 82) is that brine inflow dominates water quality by the State Line, with little contribution from Ute water or Revuelto Creek. In Texas, HGC observes that the flows freshen but the chloride load remains almost the same. The report indicates that chloride loads have increased over time, but the explanation is not clear. HGC states that there may be a small inflow of chloride between Tascosa and Amarillo, due to sewage effluent or inflow from Permian rocks.

HGC also presents data or interpretations on various salinity issues.

- Figures 40 and 41 (included in **TAB 22**) show a general correspondence between chloride loads and streamflow rates. HGC states (p. 85) that this "violates our simple conceptual model of a constant salt input from brine seeps". HGC advances the hypothesis that at low flows, evaporation concentrates salts in the channel and these are flushed out at high flows.

- HGC estimates that about 45,000 AFY may be evaporated between Ute Dam and Lake Meredith. Periodic freshening of shallow ground water is said to support this interpretation. The report does not adjust the water balance for this loss or explain exactly how it relates to salt transport.

- Figure 43 shows bromide/chloride ratios in surface and ground water. There are none of the high bromide values indicative of oil field brines. The report interprets the figure as showing the dominance of halite dissolution; but there is no comparable discussion of gypsum dissolution as a sulfate source.

- Figure 44 shows the Na/Cl ratio (which does in fact partly account for sulfates). There is less "brine" impact as one goes downstream toward Amarillo, but a lot more brine after closure of Ute than before.

HGC presents a <u>water and salt budget</u> for Lake Meredith, beginning on page 95. Information on these budgets is as follows.

- The water budget uses "known" values to calculate a term which combines net inflow below Amarillo gage (i.e. excess of runoff and precipitation to evaporation) with the net ground water flux, including bank storage; it also includes all errors in all input data. Data sources include nearby rain and evaporation measurements, reservoir area/storage records, streamflows measured at the Amarillo gage, and a volume-based reservoir seepage value which has a maximum of 6.5 cfs.

- The monthly water budget is provided in Appendix C of the HGC report. We have extracted the budget into a worksheet which is provided at **TAB 23**. HGC calculates an average value of -2100 AF/month of "inflow" between Amarillo and Meredith. The negative value is interpreted by HGC as a bank storage effect at the reservoir, and in particular they observe that there is a strong negative value in 38% of the months, when flows at Amarillo are large.

- When Amarillo flows are small, small positive residuals occur. This is said to be a ground water inflow, which apparently means that it is the release of water from bank storage. The analysis doesn't indicate whether the bank storage is balanced by bank releases and if not, why not. HGC gave no consideration to any change in conditions related to reductions in Amarillo effluent.

- The salt balance is presented beginning on page 98, with the results summarized in Figure 46. The budget itself is not tabulated in the report. Based on the text discussion, the budget basically inputs salt from inflow and removes it by diversions and seepage, to produce an estimate of net salt mass and a concentration value. The budget estimates are said to generally agree with the observed mid-lake chlorides in Lake Meredith, but over-estimate chlorides prior to 1972 and under-predict them since. During the period after impoundment in Lake Meredith began, sulfates (and TDS) were much higher than would be expected from the Amarillo inputs. HGC attributes this to dissolution of gypsum when the reservoir first filled. The report indicates that, at present, the salt budget is determined almost completely by what passes the Amarillo gage.

- By assuming that the period 1969-82 represents the long-term steady state condition of the reservoir, HGC predicted steady state concentrations as follows: chloride = 400 mg/l; sulfate = 360 mg/l; TDS = 1550 mg/l. Dissolution of minerals within the reservoir could result in higher values. Some of the key inputs to this analysis are: Amarillo flow = 146,600 AFY (over 200 cfs, higher than the value HGC used when it developed a water balance for the basin); diversions = 68,000 AFY; a net evaporation of roughly 6 2/3 feet/year; and chlorides at Amarillo which range from 172 mg/l in the high flow months to 647 mg/l in mid-winter.

- The salt budget is said to ignore "exceptional flow conditions" such as those which produced the "temporary" high salinities from 1978 to 1981. Apparently this means simply that in drought conditions, salinities will exceed the average which is predicted by the model.

HGC developed a mixing cell model (p. 108) of salinity concentrations. The model deals with low flow conditions only and is said by HGC to be "conservative". The model calibrates with TDS of about 6,000 mg/l at the same location where the field surveys were finding 12,000 mg/l. The model predicts a potential salinity reduction of 70% if brine inflows are completely controlled, an estimate which is much larger than utilized in USBR reports prepared prior to or subsequent to the HGC studies.

USBR (1984). This report documents USBR's field work in 1983-84 and is a major data source for Project evaluation. Unless clearly noted, all statements made regarding the report represent findings or observations of USBR, and not our interpretations.

Data files from the report have been compiled in worksheet format in **TABS 10 AND 11**. Data were collected at:

- Site 1, 1.6 miles below the dam and near the Logan gage;
- Site 2, 2.2 miles below the dam;
- Site 3, 5.4 miles below the dam;
- Site 4, on Revuelto Creek 0.2 miles above the Canadian confluence; and
- Site 6, 9.9 miles below the dam (Site 5 was not developed.)

TAB 24 is a map compiled for the ground-water report, but which is also included here because it shows the sites listed above. In addition to piezometer nests, discussed in the ground-water report, there were staff gages installed at each site, with monthly collection of flow and water-quality data for about 15 months.

Overall, conditions at sites 1 and 2 were similar, with an average flow of about 2 cfs, a chloride concentration just under 3,000 mg/l and a chloride load of about 0.14 kg/sec (or nearly 4900 tons/year). At site 3, the flow averaged about 3 cfs, chlorides averaged about 5800 mg/l and the chloride load was about 0.45 kg/sec (15,700 tons/year). Dilution from Revuelto Creek resulted in conditions at site 6 as follows: average flow of nearly 22 cfs; chlorides averging 3000 mg/l; and a chloride loading of 0.49 kg/sec (roughly 17,000 tons/year).

Data on streamflow are interpreted by USBR as indicating spring discharge from the upper Triassic geologic units. The cumulative fresh water discharge between sites 0 and 6 may be about 1 cfs, creating pools and freshwater zones along the river. Coupled with about 2 cfs of seepage from Ute Reservoir, this makes for about 3 cfs of baseflow. The pools and zones are especially noticeable on the north bank of the river. The spring discharge, combined with seepage flow from Ute Reservoir, makes up the present freshwater base flow in the Logan area. Some freshwater runoff occurs intermittently from small drainages along the Canadian River; and, of course, high flows occur in response to spills from Ute Reservoir.

Revuelto Creek contributes to the freshwater flow of the river also, but on an irregular basis, with flows ranging from 0 to thousands of cubic feet per second, sometimes reaching these extreme peaks within 24 to 48 hours of a storm and receding just as rapidly. Floods from Revuelto Creek back water up the Canadian River a considerable distance. The possible implications of this to salt movement in flooded alluvium are not discussed in the report.

Water quality sampling was conducted monthly. Problems were observed including some samples where the ionic balance indicated errors; data points which were outliers (i.e. far outside normal ranges); data points where total dissolved solids and conductance did not follow normally observed relationships. USBR hypothesizes that one problem may have been the use of potassium chloride to make the temperature correction of conductance data; however, our review of the primary reference on specific conductance - USGS Water Supply Paper 2311 - suggests that the error is not large enough to explain the observed anomalies. At page IV-47, indicates that these errors are collectively significant enough that no conclusions should be drawn based on small fluctuations in the data.

Key findings are as follows. All waters were dominated by sodium chloride dominated unless otherwise noted. Acronyms and units are as defined for HGC (1984).

Location	Salinity values	Comments
Ute Reservoir	TDS = 565	Reservoir surface
Ute Reservoir	TDS = 617	Outlet works; this and above sample show slight dominance of sodium, chloride and sulfate ions
Toe drains	TDS = 1,305	Increased sodium, chloride compared to reservoir
Sites 1, 2, 6	Cl = <3000 SO_4 = <700	Typical values; site 6 values show dilution from Revuelto Creek; ground water often 2 to 3 times saltier
Site 3	Cl = 5700 SO_4 = 1000	Site of highest salt concentrations; shallow ground water often similar but deeper alluvial ground water is the saltiest found in the study
Site 4	Cl = 327 SO_4 = 476	Revuelto Creek

Based on the flow and quality data, in the Canadian River below the Revuelto confluence, most salt comes from the Canadian but most flow comes from Revuelto.

Statistical analyses demonstrated that surface water data and ground water data show the same patterns; these analyses are provided here in **TAB 25**. USBR reports a good correlation between chloride, TDS, and field specific conductance for the data, but a poor linear correlation between streamflow and these same parameters. The correlation did not improve using either the log or inverse of flow versus the three different consituents. Our inspection of the data indicates that better correlations might result if the data were stratified into baseflow and spill conditions. This also is implied by the

USBR, who did observe a flow-quality relationship at mile 2.2 during the June-July 1983 period of releases from Ute Reservoir. USBR did find a flow-quality relationship at site 1, especially during the June-July 1983 period of releases from Ute Reservoir.

In 1983, USBR did a stream survey (see **TAB 12**). The data appear to show conditions similar to those observed by HGC. USBR interprets the data as showing no obvious impact from the construction of Ute Reservoir.

USBR recommended future monitoring rely on a single laboratory which is expert in analyzing brines, and that proper procedures (including temperature correction of conductance data) be followed. A major recommendation (p. IV-57) is that "all data that has been collected from the Canadian River and alluvium near Logan by numerous investigators should be combined and looked at together. Both 'pre' and 'post' Ute Reservoir data could be combined as one data set and analyzed to show trends, if any, that may have been missed by previous evaluations. These determinations would be necessary to establish a base for comparing data collected after a salinity control project was implemented." To date, the recommendations have not been implemented. Note that USBR did interpret the data as showing no obvious impact from the construction of Ute Reservoir.

USBR (1985). The main Project report concludes that about 70% of the sodium chloride entering Lake Meredith comes from New Mexico. Control of the New Mexico brine through pumping is recommended and would reduce TDS at Lake Meredith by about 24%. However, it is noted that, because of influences from freshwater springs and floodflows, discrete sites of brine discharge near Logan have not been adequately defined and may in fact not exist.

Most of the hydrologic data supporting the report comes from the two 1984 studies abstracted above. However, USBR does provide a useful restatement of information from the HGC report. Average surface flows are as follows.

Average Surface Water Flow

Gaging stations	Average Flow (ft^3/s)	Median Flow (ft^3/s)	Period of Record (water years)
Canadian River at Logan	30	2	1963-Spring 1984
Revuelto Creek near Logan	45	8	1963-Spring 1984
Canadian River above the State Line	81	13	1969-Spring 1984
Canadian River at Tascosa, Texas	168	30	1968-1977
Canadian River near Amarillo	190	50	1963-Spring 1984

USBR also tabulates data which show how, on the average, the Canadian River gains in flow between Ute Dam and the gauge near Amarillo.

Flow Gains (cfs)	Percent	Source of water
30	16	Below Ute Dam, of which about 2 cfs is from seepage and ground water inflow, the rest from the few occasions of flow over the spillway. This change due to modifications made to the spillway in spring 1984.
45	24	Revuelto Creek, primarily from irrigation return (about 8 cfs) and floodflows.
5	2	Between Revuelto creek and State Line, primarily from ground water inflow.
87	46	Between State Line and Tascosa, primarily from floodflows, probably from the Punta de Aqua drainage.
22	12	Between Tascosa and Amarillo, mostly from ground water inflow, some from irrigation return and little from flood flows.
Total 190	100	At Amarillo gauge.

At page IV-3 the report summarizes some of the limitations in the available information.

"[T]he surface and alluvial sampling program was designed to help explain the mechanisms controlling movement of salt in the streambed and the interchange between the stream and the alluvium. The HGC (sic) presents annual data indicating that transport of salt in the river varies with flow rate. They also concluded that the salt concentrations in the shallow piezometers resulted from periodic flushing. As stated previously, statistical analysis of the water quality data collected from the piezometers did not correlate with surface flows directly, indirectly, or with various transformations of data including log, natural log, and lagging of the data. Most variations in a single piezometer or grouped piezometers appeared statistically insignificant. However, the data set is also small. The data to support either large storage of salt in the channel alluvium or the flushing of salts from the alluvium by high flows is not available."

At page IV-6, data on tritium are used to reach the interpretation that the actual brine water leaking into the Canadian River is not directly from Ute Reservoir.

At page V-36, the environmental assessment indicates that 35 locations of possible seepage have been identified by EPA based on remote sensing; details are not provided. Note that a final environmental assessment of the Project is provided as USBR (1986). This document mentions the possibility that seepage rates may have increased after the raising of pool levels at Ute in 1984.

3.3 Lake and Stream Surveys

Numerous reports have been prepared which provide water quality data on Ute Reservoir, Lake Meredith and/or the Canadian River, but where the focus is on sanitary conditions, nutrients or general chemistry, rather than salinity.

NMWQC (1975). New Mexico's basin plan for the project area identifies no major point sources of pollution. We also have reviewed the files of the New Mexico Environment Department and the New Mexico Water Quality Control Commission. No major point sources of pollution are reported for the Logan area. Logan itself discharges a relatively small amount of sewage to lagoons which are said to be lined. It may be noteworthy that New Mexico's stream standard for total dissolved solids in the Canadian River below Ute Dam is 6,500 mg/l; and this standard only applies at flows above 25 cfs.

McCarley (1975). This is a water quality report for the Canadian River in Texas. Figure 2 in the report shows a good correlation between streamflow and precipitation. Data tables include TWQB salinity records for the Tascosa and Amarillo gages.

Kirkpatrick (1976). This is the most detailed stream survey for the Texas reach of the Canadian River. It shows the dominant impact of Amarillo effluent at low flows. It is the only reference identified which provides simultaneous observations of flow and salinity for streams directly tributary to the Lake. Big Blue Creek flowed about 5 cfs with a TDS of about 500 mg/l; it was sulfate dominant; this implies an average annual salt load of perhaps 2,500 tons per year, large enough to require accounting in a reservoir salt balance. Four other streams combined to flow about 2.5 cfs, but generally were of better quality than Big Blue Creek.

EPA (1977). A eutrophication study of Lake Meredith, this report deals primarily with loadings and effects of nitrogen and phosphorus. As part of the nutrient budget calculation, EPA estimates an average inflow to the reservoir from the Canadian River of slightly more than 160,000 AFY. It also estimates that direct inflows at 15,200 AFY, of which 6,500 AFY is from Big Blue Creek and 1,500 AFY is from Bonita Creek. Conductance data are reported from four sampling sites for four dates in 1974. Similar reports are available for Ute and Conchas Reservoirs.

Dutton (1978). This intensive survey of the Texas reach of the Canadian River shows the dominant impact of Amarillo effluent at low flows. At page 15, the report hypothesizes that flows at the Amarillo gage are significantly impacted by good quality springflows from Triassic-age geologic units.

Ottmers (1986). This intensive survey of the Texas reach of the Canadian River shows the significant impact of Amarillo effluent, even at a reduced flow quantity. The following statements at page iii are not substantially expanded upon in the text. "One known source of (salts) is an artesian saline aquifer located in New Mexico. Additional salt water springs and seeps are believed to exist along the watercourse."

Smolka (1988). New Mexico's most recent intensive survey of water-quality conditions in the Canadian River below Conchas found TDS at Logan of 5,000 mg/l. Benthic organisms at that site were of poor quality. The State attributed salinities in the river to irrigation return flows and geologic conditions.

Potter and Davis (1989). New Mexico's most recent intensive survey of Ute Reservoir found a small but pronounced salinity stratification near the dam, with the highest salinities in the bottom third of the water column. Conductance values were consistent with a TDS content in the 500-600 mg/l range.

TWC (1990). Data specific to the Canadian River are presented beginning at page 161. The report notes that high chlorides are observed below Lake Meredith, due apparently to sources in the drainage basin of Cottonwood Creek.

3.4 Recent Safe Yield Studies

Two studies published in 1987 provide important information on water supply conditions at Ute Reservoir (Whipple, 1987) and Lake Meredith (HDR, 1987). In addition, while not a safe yield study, the Corps of Engineers drought contingency plan for Conchas Lake (COE, 1991) contains useful information on water supply conditions in the Canadian Basin.

Whipple (1987). This file memorandum of the New Mexico State Engineer Office updates prior safe yield studies of Ute Reservoir to reflect low inflows in the 1970's. Based on a computer model, the report confirms that the safe yield of Ute Reservoir is lower than previously estimated and lower still than had been expected when the reservoir was built. We have extracted results of the Whipple model into a LOTUS worksheet. The hard-copy of the monthly results of his model are provided at **TAB 26**.

With respect to model construction, some key elements of Whipple's methodology are as follows.

- Model inputs include precipitation and evaporation data, with missing points estimated through regressions against more complete (but more distant) data sets.

- Logan streamflows are assumed to equal reservoir inflows for the period prior to dam closure; for subsequent years, inflows were estimated by a mass balance procedure.

- Sediment surveys from 1963, 1975 and 1983 were used to adjust stage-area-volume relationships.

- Bank storage is ignored.

- For the 1939-85 period, i.e. after closure of Conchas, the critical yield period is shown to be October 1972 through July 1981.

- The methodology is considered to underestimate evaporation, hence inflow.

Some of the basic hydrologic relationships shown by the Whipple report are as follows.

- Inflows for 1963-85 were about half of what was measured in 1943-62; this is broadly comparable to the decline in gaged flow at Ute Creek.

- The report notes that there was more spill from Conchas prior to 1963 than since, but the effect of this is not quantified.

- Dam seepage is a function of reservoir elevation; values range from 1.6 to 3.4 cfs. The analysis assumes that much and perhaps all of this might be captured and counted as part of the safe yield; the USBR salinity control project is said to have unknown impacts on the availability of the seepage.

Future yields for the year 2033 are predicted by Whipple's model based on several types of assumptions or computations.

- Future sedimentation was extrapolated based on the historically observed rate, which is half of the original design estimate.

- Historical evaporation rates and inflows are assumed to be repeated.

- Diversions of 20,600 AFY are assumed to be made for municipal demand except for very limited periods when this would lower the reservoir into the inactive pool.

- Projected seepage rates range from 1,300 to 2,400 AFY, averaging about 2,100 AFY. During the critical drought period the seepage average is about 1,700 AFY. Both values appear to exceed historical values given in Project reports, possibly because of higher pool levels which result from enlargement of the dam (completed in 1987) and because Whipple is including the downstream inflows in his seepage number.

- In Whipple's outputs, spills average 66,700 AFY but this value is dominated by anomalous conditions in 1941-42. For the period 1963-83, spills are estimated at only 1,600 AFY and during the critical drought no spills are projected. In effect, what this says is that the actual historic spills (some 20,000 AFY) would be almost completely consumed by the assumed diversion of water to municipal demand in New Mexico.

The result of the model is an estimate of firm yield at 19,300 AFY, without including capture of seepage, and without consideration that brief shortages might be tolerated. The results are quite sensitive to assumptions about reservoir capacity (i.e. sediment deposition rate).

Our interpretation of Whipple's outputs (done as part of this study) indicate that for the hypothetical forecast, inflows to the reservoir would be distributed roughly 23% to evaporation, 18% to municipal demand, 2% to seepage and 58% to spills. On this basis, one would expect steady-state salinity to be only moderately above inflow salinity. However, for conditions equivalent to those experienced in 1963-83 (i.e. similar to the HGC study period), almost all the inflows go to evaporation and municipal demand. This means that reservoir salinity should approach a value about double that in inflow waters.

We asked SEO for a copy of the model, so that it could be rerun to hindcast; or to forecast with different assumptions. They declined, due to the fact that Compact litigation is ongoing. A modified version of the model was obtained from USBR. At some point, it could be useful to compare the Whipple and HDR methodologies, and also their results (e.g. evaporation estimates for Ute Reservoir). The following comments relate to potential uses of the model.

- Whipple's model could be used to forecast spills and seepage (i.e. supplies potentially available to CRMWA) if the diversions from Ute Reservoir are less than the assumed value of 20,600 AFY. Diversions less than the assumed amount seem likely, because the costs of using Ute for municipal supplies in New Mexico are high - at least $2.50 per thousand gallons - and most communities have access to lower cost Ogallala ground water.

- The model also could help answer questions about the benefits from different outcomes to the current Compact litigation, i.e. releases to compensate Texas for past Compact violations and/or to avoid future Compact violations. Note that any policy which drew Ute down in order to release water downstream would decrease evaporation and seepage losses from the reservoir. However, the model did assume that as of 2033 there would be less than 200,000 AFY of storage available in Ute Reservoir. In effect, then, it may be that the results can be considered to implicitly reflect the Compact limitation of 200,000 AFY conservation storage in the reservoir.

Discussions with Paul Elliot of the Texas Attorney General's Office indicate that the Compact proceedings have not involved any studies to quantify possible future flows. Probably the Whipple model would be the best tool if CRMWA or the State wishes to estimate such flows. Whipple's model also would be the appropriate hydrologic basis for development of a Ute Reservoir salt balance.

HDR (1987). This safe yield study for Lake Meredith is based on 1940-84 conditions, and includes estimated yields for Conchas and Ute. The report compiles useful data on streamflow, precipitation, pan evaporation, diversions, reservoir contents and elevation-area-storage relationships. **TAB 27** is used to present some of tables and graphs from the report. The report notes numerous problems in the source data, e.g. the fact that even USGS gaging station records may be off by 8% or more. HDR filled in some missing or questionable data through comparisons to other stations; it would be interesting to compare the results to those generated by Whipple.

The data show a very large decline in flow at the Logan gage after 1963 (187,563 AFY 1940-62, 27,433 AFY 1963-84). The decreased flow at Amarillo is broadly comparable, with 1963-84 average and median of 131,730 AFY and 90,000 AFY respectively. Note that inflows were estimated through use of regression techniques, along with a mass balance method. Apparently, this was done in order that hypothetical operations studies could be performed. We note that the regressions appear to be based on the entire historical data set, but are applied only when certain conditions are met (i.e. mostly to predict high flows). This use of regressions is not conventional.

It would require substantial effort to work through the model inputs and outputs to replicate and understand the methodology. Without such an effort, our provisional judgment is that Whipple's approach to safe yield analysis is preferable. To provide further insights, we have extracted the 1963-84 water balance from the model run most representative of actual conditions (no Ute diversions, Conchas spills, 1980 elevation-area-storage relationships). This is provided in **TAB 28** along with a Lotus worksheet which summarizes annual values. Based on that model run, and on HDR's text, we make the following observations.

- For Conchas and Ute, special regressions were used for 1940-41. It isn't clear why HDR didn't follow the conventional custom and ignore these hydrologically unique years.

- At Logan, 65% of monthly flows are between 100 and 200 AF (10% are less, 25% are more). This reflects steady seepage from Ute, i.e. at a rate betwen 1.5 and 3 cfs.

- At Meredith, seepage was estimated from average water surface elevation using a power curve fitted to CRMWA data. Seepage at Conchas and Ute (along with releases/spills) was assumed to be captured by gage data. Gaging at Conchas ended in 1972, but this isn't a problem since there were no major spills in the 1972-84 period.

- Amarillo flows correlate reasonably well with flows at Logan; about 38% of the Logan flow is lost before it reaches Amarillo.

- Estimated inflows to Lake Meredith correlate with Amarillo gaged flows. The regression indicates that 15.4% of Amarillo flow is lost above the reservoir; this would make inflows only about 110,000 AFY, an estimate which seems low compared to other information.

- While the estimated evaporation rate of 40,600 AFY is computed based on assumed reservoir operations at safe yield, rather than for real conditions, it still seems low compared to other studies.

- Data from mid-82 through 1984 were not used in the model. The explanation, that "there were no releases from Ute at that time", isn't clear, since there have been no releases from Ute at many other times.

- The report does not account for reduced flows when Amarillo effluent went off-line in 1977.

- Data plots suggest a need to stratify the data (e.g. to separately consider flood flow and baseflow hydrology), but this was not done consistently.

Although the model methodology isn't entirely clear, and may be problematical in some respects, the results are well-stated. 1973-81 is the critical period for a safe yield analysis. Yields at Meredith range from 64,750 AFY with assumptions which retain the most water in New Mexico, to 77,300 AFY with those that retain the least. Accounting for future sedimentation, a safe yield estimate of 71,450 AFY may be appropriate. We interpret the water balance as suggesting that long-term salinity will be about 1.5 to 1.67 times inflow salinities, which is less than shown by other studies.

COE, 1991. The purpuose of this Drought Contingency Plan (DCP) is to provide a basic reference for water management decisions and responses to a water shortage induced by climatological droughts in the Canadian River Basin downstream to the New Mexico-Texas State Line. As a water management document it is limited to those drought concerns relating to water control management actions. Because of the long-term nature of a drought and uncertainties of the specific problems that may result, this document details only a limited number of specific actions that can be carried out related to water control. Its primary value is in documenting data needed to manage the District's water resources to insure that they are used in a manner consistent with the needs which develop. This Drought Contingency Plan is Appendix A to the Conchas Reservoir Regulation Manual dated October 1965. It covers Conchas Lake.

The drought analysis uses the Palmer Drought Severity Index. The longest drought on record for the upper Canadian River Basin is an 88-month period, November 1949 thorugh February 1957. However, in terms of the frequency of extreme dry months, this period ranks second to the 30 month drought from May 1962 through October 1964. The report provides extensive information on water uses which rely on Conchas, and how they would be adjusted when different drought conditions recur.

Note that COE has prepared numerous other documents regarding Conchas Reservoir, such as planning and engineering reports and operations manuals. These documents could need to be studied if CRMWA were to include Conchas operations in any safe yield model developed for Lake Meredith. They have not been studied as part of the preparation of this basic data notebook.

4. CONCLUSIONS, QUESTIONS AND RECOMMENDATIONS

4.1 The Basic Conclusions of the Project Reports

The Project reports present a relatively simple water balance for the study area, based mostly on HGC (1984). Since Ute Reservoir was completed, the average annual flow at Amarillo has been 190 cfs (roughly 137,000 AFY). There are both gains and losses in flow between Amarillo and Lake Meredith, where the net inflow is roughly 125,000 to 130,000 AFY. On a quantitative basis, it is clear that less than half of this flow originates in New Mexico; and for practical purposes, the water supply contribution of the Logan brine aquifer is negligible.

The water budget for Lake Meredith indicates that long-term salt concentrations in the reservoir will be roughly double the concentrations measured at the Amarillo gage. USBR (1979) computed salt loadings to Lake Meredith (chloride, sulfate, sodium) of more than 84,000 tons per year. The Project reports estimate that 70% of the sodium chloride originates in New Mexico; 44% is from the brine aquifer. On this basis, a small amount of water control at Logan could accomplish substantial salinity control at Meredith.

4.2 Remaining Questions, and Some Answers

Despite the relatively simple and straightforward conclusions in the Project reports, the reports themselves do identify problems in the underlying data. The comments we have provided in Section 3 indicate additional concerns, not only with the data but with certain data analyses and interpretations. To assist CRMWA in determining what is truly known about the link between Logan brine and Lake Meredith salt, we have posed a series of questions regarding hydrology and/or salinity in the Canadian River system and we have performed initial research to answer some of these questions. The purpose of the questions and answers is to help determine what further studies may be needed before deciding on how (or whether) to build the Project.

The questions are presented and explained below; and the preliminary answers are provided where available. The discussion proceeds more or less downstream from Ute Reservoir. Most of the discussion is on conditions in New Mexico, since this is the area emphasized by the Project reports. The questions specifically raised are as follows:

- why has the yield of the Canadian River dropped so dramatically since Ute Reservoir was constructed?

- is it true that there has been no trend toward increased salinity at Ute Reservoir?

- is it true that there is no salinity stratification at Ute Reservoir?
- how much seepage occurs from Ute Reservoir?
- how much salt does Ute Reservoir contribute to Lake Meredith?
- was there steady brine flow into the Canadian River before Ute Reservoir was constructed?
- has the baseflow of the Canadian River changed since Ute Reservoir was expanded?
- has the increase in Logan baseflow had any impact on salt loading?
- is brine inflow continuous or localized?
- is brine inflow really 0.6 cfs?
- does the brine aquifer contribute 5,400 tons/year of sulfate?
- is the location of the brine aquifer as described in USBR (1979)?
- what is the rate of ground water inflow from Logan to the State Line?
- are there other brine inflows in New Mexico?

Note that the answers provided are modified from those given in a previous report to the extent that new information has become available. Further, the previous report recommended and CRMWA authorized two specific studies. The results of these studies are summarized in the current notebook as follows: Section 4.3 summarizes our modeling of State Line salinity conditions; Section 4.4 provides a brief review of the results of the 1992 stream survey.

Why has the yield of the Canadian River dropped so dramatically since Ute Reservoir was constructed? The Project reports don't directly answer the question of why flows at the Logan gage have been remarkably low since 1962. Based on Whipple's model, the primary cause is decreased natural runoff and not reservoir evaporation and diversions. We are aware of a report analyzing runoff conditions in the North Canadian Basin of Oklahoma (Boyle, 1987). While the Boyle report has not been reviewed for this study, the report abstract attributes runoff declines to ground-water pumping and to development of soil and water conservation practices.

Is it true that there has been no trend toward increased salinity at Ute Reservoir? The Project reports state that no such trend has been identified. However, any arid-zone reservoir should show increased salt concentrations over time. The data necessary to evaluate Ute are provided in **TAB 29**. While the data clearly show freshening after times when inflows have been large (i.e. when storage increases), a trend toward increased salinity *is* evident.

Specifically, in the period 1968-73, chlorides typically were less than 30 mg/l and sulfates were less than 150 mg/l. Since then they have been over 40 mg/l and 200 mg/l respectively, with maxima of 71 and 260 mg/l. Specific conductance has increased from values mostly less than 700 umhos/cm to values approaching 1000 umhos/cm. The data indicate TDS is about 63% of conductance at the reservoir, so this conductance change suggests that dissolved solids have increased from roughly 400 mg/l to 600 mg/l.

Is it true that there is no salinity stratification at Ute Reservoir? HGC reported that no such stratification had been observed, but New Mexico's most recent intensive survey of Ute Reservoir found a small but pronounced salinity stratification near the dam, with the highest salinities in the bottom third of the water column (Potter and Davis, 1989). (Limited USGS data are consistent with the existence of stratification.) Our judgment is that this stratification existed before 1989 and was demonstrated by Potter and Davis simply because their study was relatively intensive. Stratification in the reservoir probably doesn't have a marked impact on salinity conditions in the Canadian River at present, but could be important if the Canadian River Compact leads to planned releases from the reservoir.

How much seepage occurs from Ute Reservoir? [Note, this discussion refers to conditions characterized by USBR reports, and does not consider increased seepage known to have occurred since Ute Reservoir was enlarged.] HGC (1984) observed about 1 cfs or so of seepage from Ute Reservoir. However none of the Project reports provide any clear and convincing basis for explaining why baseflow at Logan is typically at least 2 cfs. Whipple's water balance for Ute Reservoir estimated seepage rates substantially exceeding 2 cfs on average, and some studies we have performed (discussed below) also suggest that the seepage loss is significantly above 1 cfs. We have found no engineering or hydrologic studies which calculate the seepage loss directly, i.e. as a function of reservoir levels and aquifer properties. On balance, we expect Ute seepage prior to dam enlargement was higher than the 1 cfs estimated by HGC. In any case, it is certain that today's seepage rates are much higher than 1 cfs (see subsequent discussions).

How much total dissolved solids does Ute Reservoir contribute to Lake Meredith? The contribution of the Reservoir to Lake Meredith's salt budget is scarcely discussed in the Project reports. Our quick calculations indicate that current TDS loading to the Canadian River from Ute Reservoir may approach 20,000 tons/year. This assumes 2 cfs of reservoir seepage at 1300 mg/l; and 28 cfs of spills at 600 mg/l. Although little of this load is chloride, the sulfate load is significant - perhaps 7,000 tons per year, or roughly 25% of the total sulfate input to Meredith calculated by USBR.

Was there steady brine flow into the Canadian River before Ute Reservoir was constructed? The Project reports say there is no evidence that construction of Ute impacted brine inflow to the Canadian. However, before

Ute was built the Canadian was dry (or nearly so) at the Logan gage more than 25% of the time. This should not have been the case if there was a steady brine inflow. In constrast, all evidence indicates that under current conditions, brine inflow above (and below) the Logan gage is continuous. The implication is that the reservoir may have increased the brine inflow to some extent, by making the flow more constant.

Has the baseflow of the Canadian River changed since Ute Reservoir was expanded? In the mid 1980's, the spillway level at Ute Dam was raised, allowing increased reservoir storage. The Project reports recommend that the hydrologic impacts of this change be studied. The work we have done in making the USGS data set readily available for analysis makes it easy to conduct the study. **TAB 30** plots the relevant data (streamflow at Logan; water stored in reservoir) for a roughly 1 year period in 1986-87, the time when the expansion project was completed and the reservoir was refilled.

Initially, the increase in storage caused baseflow to decrease from the typical 2 cfs value! Then baseflow increased, to above 3 cfs, and this higher rate has continued through the present. Based on CRMWA's stream survey in 1992, most of this baseflow (about 2.35 cfs) originates from Ute Reservoir, through dam and spillway leakage or reservoir seepage.

Has the increase in Logan baseflow had any impact on salt loading? A previous draft of this document asked whether the increase in baseflow might reflect larger brine inflow. The question couldn't be answered from data on hand, because water-quality measurements aren't routinely made at the Logan gage, and there had been no stream surveys to measure salinity since the reservoir was expanded. Now, with the data from the 1992 CRMWA stream survey, it appears that salt loading has not increaased because of the increase in baseflow at the Logan gage; see Section 4.4.

Is brine inflow continuous or localized? Data compiled by USBR are not sufficient to answer this question, and we developed a model to show that it was arguable that inflow was continuous in the first six miles below Ute Dam. The modeling is discussed in **TAB 31** and the results were one reason why we recommended that CRMWA resolve the uncertainties by performing a stream survey which compiled both flow and salinity data. Now, the CRMWA stream survey (Section 4.4) indicates that the answer is "localized", with maximum inflow in the reach just above Revuelto Creek.

Is brine inflow really 0.6 cfs? The simple model describe in **TAB 31** generates a chloride load of 0.55 kg/second at mile 6. Adjusting downward by 10% (to account for model bias as described in the tab), and subtracting out Ute seepage, the chloride load in ground water inflow is roughly 0.5 kg/second (17,400 tons/year). If all of this comes from the brine aquifer, and if chlorides in the brine average 22,000 mg/l, then the brine inflow rate is 0.8 cfs, not 0.6 cfs. And, if this is true, then the total chloride load from the aquifer is higher than given in the Project reports.

A partially independent check on this result is that, at 0.8 cfs, the brine aquifer would deliver some 17,250 tons/year of chloride to the Canadian River. During 1983-84, USBR typically measured 3 cfs of flow at mile 5.4, with an average chloride of 5780 mg/l, or 17,340 tons/year. Note, these calculations do not reflect current conditions.

Does the brine aquifer contribute 5,400 tons/year of sulfate? It does if the brine inflow is 0.6 cfs, as estimated by the Project reports, and if sulfates in the brine aquifer average 9,000 mg/l, as stated in USBR (1979). However, the data in USBR (1979) also indicate that the chloride:sulfate ratio in the brine aquifer is less than 2.5:1. In comparison, USBR (1984) demonstrates that Logan area base flows and shallow ground water have a chloride:sulfate ratio of 6:1 to 10:1. The two different ratios imply that two different types of water are involved. The salt water seen in the Canadian River near Logan must be coming from a source which is low in sulfates. The obvious question is: does this mean that the brine aquifer is not the source of the salt water seen in Logan streamflows?

With the help of CRMWA, we checked the data from USBR (1979) against other samples taken from the USBR test wells. The data indicwte that sulfates in the brine aquifer average only 2500 mg/l, with a chloride:sulfate ratio of nearly 9:1. Consequently, we conclude that USBR (1979) is in error in its estimate of sulfate concentrations in the brine aquifer and that it is reasonable to conclude that the brine aquifer *is* the source of the high chloride, low sulfate baseflow observed near Logan.

The low sulfate concentrations in the brine aquifer mean that the Project reports overestimate the significance of the aquifer in salt loading to Lake Meredith and consequently overestimate the benefits of pumping the brine aquifer, at least with respect to sulfate. Actual sulfate loads from the brine aquifer (prior to reservoir expansion) were no more than 2000 tons/year.

Is the location of the brine aquifer as described in USBR (1979)? Based on Figure 5 is USBR (1979), the brine aquifer underlies Ute Reservoir and the first 3 or so stream miles below the dam, but does not extend to mile 6. It is not clear how this location can be correct, and still explain brine inflows which do extend to mile 6. As discussed in the ground-water notebook, several lines of evidence support an interpretation that the brine aquifer extends nearly to Revuelto Creek.

What is the rate of ground water inflow from Logan to the State Line? Based on HGC (1984), ground water inflow from the Triassic aquifer between Ute Dam and the State Line is about 0.15 cfs/stream mile; this would amount to nearly 5 cfs in the reach from Logan to the State Line. Note, however, that when one adds this 5 cfs to the 2 cfs median flow at Logan and the 8 cfs median flow in Revuelto Creek, the median flow at State Line should be 15 cfs, rather than the 13 cfs reported by HGC. HGC and USBR are consistent in indicating that about 1 cfs of the 5 cfs occurs upstream of Revuelto Creek, and the rest comes into the system between Revuelto and the State Line.

For this study, we have taken the USGS data and developed a rough water and salt balance for the State Line. The results are discussed in Section 4.3 and presented in **TAB 32**.

Are there other brine inflows in New Mexico? In the previous report, we answered this question by indicating that significant brine inflows may occur between Revuelto Creek and the State Line. The State Line salt balance (Section 4.3) and the 1992 stream survey results confirm that brine inflows in New Mexico are not limited to the Logan area. Section 4.3 includes our best estimates as to the relative importance of the Logan brine aquifer to salt loading at the State Line and at Lake Meredith.

4.3 Salt Loading at the State Line

Background. Table 7 in HGC (1984) indicates that the average chloride load at the State Line gage, 1969-83, was 0.80 kg/sec or about 28,000 tons/year. Combining information from the Project reports, some of this load can be accounted for as follows:

- seepage from Ute Reservoir - 0.01 kg/sec (Table 7, HGC, 1984);
- spills from Ute Reservoir - 0.04 kg/sec (assumes 50 mg/l in 28 cfs; see discussion in Section 4.2);
- brine inflow near Logan - 0.45 kg/sec (USBR, 1984, based on measurements over more than 1 year, 1983-84; measured at mile 5.4);
- runoff from Revuelto Creek - 0.08 kg/sec (Table 7, HGC, 1984);

These estimates are not based on identical methods or measurement periods and are not fully comparable. However, assuming that they are all of the correct order of magnitude, their sum is 0.58 kg/sec, which is 0.22 kg/sec less than the load reported for the State Line. This rather large difference requires an explanation.

The explanation was obtained by applying the computer hardware and software tools which are discussed in Section 2.1 and which provide previously unavailable opportunities to analyze hydrologic (and other) data. **TAB 32** presents major products of the computer analysis: a printout of the basic data base; printouts of spreadsheets summarizing salt loading calculations; and graphs showing various results of the analysis.

Concept. For practical purposes virtually all of the flow and salt load measured at the State Line gage must come from one of five sources:

- **1)** seepage and spills from Ute Reservoir;

- **2)** runoff from Revuelto Creek, the major tributary to the Canadian River between Ute and the State Line;

- **3)** runoff from other surface water tributaries to the Canadian River between Ute and the State Line, termed here "local runoff";

- **4)** ground-water inflow (termed baseflow) which occurs in the six-mile reach between Ute Reservoir and Revuelto Creek, termed here "Logan baseflow"; and

- **5)** baseflow between Revuelto Creek and the State Line, termed here "Dunes baseflow" after the "Dunes dam site" which was studied by the New Mexico State Engineer in the 1950's-1960's and which occurs within the reach.

Sources 3 and 5 are the ones which were not accounted for in the salt loading information derived from the Project reports. The purpose of the computer analysis is to see if it is possible to determine whether either of the sources is in fact likely to generate a significant amount of salt loading at the State Line.

Data base. The approach taken was to go behind the average salt loading numbers which were presented in the Project reports and to examine data from individual points in time to see how the salt loads vary during different hydrologic conditions. It should be possible to explain variations in loads at the State Line as a function of predictable variations in the loads contributed by the upstream sources.

The maximum data base for any one point in time occurs on a day when USGS measured flow at all three of its gages in the area - Logan, Revuelto and State Line - and chloride and sulfate data also were collected at State Line. [Ideally, one would like same-day chloride and sulfate data for Logan and Revuelto, but in fact USGS has collected limited data on those parameters at these gages.] Computer programs described in Section 2.1 were used to sort out relevant records from the USGS data base for the period 1969-86, when all three gages were operating.

The data base for the Logan and Revuelto gages is large - several thousand days of measurement - but that for State Line is limited. In total, there are 135 ideal data sets, that is dates on which all five types of data are available (flows at the three gages; chloride and sulfate at State Line). The data set is included in **TAB 32**.

Overall patterns in data. For the 135 data sets as a whole, flow at Logan averaged 34 cfs, Revuelto flow was 41 cfs and State Line flow was 79 cfs. These flows are consistent with estimates made in HGC (1984), which were 30 cfs, 45 cfs and 81 cfs respectively; they also are consistent with the flows observed in the entire USGS data set. The data indicate that State Line flows average about 4 cfs higher than the combined flow at Logan and Revuelto, whereas HGC (1984) estimated a gain of 5 to 6 cfs. Interestingly, based on **TAB 32**, Logan streamflow was unusually low and Revuelto flow was unusually high in the period 1974-80, a time of generally low inflow to Lake Meredith.

For the 135 dates combined, the average chloride load was 0.77 kilograms/second, very close to the 0.80 kg/sec calculated by HGC (1984). The average chloride concentration was 1800 mg/l, compared to 1728 mg/l estimated in HGC (1984). The loading rate was over 0.9 kg/sec prior to 1973 and has been about 0.7 kg/sec since then. These values place the annual load in the range 25,000 to 30,000 tons/year. An important test of any procedure used to calculate salt loadings at the State Line is to see if it can explain the decline in loading rate since the early 70's.

Hydrologic patterns. The next step was to inspect the data to identify hydrologic patterns, i.e. patterns of flow which might reflect differing influences over time of the different salt sources. There are two basic patterns.

- In one, flow at the State Line is small (usually 20 cfs or less) and flows at Logan and Revuelto are even smaller. This pattern is taken to represent conditions of baseflow (no significant runoff) throughout the river reach from Ute to State Line. The data from baseflow periods reflect conditions of relative stability in the hydrologic system and thus are ideal for investigating salt loading conditions, especially the influence of brine inflow. During the winter months, the majority of data sets show baseflow conditions. During summer months, baseflow periods are mixed in with spill/runoff periods (see below).

- The second pattern is one when spill or runoff is occurring, and flows at State Line are tens to hundreds of cfs. Sometimes the flow can be ascribed to Ute spills (e.g. flows at Logan are near or above 100 cfs); or to Revuelto runoff (40 cfs or more in summer, 10 cfs or more in winter); or to local runoff (flows at State Line are tens to hundreds of cfs higher than the sum of the Logan and Revuelto flows); or to a combination of the three sources. Inspection of the full gaging station record indicates that, as expected, during spill or runoff, the flows can vary substantially from day to day at a given point; and, further, peaks that are measured at the Logan or Revuelto gage don't reach State Line until the following day or later. Thus, during runoff or spill events, a direct comparison between conditions observed at State Line and conditions observed upstream on the same day may not be entirely appropriate. However, no simple rule-of-thumb exists to fix this problem, and so while we used the same-day comparisons in our analysis, we relied especially on the baseflow data for our interpretations.

Stratification of data set. After identifying these two basic flow patterns, we organized ("stratified") the 135 data sets according to hydrologic condition (see **TAB 32** for details) and then built water and salt budgets for each data set (see subsequent discussion). The stratified data set can be used to look directly at baseflow conditions, to see if there is evidence that Dunes baseflow is a real process.

Data for baseflow periods in winter (when evapotranspiration isn't a major complicating factor, and the total data base is relatively large) indicate a consistent gain in flow between the Logan gage and the State Line gage, with the gain averaging nearly 7 cfs after (the usually small) Revuelto flows are subtracted out. On average, the baseflow gain between Logan-Revuelto and State Line is more than half the total flow at State Line, so this interpretation is not based on subtle patterns in the data. We judge the data as providing convincing evidence that ground water is discharging to the Canadian River in the Dunes reach.

During summmer baseflow conditions, the pattern is more irregular and there are even days of flow loss, but on average the gain is nearly 3 cfs. On an annual average, then, the baseflow gain is about 5 cfs, which is consistent with information provided previously. Based on USBR (1984), 1 cfs of this gain occurs in the general area of the gravel pit reach.

<u>Streamflow values used to calculate salt loads</u>. For each date in the data set, an estimate was made as to the amount of flow coming from the different water sources. These estimates were made based on actual USGS data where possible, and on the Project reports otherwise. The estimating procedures were as follows.

- Revuelto flows were taken directly from the USGS data.
- During baseflow periods, Logan baseflow was assumed to be 2 cfs measured at the Logan gage and another 1 cfs downstream (e.g. in the gravel pit reach); this is the pattern observed by USBR (1984).
- Dunes baseflow was assumed to be 4 cfs at times when spill or runoff was occurring; otherwise it was equal to the gain in flow between Logan-Revuelto and State Line, minus 1 cfs (the gain which occurs in the gravel pit reach);
- During spill periods, Ute spills were assumed to equal gaged flow at Logan, minus the typical baseflow at the gaging station, 2 cfs.
- Local runoff was assumed to occur only when large flows at State Line couldn't be explained by Revuelto runoff or Ute spills. The runoff quantity was equal to the gain in flow at State Line (i.e. the difference between State Line flow and the sum of flows at Logan and Revuelto), minus 5 cfs of baseflow (that is, 1 cfs from the gravel pit reach and 4 cfs in the Dunes reach).

<u>Chloride loadings from the "known" sources</u>. Average chloride concentrations can be estimated for the three sources studied in the Project reports and/or assessed previously in this notebook: Ute spill; Logan baseflow (which includes Ute seepage); and Revuelto flow. These concentrations can be multiplied by the streamflows determined for a specific date, and after an adjustment to account for units, the result will approximate the chloride loading from the source for that date. While this method for estimating chloride loads is crude, it is superior to any other method we know of for assessing long-term salinity sources above State Line.

Chloride concencentrations for Ute spills were determined based on data for reservoir quality (e.g. see **TAB 29**); these concentrations should vary only moderately over time, and should be relatively independent of flow. For Logan baseflow and Reveulto flows, chlorides were assumed to be within the range of concentrations observed by USBR in 1983-84, and to be reasonably close to the average of those concentrations. For example, when the computer analysis work began, chloride in Logan baseflow was assumed to be 5728 mg/l, the average value measured by USBR (1984). Small adjustments to the estimate were allowed as part of the computer analysis.

For Revuelto, the small data set does clearly indicate at least two salinity regimes - runoff events with relatively low salinity and return flow events with higher salinity. Thus two different chloride concentration values were used for Revuelto.

Values ultimately used to generate the printouts presented in **TAB 32** are (in mg/l):

Source	Chloride
Ute spill	40
Logan baseflow	5500
Revuelto baseflow	400
Revuelto runoff	60

When the calculations are made for the entire 135 data sets, and averaged, the loads are (see page 10 of **TAB 32**):

- 0.04 kg/sec for Ute spills;
- 0.52 kg/sec for Logan baseflow; and
- 0.10 kg/sec for Revuelto flows.

[Note: 1 kilogram/second for an entire year equals about 34,800 tons.]

These estimates are reasonably consistent with HGC (1984). While the estimate for Logan baseflow is 10% higher than estimated by USBR, it includes an extra 10% of the river (i.e. to mile 6 instead of mile 5.4) and therefore is consistent with the previous work. TThe sum of the three salt loads is 0.66 kg/sec, only 0.11 kg/sec short of what was observed at State Line. Thus, one result of the calculations reported here was to reduce the differential between State Line chlorides and Logan-Revuelto chlorides compared to HGC (1984).

Chloride loading from Dunes baseflow. To investigate the origin of the 0.11 kg/sec of chloride which reaches the State Line from sources downstream of Revuelto and Logan, we looked at both Dunes baseflow and local runoff. After testing many assumptions for Dunes baseflow, it was determined that chloride loadings in the Dunes reach may be non-linear: chloride concentrations and loads are greatest during periods of higher baseflow. This unsteady loading is quite different from the very steady loading observed in the Logan reach by USBR (1984).

Consequently, chloride concentrations in Dunes baseflow were calculated by assuming a value of 850 mg/l during runoff and very low flow periods; and by raising the computed chloride load to the 1.15 power during baseflow periods, so that the load would increase exponentially as baseflow increased.

For the entire 135 data sets, the resulting average contribution from Dunes baseflow is 0.11 kg/sec, exactly what is needed to account for the incremental chloride load observed at the State Line. Moreover, most of the load occurs in winter (0.18 kg/sec), and during winter baseflow conditions, the computer calculations of chloride load at State Line are in particularly good agreement with observed loadings (see graph, page 11 of **TAB 32**). [Note further, the model "error" or difference from observed chloride loads has a standard deviation of only 0.15 for this data set, quite low compared to the mean load estimate which is 0.72 kg/sec.]

In our judgment, the input of chloride in the Dunes reach must be real. No other source could explain why State Line chlorides during winter baseflow are one-third higher than the sum of Logan and Revuelto chlorides. However, it also seems clear that the chloride input is different from that observed near Logan - it is more dilute and much less constant. Interestingly, brine inflow at Logan was less constant prior to construction of Ute Dam.

Chloride loading from local runoff. Extensive efforts were made to find a relationship in which local runoff might provide an explanation for at least some salt loading. These efforts did not succeed. One reason may be that, as noted previously, the data from runoff periods are not entirely reliable. Moreover, inspection of the data indicates that on dates when local runoff clearly was occurring, the effect of the runoff was to greatly freshen the State Line flows.

Evidence for salt flushing. The concept of salt flushing is that salts carried by streamflows may be deposited in channel or floodplain sediments for a period of time, to be flushed out later during periods of high streamflow. Salt flushing does not increase the total salt load, but it does change the time relationship between when salt originally enters the stream system and when it reaches a measuring point such as the State Line.

Salt flushing would not be expected to be important in the Logan reach, since brine inflow there is nearly constant (USBR, 1984). In the Revuelto-State Line reach, it is not uncommon for streamflows to decline downriver, in which case much of the salt being introduced to the reach from Logan (or Reveulto) must be deposited along the channel. Certainly, the calculation results shown in **TAB 32** show many dates (mostly summer) when the chloride load at State Line is substantially less than the sum of the upstream loads.

And, conversely, a few of the data sets do represent conditions when streamflow levels were very high and the computer-calculated salt budget fell far short of the actual salt load at State Line. On these dates, it is plausible that salt which had been deposited previously was being flushed out. Examples are: 9/3/70, when the calculated chloride load was 0.94 kg/sec, versus 4.20 kg/sec measured; and 8/18/77, when the calculated chloride load was 3.91 kg/sec and the observed 5.62 kg/sec.

The study results provide no indication of any long-term shift in the salt budget at State Line except that which is explained by changes in streamflow sources over time. In particular, while a plot of cumulative chloride loadings over time (page 14 in **TAB 32**) does show a lower slope since 1973 than before 1973, the plot of model loadings shows the same pattern. This indicates that almost all the salt which we can reasonably project as reaching the Canadian River below Ute Dam in New Mexico is reaching the State Line, without being lost en route.

> [The graph does reflect a net negative load in the Dunes reach in 1973-74, which could represent a time of salt deposition. However, the negative loading calculation is the result of one value extrapolated over a period of more than 1 year when there are no data sets available for analysis.]

A plot of cumulative mass curves for the individual salt sources (page 14 in **TAB 32**) suggests that the decreased loading at the State Line reflects a combination of: 1) a slight but definite decrease in loading from Logan baseflow; 2) a very sizeable definite drop in loading from Revuelto Creek after the mid-70's; and 3) a low loading rate from Ute Reservoir from 1972 through the early 80's. Interestingly, loading rates from Dunes Baseflow appear to have been increased since the mid-1970's.

<u>Results of calculations, by hydrologic condition</u>. The chloride budgets calculated using the procedures described above can be compared to the actual salt loading at State Line, for various hydrologic flow conditions. The results are as follows.

Hydrologic condition	Observed load	Calculated load
Ute spill, Revuelto runoff	1.69 kg/sec	1.65 kg/sec
Ute spill, Dunes baseflow, summer	0.97 kg/sec	1.00 kg/sec
Ute spill, Dunes baseflow, winter	0.89 kg/sec	0.80 kg/sec
Baseflow at Logan, Revuelto runoff	1.24 kg/sec	0.96 kg/sec
Baseflow at Logan & Dunes, winter	0.70 kg/sec	0.72 kg/sec
Baseflow at Logan & Dunes, summer	0.44 kg/sec	0.55 kg/sec
Ute spill, local runoff	0.49 kg/sec	0.74 kg/sec
Overall data set, 135 data points	0.77 kg/sec	0.77 kg/sec

Of course, results for individual dates in the data set may not show such close agreement; averaging the results as shown above tends to make the calculation procedure look better than it really is. Even so, based on these comparisons, the methodology used to calculate chloride budgets produces results which we judge to be reasonable. Graphs showing winter and summer baseflow conditions also indicate the calculation procedure is reproducing the real world fairly well (see pages 11 and 12 of **TAB 32**). The graph for the entire data set (page 13 of **TAB 32**) is considered supportive of the calculation procedure as well. The most prominent exceptions occur where the calculated salt load falls far short of the actual chloride transport; the two specific dates of greatest discrepancy were discussed previously.

The nature of the computer tools is such that one can continue to evaluate the data almost indefinitely. The results presented here therefore are not necessarily final, though few major changes have occured in the basic interpretations since the calculation procedure was initially formulated.

Sulfate loads. The printouts in **TAB 32** contain the results of sulfate calculations which were made using much the same procedures as were used to calculate chloride loads. The purpose of the sulfate calculation was to double-check the chloride calculation. That is, the same basic procedures used for chloride should work for sulfate; if they don't, then the entire analytical concept is suspect. In the case of Dunes baseflow, for example, the calculated sulfate concentration is 140 mg/l, which is a reasonable value for a source which contains 850 mg/l or more chloride.

The overall loading results for sulfate show that, as expected, Revuelto Creek and Ute spills are the major sulfate sources in New Mexico. Each source explains about 37% of the 0.36 kg/sec sulfate load at the State Line. Because the brines which discharge to the Canadian River are highly chloride dominant, ground water sources of sulfate are modest - Logan inflows account for 20% of the sulfate and Dune baseflow is about 5%.

Summary of chloride sources at State Line. As the calculations now stand, the relative importance of the different chloride sources is as follows:

- Logan baseflow = 0.52 kg/sec (consistent with USBR, 1984);
- Ute spills = 0.04 kg/sec, the same as estimated earlier in this chapter;
- Revuelto runoff and baseflows = 0.10 kg/sec, only slightly higher than estimated by HGC (1984); and
- baseflow in the Dunes reach between Revuelto and State Line = 0.12 kg/sec.

Restated in tons/year, the sources contribute:

Logan baseflow	=	18,200
Dunes baseflow	=	3,900
Revuelto flows	=	3,400
Ute spills	=	1,300
TOTAL	=	26,800

And, restated as percentages, the chloride sources are:

Logan baseflow	=	68% of State Line chlorides	
Dunes baseflow	=	15%	
Revuelto flows	=	13%	
Ute spills	=	5%	(totals add to 101% due to rounding)

Because these estimates reflect as much field data as are actually available, they are considered more reliable than estimates which would be based on consideration of less complete data (e.g. the results of an individual stream survey). In our judgment, the estimates are a reasonably good reflection of long-term, real-world conditions which existed prior to enlargement of Ute Reservoir.

4.4 Results of CRMWA Stream Survey

Background. Based on a previous edition of this notebook, we recommended that CRMWA conduct a stream survey of the Canadian River, to supplement and update the surveys conducted by HGC and USBR in the 1980's. The survey was needed in order to measure how the enlargement of Ute Reservoir has altered flow and salinity conditions in the Logan area. In addition, we envisioned this survey improving upon earlier studies by: 1) including flow measurements along with water-quality data; 2) determining sulfate concentrations (and other ions) in addition to conductance and chloride; and 3) obtaining relatively detailed records for conditions in Texas, all the way to Lake Meredith.

It is important to recognize that the concept of a stream survey is to produce a "snapshot" of river conditions as they exist in a narrow moment of time. The resulting data can help resolve some of the spatial patterns in flow and salinity which occur in the Canadian system, but a single survey can not provide insights on the significant time-variations in river conditions. In particular, while the results of a single survey may be interpreted as to what they might mean to long-term salinity problems at Lake Meredith, a realistic long-term analysis will require repeated surveys coupled with interpretation of long-term USGS gaging station data.

CRMWA, with full appreciation of the benefits and limitations listed above, approved the survey concept. The survey was conducted from February 10th to February 18th, 1992. Survey participants included representatives from CRMWA, the Texas Bureau of Economic Geology (BEG), and our firm, Lee Wilson and Associates Inc. (LWA). A report prepared by BEG describes the survey methodology and results (Gustavson et al., 1992); we term this "the BEG report". CRMWA has developed a spreadsheet to present the major field data (see **TAB 15**, which also contains selected materials from the BEG report). Follow-up surveys of selected reaches were conducted in late February and in May, 1992, and are expected to be conducted in the future; these data will eventually be included in **TAB 15**.

Scope of our analysis. At the date this section was being written (mid June, 1992), CRMWA had not authorized any studies to interpret the stream survey data. However, at our own risk we have begun such studies. The analyses related to surface water are far enough along to be reported in this notebook. A request for formal authorization of the studies presented here has been made to CRMWA.

Our assessment regarding surface water data has emphasized two subjects: evaluation of the data set, to determine its usefulness in meeting project objectives; and interpretation of the data to answer the questions posed when the survey was recommended.

Quality of the data set. The planning for the 1992 survey recognized that the remote and rugged field environment would make it difficult to get consistently reliable data on the salinity of Canadian River water. Various cross-checks were designed in order to provide a basis upon which to judge the quality of the results. For example, chloride at site 31 (mile 4.41) was determined by four different methods.

source of data (method)	chloride, mg/l
BEG (indicator strips, see **TAB 15**)	4150
CRMWA (Hach kit, see **TAB 15**))	2400
BEG (lab data, see Table 7 of BEG report)	3415
BEG (calculated from conductance, Table 5, BEG Report)	2135 or 2270

This example illustrates discrepancies between chlorides obtained by different methods. Such differences occur at many sites and indicate that the data obtained in the survey must be interpreted with care.

[Note. The CRMWA value is for site 31A, near 31; based on conductance measurements made by LWA, sites 31 and 31A have comparable water quality. Site 31 is at the upstream end of the linear south-north reach of the Canadian River which lies immediately east of Logan. Because gravel pits are located on the mesa between the river and Logan, we have labelled this the "gravel pit reach".]

Identification of "reliable" data set. In our judgment, three of the methods used in the survey can be considered to produce reliable data regarding chloride. These are listed below, in approximate order of reliability, most reliable first.

- Typically, laboratory data are considered the most reliable measurements of water quality, and we presume this to be the case for the 1992 survey. Note, however, that the BEG report does not present any results demonstrating a successful quality-control program for the laboratory data, and our presumption could change if the results of such a program do not confirm the validity of the laboratory analyses.

- There are 12 sites at which CRMWA obtained Hach Kit chloride data and BEG obtained laboratory chloride data. A regression analysis indicates good agreement between the two estimates (R-SQ = 0.986), and therefore we judge the CRMWA field data to be reliable. The discrepancy at site 31, noted above, was the second worst in the data set; the other, larger problem was on a tributary, Revuelto Creek.

- There are 17 sites at which BEG obtained field chlorides using indicator strips and BEG also obtained laboratory chloride data. A regression analysis indicates fair agreement between the two estimates (R-SQ = 0.526). Because the regression of BEG field data produces a much lower R-SQ than the regression of CRMWA field data, the CRMWA data are considered more reliable. However, the BEG regression is strongly influenced by an extremely bad match at site 60; omitting that point, R-SQ = 0.989 (Figure 6 in the BEG report).

BEG did not collect field sulfate data. With respect to sulfate, CRMWA's Hach Kit functioned irregularly in the field and eventually became inoperative; the data collected don't agree well with BEG's laboratory data. Only the laboratory sulfate data will be considered "reliable" at this time.

The total dissolved solids (TDS) content of water can be approximated from BEG laboratory data (Table 7 of the BEG report). Specifically, TDS is approximately equal to the sum of concentrations given in the table for calcium, magnesium, sodium, potassium, bicarbonate (divided by 2.03), sulfate and chloride. Although actual TDS would be slightly higher when silica and other ions are added in, estimates based on Table 7 should be reliable.

Listing of reliable data. Below is a listing of the reliable chloride, sulfate and TDS data. The list includes only data collected at points where CRMWA made a contemporaneous measurement of mainstem streamflow and therefore a chloride or sulfate loading value can be calculated. The list is followed by notes regarding the data, and by a brief description of the sampling sites.

Site & mile	Flow cfs	Chloride mg/l	Data Source	Sulfate mg/l	Total Diss. Solids sum of ions, mg/l
8, 0.37	2.35	717	LAB	349	1979
17, 1.90	3.84	1890	LAB	451	4119
31, 4.41	4.69	3415	LAB	615	6939
41, 6.31	12.88	2110	BEG		
50, 12.7	12.99	2710	CRMWA		
57, 21.4	12.08	2310	BEG		
67, 38.9	21.58	2370	CRMWA		
70, 47.7	23.34	2140	CRMWA		
76, 68.4	24.72	1560	LAB	538	3592
80, 85.5	27.16	1690	CRMWA		
86, 95.6	36.77	1410	CRMWA		
90, 95.6	34.16	1130	CRMWA		
101, 140.5	34.04	1190	CRMWA		

Notes regarding the data follow.

- BEG obtained and is analyzing in the laboratory water samples for sites 57, 67 and others. The additional data will be added when it becomes available. For the most rigorous interpretations, only the data from sites 8, 17, 31 and 76 should be compared, since chlorides at all other sites are based on adjustments to field data.

- CRMWA values are presented only for sites where LAB data are not available. The value given is the laboratory equivalent of the field value, rounded to the nearest ten. To adjust CRMWA's field data to their lab equivalent, the equation is: -142 + 1.128*field chloride.

- BEG values are presented only for sites where neither LAB nor CRMWA data are available. The value given is the laboratory equivalent of the field value, backcalculated from the equation shown in Figure 6 of the BEG report; values are rounded to the nearest ten.

Site locations are as follows.

- Site 8 is just below the point at which all the leakage and seepage from Ute Reservoir has reached the river. Measurements were taken in a pool where salinity stratification was evident.
- Site 17 is at the USGS gaging station; it lies between locations 1 and 2 which were part of the monitoring network described in USBR, 1984.
- Site 31 is at the upper end of the gravel pit reach.
- Site 41 is just below the confluence with Revuelto Creek.
- Sites 50 and 57 are in New Mexico between Revuelto Creek and the State Line.
- Site 67 is approximately at the Texas-New Mexico State Line.
- Sites 70, 76 and 80 are in Texas, above the confluence with Punta del Agua.
- Site 86 is just below the confluence with Punta del Agua.
- Site 90 is a few miles downstream of Tascosa.
- Site 101 is located where Highway 87 crosses the river, near the vicinity of the USGS Amarillo gaging station.

The only "comprehensive" data set. The data points listed above are not close enough together to resolve all important spatial variations in salinity observed during the survey. Interpretation of the survey results may require use of the one water-quality measurement which was made at virtually every survey site: specific conductance. Two conductance values are available at most sites, one taken by BEG and one by LWA, and the two sets generally are in reasonable agreement.

However, the field conductance values are much lower than would be expected given the TDS levels reported from the lab analyses. For example, the total dissolved solids measured by BEG for site 17 is 4119 mg/l. Based on the ion distribution of the water, one might expect a conductance value of nearly 7000 micromhos/cm. Yet, field conductance values for this site were only 4675 micromhos/cm (BEG) and 4980 micromhos/cm (LWA).

The reason for the poor relationship between field conductance and laboratory dissolved solids has not been investigated, although it is likely that a large part of the discrepancy is because the data were not consistently corrected to the standard reporting water temperature of 25°C. Until such a correction is made, it is clear that the conductance values must be used with great care and that any calculations of "real" chloride or TDS values could be in error. In this report, we will use the data mostly for comparative purposes, and specifically will use chloride concentrations calculated by BEG using the regression which they developed based on "select" data (these are the "b" values in Table 5 of the BEG report).

Method for calculating salinity loading values. The total weight of salt being carried in the river at a given point - the salinity load in tons/year - can be calculated by multiplying flow rates (cfs) by salt concentrations (mg/l) and then multiplying by 0.984 (a coefficient which reconciles units and also annualizes the values). Note that values calculated from a single survey are not truly the average annual load; that value could only be calculated from a series of measurements made over a year (or, better, over a period of years). However, quoting values in tons/year does allow for ready comparisons among data sets generated at different locations and times, and in units familiar to the interested public.

Measured salt loads in the Logan area. We assume that loading rates can be considered as "measured" at those sites for which there are reliable chloride and flow data (i.e. using the data set presented previously). In the first six miles below Ute Reservoir, where USBR measured significant brine inflow, there are three locations where such data exist. Loading rates (and chloride:sulfate ratios) were:

Site & mile	chloride	sulfate	T D S	chloride:sulfate
8, 0.37	1660	800	5000	2.1:1
17, 1.90	7150	1700	16300	4.2:1
31, 4.41	15800	2800	33200	5.6:1

Interpretation of data: effects of Ute Reservoir. The 1,660 tons/year chloride loading at mile 0.37 represents the impact of seepage and leakage from Ute Reservoir. The discharge of 2.35 cfs is larger than the baseflow measured at the Logan gage prior to reservoir enlargement, and therefore it must be larger than the pre-enlargement leakage and seepage. Based on the following logic, brine inflow is not a significant source of the 2.35 cfs.

- In the field, virtually all the flow was observed originating at sites 1 through 5.

- Site 1 was the toe drainage, and it was enriched in chloride relative to reservoir water. However, any flow net capable of generating 1 cfs of through-dam seepage would show flow patterns far too strong to allow significant brine inflow; the pick-up in chloride mostly occurs as the water passes through the dam and foundation materials.

- Sites 2-5 represent leakage through the spillway or gates; water at these sites was comparable in quality to water in the reservoir, indicating no mixing with native ground water, and therefore no brine.

- Field investigations indicate that any brine which seeps through canyon walls into the river immediately below the dam is a minor part of the flow observed at mile 0.37.

- A highly saline pool was observed at site 7, but there was minimal impact of this pool on the quality of streamflow at site 8.

Mile 0.37 to mile 4.4. The data demonstrate that brine flow occurs in the reach from mile 0.37 to mile 4.4. On the date of the survey, the chloride load at mile 4.4 was equivalent to 15,800 tons/year. If 1,660 of this comes from Ute Reservoir (see above), then presumably 14,140 tons/year is brine inflow. Further comments are:

- The chloride loading rate is a bit higher from mile 0.37 to mile 1.9 (4700 tons/year/mile) than from mile 1.9 to mile 4.4 (3500 tons/year/mile).

- The chloride:sulfate ratio increases downstream as the chloride-rich brine reaches the river. From mile 1.9 to 4.4, the increase in chloride load was 8 times the increase in sulfate load.

Mile 4.4 to Reveulto. Site 41 is located at mile 6.3, just below the confluence with Revuelto Creek. Based on a flow of 12.88 cfs and a chloride concentration of 2110 mg/l, the chloride loading was 26,750 tons/year. About 1000 tons/year of this can be accounted for by the flow of Revuelto Creek (see calculation presented subsequently), which indicates that the load in the Canadian River just above the confluence was in excess of 25,000 tons/year.

This estimate is consistent with data collected at site 39, at mile 5.9, just above the Revuelto confluence. At that site, flow was 30% higher than observed at site 31 (mile 4.4) and conductance was 75% higher. Part of the conductance difference can be explained by a change in water temperature; eliminating the temperature factor, the data are consistent with a chloride load at site 39 of at least 25,000 tons/year. Given that load at site 31 was 15,800 tons/year, the data demonstrate that a chloride load on the order of 10,000 tons/year was entering the river between site 31 and Revuelto Creek on the day of the survey.

Evidence for increased brine flow in the Logan area. A major objective of the 1992 survey was to determine if brine inflows are greater now than they were before Ute Reservoir was enlarged. The data show a high rate of brine inflow, but not a rate that is demonstrably higher than the highest rate observed before the dam was raised.

For mile 0.37, the chloride load of 1,660 tons/year is certainly higher than occurred prior to enlargement of Ute Reservoir, simply because seepage and leakage from Ute have increased. There are no data from the early-mid 1980's which allow calculation of the increase, but based on the flow increase it might be a few to several hundred tons per year. However, as noted in the discussion of the seepage, there is no evidence that any significant part of the seepage or salt is the result of brine inflow.

In the area of mile 1.9, USBR (1984) collected data showing a chloride load of 4900 tons/year on average, but on individual dates the rate was about 6700 tons/year (see table and graph at end of **TAB 11**). In comparison, data obtained in the 1992 survey shows 7150 tons/year. The 1992 survey could be comparable to the higher end of the 1983-84 survey, plus a small additional load related to increased seepage from Ute Reservoir.

In the area of mile 5.4, USBR (1984) measured a chloride load of about 15,700 tons/year. Excluding one data set which probably reflects runoff conditions, the highest daily load was about 20,000 tons/year. A rough estimate of the load observed in 1992 is 22,500 tons/year. [This assumes that the 10,000 or so tons of chloride which reaches the river between sites 31 and 39 entered uniformly with distance; thus at mile 5.4, 6,700 tons/year was added to the 15,800 tons/year observed at site 31.] This data point is consistent with but does not prove the concept that brine inflow has increased since Ute Dam was enlarged.

Revuelto Creek. The chloride load from Revuelto Creek is estimated at 1000 tons/year, based on CRMWA's measured streamflow of 6.763 cfs and BEG's laboratory chloride value of 153 mg/l. This load is well within the range of values observed by USBR in 1983-84 but it is low compared to the average values reported in USBR (1984). It also is lower than loads which would be computed from USGS data (see HGC, 1984) and the load attributed to Revuelto Creek based on the State Line modeling (see Section 4.3).

Revuelto Creek to the State Line. Prior to the stream survey, we had reported on the preliminary results of our State Line modeling study (see Section 4.3) and had indicated the probability that an additional brine source (a "new brine aquifer") must exist between Revuelto Creek and the State Line. Loadings for this reach are calculated from the reliable data as follows.

Site & mile	Flow cfs	Chloride mg/l	Chloride load tons/year
31, 4.41	4.69	3415	15,800
41, 6.31	12.88	2110	26,750
50, 12.7	12.99	2700	34,500
57, 21.4	12.08	2310	27,500
67, 38.9	21.58	2370	50,300

The ups and downs in the chloride loading as the survey moved downstream may reflect the inate variability of the survey methods - not only variability among different techniques for measuring chlorides, but also the fact that it took more than a week to survey the entire river, and streamflow conditions varied from day to day. However, the value at site 67, the State Line, is so much larger than the upstream values that it very likely reflect a real-time loading increase.

Following are several comments on the data.

- Based on conductance data and field observations, the inflow begins near site 60 and continues downstream for several miles to about site 62. Site 60 is the "Dunes dam site" discussed in the ground-water notebook.

- During the survey, a small tributary near site 60 was discharging less than 0.1 cfs with a specific conductance of 20,500 micromhos/cm (measured by LWA). This was not a significant part of the total salt load, but indicates that saline water does occur in the area. Data in the BEG report show that water in the tributary is compositionally similar to water in brine pools near Logan, but with less than half the concentration. As discussed in the ground-water notebook, the same brine aquifer which reaches near the land surface in the gravel pit reach also surfaces in the area of the Dunes dam site.

- The reach from site 57 to 67 was resurveyed by CRMWA on February 24 and 25, 1992. Although the saline tributary noted in the early February survey was still flowing, the overall increase in salt load was much less than seen earlier in the same month. The in May, 1992, found almost no increased salt loading at all - slightly over 25,000 tons/day at site 57 on May 12th, and slightly over 26,000 tons/day at site 67 on May 13th.

Clearly, whatever source or sources account for the salt influx observed in early February, the sources or sources are not a steady brine inflow of the type observed in the Logan area. These results are consistent with Section 4.3, which found that Dunes baseflow is an important but variable source of brine loading between Revuelto Creek and the State Line. Addititional surveys (and interpretation of data from the newly reinstituted State Line gage) should help further our understanding of the current significance of saline inflows in the area of the Dunes dam site.

Sources of salt at the State Line. During the early-February survey of 1992, the chloride loading at the State Line can be characterized as follows:

Source	Tons/year	Percent of State Line Load
Ute Reservoir	1700	3%
Logan brine	25000	50%
Revuelto Ck	1000	2%
Reach 41-67	22600	45%
Total	50300	100%

These are not necessarily representative of long-term source conditions, as shown by the fact that subsequent surveys have shown much less inflow in the reach from Revuelto Creek (site 41) to State Line (site 67) and as shown by the different proportions calculated from long-term data (see Section 4.3).

Texas Reaches. Prior to the stream survey, we had reported that much of the sulfate reaching Lake Meredith must originate in Texas, because sulfate loads past the State Line are relatively low (see Section 4.3). We also reported preliminary findings suggesting that some of the salt which originates in New Mexico may be lost from the Canadian River before it reaches Lake Meredith. Further, we indicated that the stream survey might locate reaches of salt inflow in Texas.

Sulfates. The laboratory data indicate the following:

Site & mile	Flow cfs	Sulfate mg/l	Sulfate loading tons/year
8, 0.37	2.35	349	800
17, 1.90	3.84	451	1700
31, 4.41	4.69	615	2800
76, 68.4	24.72	538	13100
98, 133.9	34.1	652	21900

The survey has confirmed that most sulfates in the Canadian River originate downstream of the Logan reach. Based on Section 4.3, Revuelto Creek is a major sulfate source. Based on the tabulation above, sulfates also are important downstream of site 76, i.e. in Texas.

Salt gains and losses in Texas. The reliable data indicate the following:

Site & mile	Flow cfs	Chloride mg/l	Chloride load tons/year
67, 38.9	21.58	2370	50,300
76, 68.4	24.72	1560	38,000
80, 85.5	27.16	1690	45,200
86, 95.6	36.77	1410	51,000
90, 95.6	34.16	1130	38,600
101, 140.5	34.04	1190	40,500

While the data overall suggest a modest decrease in salt loading between the State Line and Amarillo, it is not known if the decrease is one which occurred with distance down the river, or with time during the survey (or with both - see previous discussion of data variability).

The results of the resurvey in May, 1992, are easier to interpret. Flow at the State Line (site 67) on May 13 was 8.3 cfs, a value which represents baseflow conditions. The chloride loading at the State Line was about 26,000 tons/year, which based on Section 4.3 is representative of average conditions. At Amarillo (site 101) the next day the flow was 2.9 cfs and the chloride load was 4,000 tons/day. Clearly, during this condition of low flows, the stream was experiencing a loss of both flow and salt load between State Line and Amarillo.

BEG interprets the conductance data as indicating a salinity increase between sites 68 through 72, which is in the general vicinity of a reported salt lake. In addition, we interpret the data from the Bruary survey as suggesting that there was a substantial saline inflow in a several-mile reach above and below Lahey Creek (site 96), although very little of the inflow showed up as far downstream as Amarillo. Lahey Creek itself discharged a small amount of saline water and a sample taken from a nearby seep was determined through laboratory analysis to contain chloride of 4910 mg/l and sulfate of 2160 mg/l. CRMWA's May survey confirmed a trickle of saline surface water in Lahey Creek. The full reach of previous saline impact was not surveyed in May.

The data from the Lahey reach indicate that salt inflows to the Canadian River probably do occur in Texas. The survey data overall indicate that conditions in Texas are much less regular than at Logan, and that it will take considerable data collection and interpretation to unravel the apparently complex patterns of salt inflow and loss.

<u>Summary of resurvey needs</u>. When the 1992 survey results became known, we recommended that CRMWA resurvey the Dunes dam site and Lahey Creek areas on a quarterly basis. This recommendation remains valid. The Lahey survey needs to extend upstream to site 90 and downstream to site 101, until details of the brine inflow are determined.

Based on the analyses reported here, we also recommend adding the Logan reach to the resurvey program. We specifically suggest measurements be made at sites at site 8, 17, 31, 36, 39, 40 and 41, to include flow, field conductance, temperature and chloride (using Hach kit), and sample collection for laboratory determinations of chloride, sulfate and total dissolved solids.

4.5 Some Additional Observations

As noted previously, the structure of Chapter 4 is to evaluate salt loading conditions in the Canadian River proceeding more or less downstream from Ute Reservoir. As of mid-1992, our evaluations have proceeded as far as the State Line gage (Section 4.3). This does not mean that every subject from Ute to State Line has been assessed; for example, at this time we have not undertaken a detailed water and salt budget for Ute Reservoir itself, but such a budget may be useful in the future if there is reason to believe that release schedules from the reservoir might change.

For areas downstream of State Line (that is, in Texas), neither this notebook nor the Project reports provide an adequate assessment of conditions important to salt loading at Lake Meredith. A separate study (not directly part of the Salinity Control Project) is underway to revise the safe yield estimate for Lake Meredith, and may improve the situation somewhat. The results of that study can be added to this notebook when available.

In addition, while developing the notebook we have performed some reviews of conditions in Texas. None of the work has been completed (nor, in fact, has it been submitted or authorized for CRMWA funding). Provisional results of the work are reported briefly below, to illustrate issues which arise with respect to salinity in Texas. Various graphs generated by the work are included in **TAB 33**.

<u>Tascosa</u>. We have begun to prepare a salt loading model for Tascosa which is similar in principle to the State Line model described in Section 4.3. However, conditions at Tascosa are so much more complex than at State Line, that the modeling approach must also be complex. The best results to date come from models which simultaneously compute loads for all the major ions (calcium, sodium + potassium, magnesium, carbonate + bicarbonate, sulfate, chloride).

Because the results are complex, but not yet complete, they are not discussed here except to point out a few relationships which appear important to Lake Meredith.

- The USGS data base at Tascosa appears to contain water-quality records which in fact are composites of data over extended time periods. Moreover, some of these composites are repeated in the data base, apparently because they were utilized several times to compute salt loads. Care must be taken to utilize the data base.

- While the Canadian River shows a net average gain in streamflow from State Line to Tascosa, detailed inspection of the data shows three different hydrologic patterns: flow loss at times, even to the point that the stream is dry at Tascosa; baseflow gain at times; and periodic runoff gain. We have not identified any consistent seasonal or long-term pattern in losses and gains, but the variability in the flow regimes is large relative to the median flows and undoubtedly accounts for much of the variability in salt loading from data point to data point.

- Concentrations of dissolved solids tend to be less at Tascosa than at State Line, due especially to the influence of fresh runoff. However, sulfate loads at Tascosa appear to exceed those at State Line on average. Whether or not the river at Tascosa carries a larger chloride load is not certain, due to difficulties in interpreting the USGS data base. During periods of streamflow loss, the stream tends to lose salts between the two gages - especially chloride (0.5 kg/sec loss). During periods of baseflow gain, salt loss is less, or salt gains occur.

- Computer calculations to reconstruct the Tascosa salt budgets are consistent with a hypothesis that during low flow periods, flows are lost by evaporation and seepage and salts are deposited in the channel alluvium, to be flushed out by subsequent runoff events. Because the model work is in its early stages, the calculations do not rule out either long-term permanent loss of salts which originate in New Mexico, nor long-term storage of salts in the alluvium.

Conditions further downstream. The pattern of periodic flow loss (which must mean salt loss) continues downstream of Tascosa. HDR (1987) estimated that about 38% of the Logan flow is lost before it reaches Amarillo; and 15% of the Amarillo flow is lost before it reaches Meredith. We have found no study which has clearly determined whether the salt loss is permanent (e.g. to deep ground water) or temporary; and if the latter, whether salt is flushed back to the river in a relatively short or long time frame.

The project reports don't evaluate in detail whether or not sources in Texas may have a significant impact on salt loading in Texas. However, the actual data support a conclusion that much of the sulfate which reaches the lake originates in Texas. More importantly, the data do not preclude the possibility that these Texas sources also contribute chlorides in significant amounts, and that these chlorides replace some New Mexico chlorides which are lost through deep seepage. The potential that Texas chlorides could be important also is suggested by the observation that high chloride concentrations are observed in shallow ground water along the Canadian River near Amarillo. The source of this salt and its potential flow to the river and Lake Meredith have not been evaluated in the Project reports.

We also are aware of concerns over the possibility that salt loading to Lake Meredith results from local sources such as abandoned oil wells, salt caverns used for hydrocarbon storage, and PANTEX. While no evidence indicates these sources actually are important, it may be prudent to address each source through a formal report.

Simple salt budget for Lake Meredith. We have not yet studied the salt budget for Lake Meredith in detail; work on this subject will be undertaken as part of the parallel study of reservoir safe yield.

For purposes of discussion, it is reasonable to rely on the salt budget estimated by CRMWA, which indicates a chloride loading on the order of 32,000 tons/year during the period 1965-89 **(TAB 15)**. During the period when the State Line gage was operational, the loading was about 28,600 tons/year.

Note, however, that chloride loads at the Amarillo gage are larger than this amount on average. Quantification of the difference should involve computer analysis and an effort to utilize the most comparable data, but based just on unadjusted USGS data for Amarillo, the difference is at least 5% and may be as large as 20%.

For purposes of discussion, we will assume that the chloride load at Amarillo was 35,000 tons/year during the time when the State Line gage was operational (i.e. during the time covered by the salt budget calculated in Section 4.3). Based on Section 4.3, Logan baseflow contributed 18,200 tons/year chloride during this time period, and New Mexico sources in total contributed 26,800 tons per year. Very roughly, then, 75% of the chloride observed at Amarillo (and, presumably, 75% of the chloride reaching Lake Meredith) can be accounted for by sources in New Mexico, assuming that there is no net loss in chloride from the State Line to Amarillo. Similarly, 50% of the chloride can be accounted for by brine inflow in the Logan area.

On this basis, and with the many caveats already expressed, a project which could halve the chloride loading from Logan brine would reduce chloride loadings to Lake Meredith by about 25%. This appears to be a reasonable (and hopefully conservative) planning estimate of benefits from a salinity control project.

Time patterns. In Section 4.3, we noted changes in flow and salt loading rates after 1972. Graphs such as those provided near the end of **TAB 6** indicate similar changes are even more pronounced in Texas. In New Mexico, we believe the changes at State Line reflect changes in the salt sources, not large-scale storage and flushing. But for Texas it is quite possible that salt storage has been an important process over the last two decades and that salt loadings to Lake Meredith could be very large in some future period of extremely wet conditions. Whatever explanation exists for the long-term change, it must also account for an apparent shift in Texas salt loads toward a lower chloride:sulfate ratio over time.

One time pattern known to be important is the change in contributions from Amarillo effuent discharges. TWQB (1970) indicates that Amarillo effluent was an important source of water and salt at the Amarillo gage; in effect, this source is recycled Meredith water. Stream surveys conducted in the mid-70's show that effluent dominated water quality in the Canadian River during low flow periods. The Amarillo effluent went substantially off-line in 1978 (John Williams, personal communication), although its impact today is not insignificant (see **TAB 19** and Ottmers (1986)). To date, no study has accounted for the reduced effluent discharge in assessing the water or salt budgets of Lake Meredith.

Summary. Without question, there is a large discharge of chloride brine to the Canadian River near Logan New Mexico, and this is a major source of salt loading in Lake Meredith. However, neither the Project reports nor this notebook effectively address the complex flow conditions which convey this salt to the lake. To the extent these subjects are mentioned at all in previous reports, the implication is that while salt losses do occur in Texas, they are temporary and the salt is soon flushed to Lake Meredith. But other hypotheses cannot be ruled out based on the studies to date: for example, the salt loss could be permanent, in which case a relatively large portion of the salt reaching Lake Meredith originates in Texas; or, the salt loss could be temporary but long-term, and some future runoff event or events will flush an enormous load to the lake.

The bottom line is that we agree with USBR (1979, page 20) that studies are needed to "establish proof that salt from the [Logan] brine aquifer actually reaches Lake Meredith" and to deal generally with the subject of salt sources and processes in Texas (page 32).

The program of periodic stream surveys recently begun by CRMWA will provide an important source of data needed to address these matters. CRMWA's recently initiated study of reservoir safe yield may also provide insights. Eventually, the Authority may wish to consider whether or not computer analyses of the type described in Section 4.3 provide useful insights. If the answer is yes, similar studies could be done for Tascosa, Amarillo and Lake Meredith.

an extra 10% of the river (i.e. to mile 6 instead of mile 5.4) and therefore is consistent with the previous work. TThe sum of the three salt loads is 0.66 kg/sec, only 0.11 kg/sec short of what was observed at State Line. Thus, one result of the calculations reported here was to reduce the differential between State Line chlorides and Logan-Revuelto chlorides compared to HGC (1984).

Chloride loading from Dunes baseflow. To investigate the origin of the 0.11 kg/sec of chloride which reaches the State Line from sources downstream of Revuelto and Logan, we looked at both Dunes baseflow and local runoff. After testing many assumptions for Dunes baseflow, it was determined that chloride loadings in the Dunes reach may be non-linear: chloride concentrations and loads are greatest during periods of higher baseflow. This unsteady loading is quite different from the very steady loading observed in the Logan reach by USBR (1984).

Consequently, chloride concentrations in Dunes baseflow were calculated by assuming a value of 850 mg/l during runoff and very low flow periods; and by raising the computed chloride load to the 1.15 power during baseflow periods, so that the load would increase exponentially as baseflow increased.

For the entire 135 data sets, the resulting average contribution from Dunes baseflow is 0.11 kg/sec, exactly what is needed to account for the incremental chloride load observed at the State Line. Moreover, most of the load occurs in winter (0.18 kg/sec), and during winter baseflow conditions, the computer calculations of chloride load at State Line are in particularly good agreement with observed loadings (see graph, page 11 of **TAB 32**). [Note further, the model "error" or difference from observed chloride loads has a standard deviation of only 0.15 for this data set, quite low compared to the mean load estimate which is 0.72 kg/sec.]

In our judgment, the input of chloride in the Dunes reach must be real. No other source could explain why State Line chlorides during winter baseflow are one-third higher than the sum of Logan and Revuelto chlorides. However, it also seems clear that the chloride input is different from that observed near Logan - it is more dilute and much less constant. Interestingly, brine inflow at Logan was less constant prior to construction of Ute Dam.

Chloride loading from local runoff. Extensive efforts were made to find a relationship in which local runoff might provide an explanation for at least some salt loading. These efforts did not succeed. One reason may be that, as noted previously, the data from runoff periods are not entirely reliable. Moreover, inspection of the data indicates that on dates when local runoff clearly was occurring, the effect of the runoff was to greatly freshen the State Line flows.

Evidence for salt flushing. The concept of salt flushing is that salts carried by streamflows may be deposited in channel or floodplain sediments for a period of time, to be flushed out later during periods of high streamflow. Salt flushing does not increase the total salt load, but it does change the time relationship between when salt originally enters the stream system and when it reaches a measuring point such as the State Line.

Salt flushing would not be expected to be important in the Logan reach, since brine inflow there is nearly constant (USBR, 1984). In the Revuelto-State Line reach, it is not uncommon for streamflows to decline downriver, in which case much of the salt being introduced to the reach from Logan (or Reveulto) must be deposited along the channel. Certainly, the calculation results shown in **TAB 32** show many dates (mostly summer) when the chloride load at State Line is substantially less than the sum of the upstream loads.

And, conversely, a few of the data sets do represent conditions when streamflow levels were very high and the computer-calculated salt budget fell far short of the actual salt load at State Line. On these dates, it is plausible that salt which had been deposited previously was being flushed out. Examples are: 9/3/70, when the calculated chloride load was 0.94 kg/sec, versus 4.20 kg/sec measured; and 8/18/77, when the calculated chloride load was 3.91 kg/sec and the observed 5.62 kg/sec.

The study results provide no indication of any long-term shift in the salt budget at State Line except that which is explained by changes in streamflow sources over time. In particular, while a plot of cumulative chloride loadings over time (page 14 in **TAB 32**) does show a lower slope since 1973 than before 1973, the plot of model loadings shows the same pattern. This indicates that almost all the salt which we can reasonably project as reaching the Canadian River below Ute Dam in New Mexico is reaching the State Line, without being lost en route.

> [The graph does reflect a net negative load in the Dunes reach in 1973-74, which could represent a time of salt deposition. However, the negative loading calculation is the result of one value extrapolated over a period of more than 1 year when there are no data sets available for analysis.]

A plot of cumulative mass curves for the individual salt sources (page 14 in **TAB 32**) suggests that the decreased loading at the State Line reflects a combination of: 1) a slight but definite decrease in loading from Logan baseflow; 2) a very sizeable definite drop in loading from Revuelto Creek after the mid-70's; and 3) a low loading rate from Ute Reservoir from 1972 through the early 80's. Interestingly, loading rates from Dunes Baseflow appear to have been increased since the mid-1970's.

<u>Results of calculations, by hydrologic condition</u>. The chloride budgets calculated using the procedures described above can be compared to the actual salt loading at State Line, for various hydrologic flow conditions. The results are as follows.

Hydrologic condition	Observed load	Calculated load
Ute spill, Revuelto runoff	1.69 kg/sec	1.65 kg/sec
Ute spill, Dunes baseflow, summer	0.97 kg/sec	1.00 kg/sec
Ute spill, Dunes baseflow, winter	0.89 kg/sec	0.80 kg/sec
Baseflow at Logan, Revuelto runoff	1.24 kg/sec	0.96 kg/sec
Baseflow at Logan & Dunes, winter	0.70 kg/sec	0.72 kg/sec
Baseflow at Logan & Dunes, summer	0.44 kg/sec	0.55 kg/sec
Ute spill, local runoff	0.49 kg/sec	0.74 kg/sec
Overall data set, 135 data points	0.77 kg/sec	0.77 kg/sec

Of course, results for individual dates in the data set may not show such close agreement; averaging the results as shown above tends to make the calculation procedure look better than it really is. Even so, based on these comparisons, the methodology used to calculate chloride budgets produces results which we judge to be reasonable. Graphs showing winter and summer baseflow conditions also indicate the calculation procedure is reproducing the real world fairly well (see pages 11 and 12 of **TAB 32**). The graph for the entire data set (page 13 of **TAB 32**) is considered supportive of the calculation procedure as well. The most prominent exceptions occur where the calculated salt load falls far short of the actual chloride transport; the two specific dates of greatest discrepancy were discussed previously.

The nature of the computer tools is such that one can continue to evaluate the data almost indefinitely. The results presented here therefore are not necessarily final, though few major changes have occured in the basic interpretations since the calculation procedure was initially formulated.

Sulfate loads. The printouts in **TAB 32** contain the results of sulfate calculations which were made using much the same procedures as were used to calculate chloride loads. The purpose of the sulfate calculation was to double-check the chloride calculation. That is, the same basic procedures used for chloride should work for sulfate; if they don't, then the entire analytical concept is suspect. In the case of Dunes baseflow, for example, the calculated sulfate concentration is 140 mg/l, which is a reasonable value for a source which contains 850 mg/l or more chloride.

The overall loading results for sulfate show that, as expected, Revuelto Creek and Ute spills are the major sulfate sources in New Mexico. Each source explains about 37% of the 0.36 kg/sec sulfate load at the State Line. Because the brines which discharge to the Canadian River are highly chloride dominant, ground water sources of sulfate are modest - Logan inflows account for 20% of the sulfate and Dune baseflow is about 5%.

Summary of chloride sources at State Line. As the calculations now stand, the relative importance of the different chloride sources is as follows:

- Logan baseflow = 0.52 kg/sec (consistent with USBR, 1984);
- Ute spills = 0.04 kg/sec, the same as estimated earlier in this chapter;
- Revuelto runoff and baseflows = 0.10 kg/sec, only slightly higher than estimated by HGC (1984); and
- baseflow in the Dunes reach between Revuelto and State Line = 0.12 kg/sec.

Restated in tons/year, the sources contribute:

Logan baseflow	=	18,200
Dunes baseflow	=	3,900
Revuelto flows	=	3,400
Ute spills	=	1,300
TOTAL	=	26,800

And, restated as percentages, the chloride sources are:

Logan baseflow	=	68% of State Line chlorides	
Dunes baseflow	=	15%	
Revuelto flows	=	13%	
Ute spills	=	5%	(totals add to 101% due to rounding)

Because these estimates reflect as much field data as are actually available, they are considered more reliable than estimates which would be based on consideration of less complete data (e.g. the results of an individual stream survey). In our judgment, the estimates are a reasonably good reflection of long-term, real-world conditions which existed prior to enlargement of Ute Reservoir.

4.4 Results of CRMWA Stream Survey

Background. Based on a previous edition of this notebook, we recommended that CRMWA conduct a stream survey of the Canadian River, to supplement and update the surveys conducted by HGC and USBR in the 1980's. The survey was needed in order to measure how the enlargement of Ute Reservoir has altered flow and salinity conditions in the Logan area. In addition, we envisioned this survey improving upon earlier studies by: 1) including flow measurements along with water-quality data; 2) determining sulfate concentrations (and other ions) in addition to conductance and chloride; and 3) obtaining relatively detailed records for conditions in Texas, all the way to Lake Meredith.

It is important to recognize that the concept of a stream survey is to produce a "snapshot" of river conditions as they exist in a narrow moment of time. The resulting data can help resolve some of the spatial patterns in flow and salinity which occur in the Canadian system, but a single survey can not provide insights on the significant time-variations in river conditions. In particular, while the results of a single survey may be interpreted as to what they might mean to long-term salinity problems at Lake Meredith, a realistic long-term analysis will require repeated surveys coupled with interpretation of long-term USGS gaging station data.

CRMWA, with full appreciation of the benefits and limitations listed above, approved the survey concept. The survey was conducted from February 10th to February 18th, 1992. Survey participants included representatives from CRMWA, the Texas Bureau of Economic Geology (BEG), and our firm, Lee Wilson and Associates Inc. (LWA). A report prepared by BEG describes the survey methodology and results (Gustavson et al., 1992); we term this "the BEG report". CRMWA has developed a spreadsheet to present the major field data (see **TAB 15**, which also contains selected materials from the BEG report). Follow-up surveys of selected reaches were conducted in late February and in May, 1992, and are expected to be conducted in the future; these data will eventually be included in **TAB 15**.

Scope of our analysis. At the date this section was being written (mid June, 1992), CRMWA had not authorized any studies to interpret the stream survey data. However, at our own risk we have begun such studies. The analyses related to surface water are far enough along to be reported in this notebook. A request for formal authorization of the studies presented here has been made to CRMWA.

Our assessment regarding surface water data has emphasized two subjects: evaluation of the data set, to determine its usefulness in meeting project objectives; and interpretation of the data to answer the questions posed when the survey was recommended.

Quality of the data set. The planning for the 1992 survey recognized that the remote and rugged field environment would make it difficult to get consistently reliable data on the salinity of Canadian River water. Various cross-checks were designed in order to provide a basis upon which to judge the quality of the results. For example, chloride at site 31 (mile 4.41) was determined by four different methods.

source of data (method)	chloride, mg/l
BEG (indicator strips, see **TAB 15**)	4150
CRMWA (Hach kit, see **TAB 15**))	2400
BEG (lab data, see Table 7 of BEG report)	3415
BEG (calculated from conductance, Table 5, BEG Report)	2135 or 2270

This example illustrates discrepancies between chlorides obtained by different methods. Such differences occur at many sites and indicate that the data obtained in the survey must be interpreted with care.

[Note. The CRMWA value is for site 31A, near 31; based on conductance measurements made by LWA, sites 31 and 31A have comparable water quality. Site 31 is at the upstream end of the linear south-north reach of the Canadian River which lies immediately east of Logan. Because gravel pits are located on the mesa between the river and Logan, we have labelled this the "gravel pit reach".]

Identification of "reliable" data set. In our judgment, three of the methods used in the survey can be considered to produce reliable data regarding chloride. These are listed below, in approximate order of reliability, most reliable first.

- Typically, laboratory data are considered the most reliable measurements of water quality, and we presume this to be the case for the 1992 survey. Note, however, that the BEG report does not present any results demonstrating a successful quality-control program for the laboratory data, and our presumption could change if the results of such a program do not confirm the validity of the laboratory analyses.

- There are 12 sites at which CRMWA obtained Hach Kit chloride data and BEG obtained laboratory chloride data. A regression analysis indicates good agreement between the two estimates (R-SQ = 0.986), and therefore we judge the CRMWA field data to be reliable. The discrepancy at site 31, noted above, was the second worst in the data set; the other, larger problem was on a tributary, Revuelto Creek.

- There are 17 sites at which BEG obtained field chlorides using indicator strips and BEG also obtained laboratory chloride data. A regression analysis indicates fair agreement between the two estimates (R-SQ = 0.526). Because the regression of BEG field data produces a much lower R-SQ than the regression of CRMWA field data, the CRMWA data are considered more reliable. However, the BEG regression is strongly influenced by an extremely bad match at site 60; omitting that point, R-SQ = 0.989 (Figure 6 in the BEG report).

BEG did not collect field sulfate data. With respect to sulfate, CRMWA's Hach Kit functioned irregularly in the field and eventually became inoperative; the data collected don't agree well with BEG's laboratory data. Only the laboratory sulfate data will be considered "reliable" at this time.

The total dissolved solids (TDS) content of water can be approximated from BEG laboratory data (Table 7 of the BEG report). Specifically, TDS is approximately equal to the sum of concentrations given in the table for calcium, magnesium, sodium, potassium, bicarbonate (divided by 2.03), sulfate and chloride. Although actual TDS would be slightly higher when silica and other ions are added in, estimates based on Table 7 should be reliable.

Listing of reliable data. Below is a listing of the reliable chloride, sulfate and TDS data. The list includes only data collected at points where CRMWA made a contemporaneous measurement of mainstem streamflow and therefore a chloride or sulfate loading value can be calculated. The list is followed by notes regarding the data, and by a brief description of the sampling sites.

Site & mile	Flow cfs	Chloride mg/l	Data Source	Sulfate mg/l	Total Diss. Solids sum of ions, mg/l
8, 0.37	2.35	717	LAB	349	1979
17, 1.90	3.84	1890	LAB	451	4119
31, 4.41	4.69	3415	LAB	615	6939
41, 6.31	12.88	2110	BEG		
50, 12.7	12.99	2710	CRMWA		
57, 21.4	12.08	2310	BEG		
67, 38.9	21.58	2370	CRMWA		
70, 47.7	23.34	2140	CRMWA		
76, 68.4	24.72	1560	LAB	538	3592
80, 85.5	27.16	1690	CRMWA		
86, 95.6	36.77	1410	CRMWA		
90, 95.6	34.16	1130	CRMWA		
101, 140.5	34.04	1190	CRMWA		

Notes regarding the data follow.

- BEG obtained and is analyzing in the laboratory water samples for sites 57, 67 and others. The additional data will be added when it becomes available. For the most rigorous interpretations, only the data from sites 8, 17, 31 and 76 should be compared, since chlorides at all other sites are based on adjustments to field data.

- CRMWA values are presented only for sites where LAB data are not available. The value given is the laboratory equivalent of the field value, rounded to the nearest ten. To adjust CRMWA's field data to their lab equivalent, the equation is: $-142 + 1.128*\text{field chloride}$.

- BEG values are presented only for sites where neither LAB nor CRMWA data are available. The value given is the laboratory equivalent of the field value, backcalculated from the equation shown in Figure 6 of the BEG report; values are rounded to the nearest ten.

Site locations are as follows.

- Site 8 is just below the point at which all the leakage and seepage from Ute Reservoir has reached the river. Measurements were taken in a pool where salinity stratification was evident.
- Site 17 is at the USGS gaging station; it lies between locations 1 and 2 which were part of the monitoring network described in USBR, 1984.
- Site 31 is at the upper end of the gravel pit reach.
- Site 41 is just below the confluence with Revuelto Creek.
- Sites 50 and 57 are in New Mexico between Revuelto Creek and the State Line.
- Site 67 is approximately at the Texas-New Mexico State Line.
- Sites 70, 76 and 80 are in Texas, above the confluence with Punta del Agua.
- Site 86 is just below the confluence with Punta del Agua.
- Site 90 is a few miles downstream of Tascosa.
- Site 101 is located where Highway 87 crosses the river, near the vicinity of the USGS Amarillo gaging station.

The only "comprehensive" data set. The data points listed above are not close enough together to resolve all important spatial variations in salinity observed during the survey. Interpretation of the survey results may require use of the one water-quality measurement which was made at virtually every survey site: specific conductance. Two conductance values are available at most sites, one taken by BEG and one by LWA, and the two sets generally are in reasonable agreement.

However, the field conductance values are much lower than would be expected given the TDS levels reported from the lab analyses. For example, the total dissolved solids measured by BEG for site 17 is 4119 mg/l. Based on the ion distribution of the water, one might expect a conductance value of nearly 7000 micromhos/cm. Yet, field conductance values for this site were only 4675 micromhos/cm (BEG) and 4980 micromhos/cm (LWA).

The reason for the poor relationship between field conductance and laboratory dissolved solids has not been investigated, although it is likely that a large part of the discrepancy is because the data were not consistently corrected to the standard reporting water temperature of 25°C. Until such a correction is made, it is clear that the conductance values must be used with great care and that any calculations of "real" chloride or TDS values could be in error. In this report, we will use the data mostly for comparative purposes, and specifically will use chloride concentrations calculated by BEG using the regression which they developed based on "select" data (these are the "b" values in Table 5 of the BEG report).

Method for calculating salinity loading values. The total weight of salt being carried in the river at a given point - the salinity load in tons/year - can be calculated by multiplying flow rates (cfs) by salt concentrations (mg/l) and then multiplying by 0.984 (a coefficient which reconciles units and also annualizes the values). Note that values calculated from a single survey are not truly the average annual load; that value could only be calculated from a series of measurements made over a year (or, better, over a period of years). However, quoting values in tons/year does allow for ready comparisons among data sets generated at different locations and times, and in units familiar to the interested public.

Measured salt loads in the Logan area. We assume that loading rates can be considered as "measured" at those sites for which there are reliable chloride and flow data (i.e. using the data set presented previously). In the first six miles below Ute Reservoir, where USBR measured significant brine inflow, there are three locations where such data exist. Loading rates (and chloride:sulfate ratios) were:

Site & mile	chloride	sulfate	T D S	chloride:sulfate
8, 0.37	1660	800	5000	2.1:1
17, 1.90	7150	1700	16300	4.2:1
31, 4.41	15800	2800	33200	5.6:1

Interpretation of data: effects of Ute Reservoir. The 1,660 tons/year chloride loading at mile 0.37 represents the impact of seepage and leakage from Ute Reservoir. The discharge of 2.35 cfs is larger than the baseflow measured at the Logan gage prior to reservoir enlargement, and therefore it must be larger than the pre-enlargement leakage and seepage. Based on the following logic, brine inflow is not a significant source of the 2.35 cfs.

- In the field, virtually all the flow was observed originating at sites 1 through 5.
- Site 1 was the toe drainage, and it was enriched in chloride relative to reservoir water. However, any flow net capable of generating 1 cfs of

through-dam seepage would show flow patterns far too strong to allow significant brine inflow; the pick-up in chloride mostly occurs as the water passes through the dam and foundation materials.

- Sites 2-5 represent leakage through the spillway or gates; water at these sites was comparable in quality to water in the reservoir, indicating no mixing with native ground water, and therefore no brine.

- Field investigations indicate that any brine which seeps through canyon walls into the river immediately below the dam is a minor part of the flow observed at mile 0.37.

- A highly saline pool was observed at site 7, but there was minimal impact of this pool on the quality of streamflow at site 8.

Mile 0.37 to mile 4.4. The data demonstrate that brine flow occurs in the reach from mile 0.37 to mile 4.4. On the date of the survey, the chloride load at mile 4.4 was equivalent to 15,800 tons/year. If 1,660 of this comes from Ute Reservoir (see above), then presumably 14,140 tons/year is brine inflow. Further comments are:

- The chloride loading rate is a bit higher from mile 0.37 to mile 1.9 (4700 tons/year/mile) than from mile 1.9 to mile 4.4 (3500 tons/year/mile).

- The chloride:sulfate ratio increases downstream as the chloride-rich brine reaches the river. From mile 1.9 to 4.4, the increase in chloride load was 8 times the increase in sulfate load.

Mile 4.4 to Reveulto. Site 41 is located at mile 6.3, just below the confluence with Revuelto Creek. Based on a flow of 12.88 cfs and a chloride concentration of 2110 mg/l, the chloride loading was 26,750 tons/year. About 1000 tons/year of this can be accounted for by the flow of Revuelto Creek (see calculation presented subsequently), which indicates that the load in the Canadian River just above the confluence was in excess of 25,000 tons/year.

This estimate is consistent with data collected at site 39, at mile 5.9, just above the Revuelto confluence. At that site, flow was 30% higher than observed at site 31 (mile 4.4) and conductance was 75% higher. Part of the conductance difference can be explained by a change in water temperature; eliminating the temperature factor, the data are consistent with a chloride load at site 39 of at least 25,000 tons/year. Given that load at site 31 was 15,800 tons/year, the data demonstrate that a chloride load on the order of 10,000 tons/year was entering the river between site 31 and Revuelto Creek on the day of the survey.

Evidence for increased brine flow in the Logan area. A major objective of the 1992 survey was to determine if brine inflows are greater now than they were before Ute Reservoir was enlarged. The data show a high rate of brine inflow, but not a rate that is demonstrably higher than the highest rate observed before the dam was raised.

For mile 0.37, the chloride load of 1,660 tons/year is certainly higher than occurred prior to enlargement of Ute Reservoir, simply because seepage and leakage from Ute have increased. There are no data from the early-mid 1980's which allow calculation of the increase, but based on the flow increase it might be a few to several hundred tons per year. However, as noted in the discussion of the seepage, there is no evidence that any significant part of the seepage or salt is the result of brine inflow.

In the area of mile 1.9, USBR (1984) collected data showing a chloride load of 4900 tons/year on average, but on individual dates the rate was about 6700 tons/year (see table and graph at end of **TAB 11**). In comparison, data obtained in the 1992 survey shows 7150 tons/year. The 1992 survey could be comparable to the higher end of the 1983-84 survey, plus a small additional load related to increased seepage from Ute Reservoir.

In the area of mile 5.4, USBR (1984) measured a chloride load of about 15,700 tons/year. Excluding one data set which probably reflects runoff conditions, the highest daily load was about 20,000 tons/year. A rough estimate of the load observed in 1992 is 22,500 tons/year. [This assumes that the 10,000 or so tons of chloride which reaches the river between sites 31 and 39 entered uniformly with distance; thus at mile 5.4, 6,700 tons/year was added to the 15,800 tons/year observed at site 31.] This data point is consistent with but does not prove the concept that brine inflow has increased since Ute Dam was enlarged.

Revuelto Creek. The chloride load from Revuelto Creek is estimated at 1000 tons/year, based on CRMWA's measured streamflow of 6.763 cfs and BEG's laboratory chloride value of 153 mg/l. This load is well within the range of values observed by USBR in 1983-84 but it is low compared to the average values reported in USBR (1984). It also is lower than loads which would be computed from USGS data (see HGC, 1984) and the load attributed to Revuelto Creek based on the State Line modeling (see Section 4.3).

Revuelto Creek to the State Line. Prior to the stream survey, we had reported on the preliminary results of our State Line modeling study (see Section 4.3) and had indicated the probability that an additional brine source (a "new brine aquifer") must exist between Revuelto Creek and the State Line. Loadings for this reach are calculated from the reliable data as follows.

Site & mile	Flow cfs	Chloride mg/l	Chloride load tons/year
31, 4.41	4.69	3415	15,800
41, 6.31	12.88	2110	26,750
50, 12.7	12.99	2700	34,500
57, 21.4	12.08	2310	27,500
67, 38.9	21.58	2370	50,300

The ups and downs in the chloride loading as the survey moved downstream may reflect the inate variability of the survey methods - not only variability among different techniques for measuring chlorides, but also the fact that it took more than a week to survey the entire river, and streamflow conditions varied from day to day. However, the value at site 67, the State Line, is so much larger than the upstream values that it very likely reflect a real-time loading increase.

Following are several comments on the data.

- Based on conductance data and field observations, the inflow begins near site 60 and continues downstream for several miles to about site 62. Site 60 is the "Dunes dam site" discussed in the ground-water notebook.

- During the survey, a small tributary near site 60 was discharging less than 0.1 cfs with a specific conductance of 20,500 micromhos/cm (measured by LWA). This was not a significant part of the total salt load, but indicates that <u>saline water does occur in the area</u>. Data in the BEG report show that water in the tributary is compositionally similar to water in brine pools near Logan, but with less than half the concentration. As discussed in the ground-water notebook, the same brine aquifer which reaches near the land surface in the gravel pit reach also surfaces in the area of the Dunes dam site.

- The reach from site 57 to 67 was resurveyed by CRMWA on February 24 and 25, 1992. Although the saline tributary noted in the early February survey was still flowing, the overall increase in salt load was much less than seen earlier in the same month. The in May, 1992, found almost no increased salt loading at all - slightly over 25,000 tons/day at site 57 on May 12th, and slightly over 26,000 tons/day at site 67 on May 13th.

Clearly, whatever source or sources account for the salt influx observed in early February, the sources or sources are not a steady brine inflow of the type observed in the Logan area. These results are consistent with Section 4.3, which found that Dunes baseflow is an important but variable source of brine loading between Revuelto Creek and the State Line. Addititional surveys (and interpretation of data from the newly reinstituted State Line gage) should help further our understanding of the current significance of saline inflows in the area of the Dunes dam site.

<u>Sources of salt at the State Line</u>. During the early-February survey of 1992, the chloride loading at the State Line can be characterized as follows:

Source	Tons/year	Percent of State Line Load
Ute Reservoir	1700	3%
Logan brine	25000	50%
Revuelto Ck	1000	2%
Reach 41-67	22600	45%
Total	50300	100%

These are not necessarily representative of long-term source conditions, as shown by the fact that subsequent surveys have shown much less inflow in the reach from Revuelto Creek (site 41) to State Line (site 67) and as shown by the different proportions calculated from long-term data (see Section 4.3).

Texas Reaches. Prior to the stream survey, we had reported that much of the sulfate reaching Lake Meredith must originate in Texas, because sulfate loads past the State Line are relatively low (see Section 4.3). We also reported preliminary findings suggesting that some of the salt which originates in New Mexico may be lost from the Canadian River before it reaches Lake Meredith. Further, we indicated that the stream survey might locate reaches of salt inflow in Texas.

Sulfates. The laboratory data indicate the following:

Site & mile	Flow cfs	Sulfate mg/l	Sulfate loading tons/year
8, 0.37	2.35	349	800
17, 1.90	3.84	451	1700
31, 4.41	4.69	615	2800
76, 68.4	24.72	538	13100
98, 133.9	34.1	652	21900

The survey has confirmed that most sulfates in the Canadian River originate downstream of the Logan reach. Based on Section 4.3, Revuelto Creek is a major sulfate source. Based on the tabulation above, sulfates also are important downstream of site 76, i.e. in Texas.

Salt gains and losses in Texas. The reliable data indicate the following:

Site & mile	Flow cfs	Chloride mg/l	Chloride load tons/year
67, 38.9	21.58	2370	50,300
76, 68.4	24.72	1560	38,000
80, 85.5	27.16	1690	45,200
86, 95.6	36.77	1410	51,000
90, 95.6	34.16	1130	38,600
101, 140.5	34.04	1190	40,500

While the data overall suggest a modest decrease in salt loading between the State Line and Amarillo, it is not known if the decrease is one which occurred with distance down the river, or with time during the survey (or with both - see previous discussion of data variability).

The results of the resurvey in May, 1992, are easier to interpret. Flow at the State Line (site 67) on May 13 was 8.3 cfs, a value which represents baseflow conditions. The chloride loading at the State Line was about 26,000 tons/year, which based on Section 4.3 is representative of average conditions. At Amarillo (site 101) the next day the flow was 2.9 cfs and the chloride load was 4,000 tons/day. Clearly, during this condition of low flows, the stream was experiencing a loss of both flow and salt load between State Line and Amarillo.

BEG interprets the conductance data as indicating a salinity increase between sites 68 through 72, which is in the general vicinity of a reported salt lake. In addition, we interpret the data from the Bruary survey as suggesting that there was a substantial saline inflow in a several-mile reach above and below Lahey Creek (site 96), although very little of the inflow showed up as far downstream as Amarillo. Lahey Creek itself discharged a small amount of saline water and a sample taken from a nearby seep was determined through laboratory analysis to contain chloride of 4910 mg/l and sulfate of 2160 mg/l. CRMWA's May survey confirmed a trickle of saline surface water in Lahey Creek. The full reach of previous saline impact was not surveyed in May.

The data from the Lahey reach indicate that salt inflows to the Canadian River probably do occur in Texas. The survey data overall indicate that conditions in Texas are much less regular than at Logan, and that it will take considerable data collection and interpretation to unravel the apparently complex patterns of salt inflow and loss.

Summary of resurvey needs. When the 1992 survey results became known, we recommended that CRMWA resurvey the Dunes dam site and Lahey Creek areas on a quarterly basis. This recommendation remains valid. The Lahey survey needs to extend upstream to site 90 and downstream to site 101, until details of the brine inflow are determined.

Based on the analyses reported here, we also recommend adding the Logan reach to the resurvey program. We specifically suggest measurements be made at sites at site 8, 17, 31, 36, 39, 40 and 41, to include flow, field conductance, temperature and chloride (using Hach kit), and sample collection for laboratory determinations of chloride, sulfate and total dissolved solids.

4.5 Some Additional Observations

As noted previously, the structure of Chapter 4 is to evaluate salt loading conditions in the Canadian River proceeding more or less downstream from Ute Reservoir. As of mid-1992, our evaluations have proceeded as far as the State Line gage (Section 4.3). This does not mean that every subject from Ute to State Line has been assessed; for example, at this time we have not undertaken a detailed water and salt budget for Ute Reservoir itself, but such a budget may be useful in the future if there is reason to believe that release schedules from the reservoir might change.

For areas downstream of State Line (that is, in Texas), neither this notebook nor the Project reports provide an adequate assessment of conditions important to salt loading at Lake Meredith. A separate study (not directly part of the Salinity Control Project) is underway to revise the safe yield estimate for Lake Meredith, and may improve the situation somewhat. The results of that study can be added to this notebook when available.

In addition, while developing the notebook we have performed some reviews of conditions in Texas. None of the work has been completed (nor, in fact, has it been submitted or authorized for CRMWA funding). Provisional results of the work are reported briefly below, to illustrate issues which arise with respect to salinity in Texas. Various graphs generated by the work are included in **TAB 33**.

Tascosa. We have begun to prepare a salt loading model for Tascosa which is similar in principle to the State Line model described in Section 4.3. However, conditions at Tascosa are so much more complex than at State Line, that the modeling approach must also be complex. The best results to date come from models which simultaneously compute loads for all the major ions (calcium, sodium + potassium, magnesium, carbonate + bicarbonate, sulfate, chloride).

Because the results are complex, but not yet complete, they are not discussed here except to point out a few relationships which appear important to Lake Meredith.

- The USGS data base at Tascosa appears to contain water-quality records which in fact are composites of data over extended time periods. Moreover, some of these composites are repeated in the data base, apparently because they were utilized several times to compute salt loads. Care must be taken to utilize the data base.

- While the Canadian River shows a net average gain in streamflow from State Line to Tascosa, detailed inspection of the data shows three different hydrologic patterns: flow loss at times, even to the point that the stream is dry at Tascosa; baseflow gain at times; and periodic runoff gain. We have not identified any consistent seasonal or long-term pattern in losses and gains, but the variability in the flow regimes is large relative to the median flows and undoubtedly accounts for much of the variability in salt loading from data point to data point.

- Concentrations of dissolved solids tend to be less at Tascosa than at State Line, due especially to the influence of fresh runoff. However, sulfate loads at Tascosa appear to exceed those at State Line on average. Whether or not the river at Tascosa carries a larger chloride load is not certain, due to difficulties in interpreting the USGS data base. During periods of streamflow loss, the stream tends to lose salts between the two gages - especially chloride (0.5 kg/sec loss). During periods of baseflow gain, salt loss is less, or salt gains occur.

- Computer calculations to reconstruct the Tascosa salt budgets are consistent with a hypothesis that during low flow periods, flows are lost by evaporation and seepage and salts are deposited in the channel alluvium, to be flushed out by subsequent runoff events. Because the model work is in its early stages, the calculations do not rule out either long-term permanent loss of salts which originate in New Mexico, nor long-term storage of salts in the alluvium.

Conditions further downstream. The pattern of periodic flow loss (which must mean salt loss) continues downstream of Tascosa. HDR (1987) estimated that about 38% of the Logan flow is lost before it reaches Amarillo; and 15% of the Amarillo flow is lost before it reaches Meredith. We have found no study which has clearly determined whether the salt loss is permanent (e.g. to deep ground water) or temporary; and if the latter, whether salt is flushed back to the river in a relatively short or long time frame.

The project reports don't evaluate in detail whether or not sources in Texas may have a significant impact on salt loading in Texas. However, the actual data support a conclusion that much of the sulfate which reaches the lake originates in Texas. More importantly, the data do not preclude the possibility that these Texas sources also contribute chlorides in significant amounts, and that these chlorides replace some New Mexico chlorides which are lost through deep seepage. The potential that Texas chlorides could be important also is suggested by the observation that high chloride concentrations are observed in shallow ground water along the Canadian River near Amarillo. The source of this salt and its potential flow to the river and Lake Meredith have not been evaluated in the Project reports.

We also are aware of concerns over the possibility that salt loading to Lake Meredith results from local sources such as abandoned oil wells, salt caverns used for hydrocarbon storage, and PANTEX. While no evidence indicates these sources actually are important, it may be prudent to address each source through a formal report.

Simple salt budget for Lake Meredith. We have not yet studied the salt budget for Lake Meredith in detail; work on this subject will be undertaken as part of the parallel study of reservoir safe yield.

For purposes of discussion, it is reasonable to rely on the salt budget estimated by CRMWA, which indicates a chloride loading on the order of 32,000 tons/year during the period 1965-89 **(TAB 15)**. During the period when the State Line gage was operational, the loading was about 28,600 tons/year.

Note, however, that chloride loads at the Amarillo gage are larger than this amount on average. Quantification of the difference should involve computer analysis and an effort to utilize the most comparable data, but based just on unadjusted USGS data for Amarillo, the difference is at least 5% and may be as large as 20%.

For purposes of discussion, we will assume that the chloride load at Amarillo was 35,000 tons/year during the time when the State Line gage was operational (i.e. during the time covered by the salt budget calculated in Section 4.3). Based on Section 4.3, Logan baseflow contributed 18,200 tons/year chloride during this time period, and New Mexico sources in total contributed 26,800 tons per year. Very roughly, then, 75% of the chloride observed at Amarillo (and, presumably, 75% of the chloride reaching Lake Meredith) can be accounted for by sources in New Mexico, assuming that there is no net loss in chloride from the State Line to Amarillo. Similarly, 50% of the chloride can be accounted for by brine inflow in the Logan area.

On this basis, and with the many caveats already expressed, a project which could halve the chloride loading from Logan brine would reduce chloride loadings to Lake Meredith by about 25%. This appears to be a reasonable (and hopefully conservative) planning estimate of benefits from a salinity control project.

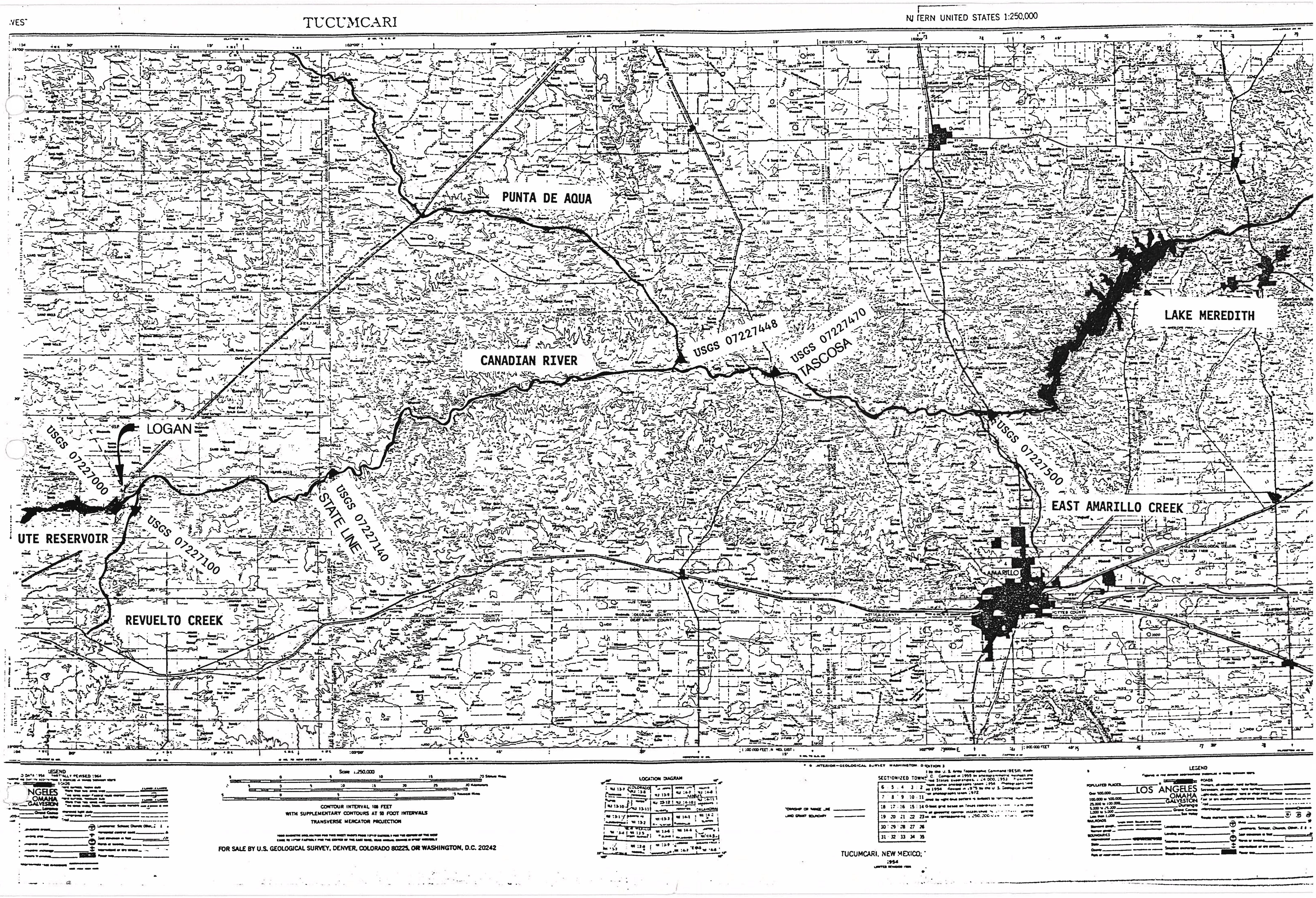
Time patterns. In Section 4.3, we noted changes in flow and salt loading rates after 1972. Graphs such as those provided near the end of **TAB 6** indicate similar changes are even more pronounced in Texas. In New Mexico, we believe the changes at State Line reflect changes in the salt sources, not large-scale storage and flushing. But for Texas it is quite possible that salt storage has been an important process over the last two decades and that salt loadings to Lake Meredith could be very large in some future period of extremely wet conditions. Whatever explanation exists for the long-term change, it must also account for an apparent shift in Texas salt loads toward a lower chloride:sulfate ratio over time.

One time pattern known to be important is the change in contributions from Amarillo effuent discharges. TWQB (1970) indicates that Amarillo effluent was an important source of water and salt at the Amarillo gage; in effect, this source is recycled Meredith water. Stream surveys conducted in the mid-70's show that effluent dominated water quality in the Canadian River during low flow periods. The Amarillo effluent went substantially off-line in 1978 (John Williams, personal communication), although its impact today is not insignificant (see **TAB 19** and Ottmers (1986)). To date, no study has accounted for the reduced effluent discharge in assessing the water or salt budgets of Lake Meredith.

Summary. Without question, there is a large discharge of chloride brine to the Canadian River near Logan New Mexico, and this is a major source of salt loading in Lake Meredith. However, neither the Project reports nor this notebook effectively address the complex flow conditions which convey this salt to the lake. To the extent these subjects are mentioned at all in previous reports, the implication is that while salt losses do occur in Texas, they are temporary and the salt is soon flushed to Lake Meredith. But other hypotheses cannot be ruled out based on the studies to date: for example, the salt loss could be permanent, in which case a relatively large portion of the salt reaching Lake Meredith originates in Texas; or, the salt loss could be temporary but long-term, and some future runoff event or events will flush an enormous load to the lake.

The bottom line is that we agree with USBR (1979, page 20) that studies are needed to "establish proof that salt from the [Logan] brine aquifer actually reaches Lake Meredith" and to deal generally with the subject of salt sources and processes in Texas (page 32).

The program of periodic stream surveys recently begun by CRMWA will provide an important source of data needed to address these matters. CRMWA's recently initiated study of reservoir safe yield may also provide insights. Eventually, the Authority may wish to consider whether or not computer analyses of the type described in Section 4.3 provide useful insights. If the answer is yes, similar studies could be done for Tascosa, Amarillo and Lake Meredith.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PUNTA DE AQUA
CANADIAN RIVER
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TASCOSA
LOGAN
USGS 07227000
UTE RESERVOIR
USGS 07227100
USGS 07227140
STATE LINE
REVUELTO CREEK
USGS 07227500
EAST AMARILLO CREEK
AMARILLO
CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 50 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D.C. 20242
LOCATION DIAGRAM
TUCUMCARI, NEW MEXICO;
1954
LEGEND
LOS ANGELES
OMAHA
GALVESTON

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surface-water data report

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TAB 3. INDEX TO USGS WATSTORE COMPUTER PRINTOUT

DISCHARGE DATA STATIONS, CANADIAN BASIN

Station Number	Station Name	Calendar Yr. Period	Area(sm)	Data
07223000	Bell Ranch Canal below Conchas Dam, NM	1970-1984[b]		Mean daily discharge; 1/72-12/73 missing
07223300	Conchas Canal below Conchas Dam, NM	1970-1990[c]		Mean daily discharge; discontinuous; water quality data
07223500	Conchas Lake at Conchas Dam, NM	1965-1990[d]	7409	COE[e]; daily reservoir storage; water quality data
07224500	Canadian River below Conchas Dam, NM	1936-1972	7417	Mean daily discharge; 1/39-12/41 missing; water quality data
07226500	Ute Creek near Logan, NM	1942-1990[f]	2060	Mean daily discharge; water quality data
*07226800	Ute Reservoir near Logan, NM	1965-1990[g]	11140	ISC[h]; daily reservoir storage; water quality data
*07227000	Canadian River at Logan, NM	1909-1990[i]	11141	Mean daily discharge; continuous since 1/30; water quality data
*07227100	Revuelto Creek near Logan, NM	1959-1990	786	Mean daily discharge; water quality data
07227200	Tramperos Creek near Stead, NM	1966-1973[j]	556	Mean daily discharge
*07227448	Punta de Agua Creek near Channing, TX	1967-1973	3568	Mean daily discharge; water quality data

Station Number	Station Name	Calendar Yr. Period	Area(sm)	Data
*07227470	Canadian River at Tascosa, TX	1968-1977	18536	Mean daily discharge; water quality data
*07227500	Canadian River near Amarillo, TX	1924-1990	19445	Mean daily discharge; continuous since 4/38; water quality data
*07227900	Lake Meredith near Sanford, TX	1964-1988	20220	CRMWA[k]; daily reservoir storage; data gaps 5/87 on; water quality data

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a This list does not include some additional records known to exist, mostly peak discharge and stage. For example, see Catalog of Information on Water Data, Water Resources Region 11 (Arkansas-White-Red), p. A-32 & A-34. Note also that instantaneous discharge measurements made at the time of water quality sample collection are not included. And any discharge data collected by entities other than USGS are unlikely to be included, since they are unlikely to appear in WATSTORE.

b Water Resources Data, NM, Water Year 1984 lists period of record as 10/42-9/84.

c Water Resources Data, NM, Water Year 1990 lists period of record as 9/45-6/49, 4/54-6/55, 9/61-10/82 and 10/84 - current year.

d Water Resources Data, NM, Water Year 1990 lists period of record as 12/38-9/65 (monthend contents only) & 10/65 - current year.

e Records provided by US Army Corps of Engineers; capacity table based on 1970 survey by Corps.

f Water Resources Data, NM, Water Year 1990 lists period of record as 1/12-5/14 (gage heights and discharge only) and 1/42 - current year.

g Water Resources Data, NM, Water Year 1990 lists period of record as 5/63-9/65 (monthend contents only) & 10/65 - current year. Discharge data for 1/26/83 and 8/09/83.

h Levels by Interstate Stream Commission, State of New Mexico; capacity table based on 1983 survey by USGS and ISC.

i Water Resources Data, NM, Water Year 1990 lists period of record as 6/04-11/05, 12/08-9/09, 2/10, 4-7/10, 8/10-9/11 (gage heights & discharge only); 10/11-5/14, 1-5/24, 9/24-7/25, 1/27-4/34, 8/34 - current year. Records for 12/09, 1/10 & 5-7/34 "unreliable".

j Water Resources Data, NM, Water Year 1973, Part 1 lists period of record as 10/64-5/66 (annual maximum only) & 6/66-12/73.

k Records of elevations furnished by Canadian River Municipal Water Authority; capacity table based on 1980 survey by US Bureau of Reclamation.

* Copies of the most current available detailed information on these key stations are in Tab 4.

WATER-QUALITY DATA STATIONS, CANADIAN BASIN

(1) Station Number	(2) Station Name	(3) Period of Record	(4) Number of analyses[a]	(5) Mean frequency (4 divided by 3)
07223000	Bell Ranch Canal below Conchas Dam, NM	4/63-8/64	10	1/1.5 months
07223300	Conchas Canal below Conchas Dam, NM	8/08-6/77	218	3/year
07223500	Conchas Lake at Conchas Dam, NM	6/24/75	1	-
07224500	Canadian River below Conchas Dam, NM	4/63-8/64	14	1/month
07225500	Ute Creek near Gladstone, NM	10/53-9/81	68	2/year
07226500	Ute Creek near Logan, NM	4/63-4/73	24	2.4/year
07226510	Ute Reservoir at Site F, 9.1 miles above Ute Dam, NM	10/68-8/86	98	5.4/year
07226515	Ute Reservoir at Site I, 5.0 miles above Ute Dam, NM	10/68-8/86	77	4.3/year
07226520	Ute Reservoir at Site G, 6.9 miles above Ute Dam, NM	3/76-8/86	15	1.5/year
07226530	Ute Reservoir at Site D, 5.7 miles above Ute Dam, NM	10/68-4/74	30	5/year
07226540	Ute Reservoir at Site E, 3.8 miles above Ute Dam, NM	10/68-4/73	42	4.7/year
*07226560	Ute Reservoir at Site B, 0.6 miles above Ute Dam, NM	10/68-6/90	252	11.4/year
07226800	Ute Reservoir near Logan, NM	3/63-8/83	15	1/1.33 years
07226810	Ute Reservoir at north spillway at Ute Dam, NM	1/14/67	2	-
07226820	Ute Reservoir at north drain outlet, Ute Dam, NM	10/20/67	2	-
07226830	Canadian River below Ute Dam near Logan, NM	10/02/68	1	-
*07227000	Canadian River at Logan, NM	10/59-8/71	332	27.6/year
07227070	Plaza Larga Creek above Barranca Creek near Tucumcari, NM	7/64-9/64	3	1.5/month
07227073	Plaza Larga Creek below Barranca Creek near Tucumcari, NM	11/64-1/66	11	0.8/month
07227080	Revuelto Creek below Plaza Larga Creek near Tucumcari, NM	11/06/64	1	-
*07227100	Revuelto Creek near Logan, NM	10/59-9/90	655	21/year
*07227125	Canadian River near Glenrio, NM	7/64-1/66	59	3.3/month
*07227140	Canadian River above NM - TX state line, NM	7/69-11/86	152	8.9/year
*07227448	Punta de Agua Creek near Channing, TX	2/68-5/73	32	6.4/year
*07227470	Canadian River at Tascosa, TX	11/49-9/77	286	10/year
*07227500	Canadian River near Amarillo, TX	7/38-8/90	1180	22.6/year
*07227900	Lake Meredith near Sanford, TX	11/65-1/84	41	2.2/year

[a] Each sample coded as a sample of surface water with a unique date and time, is counted as one analysis.

* Copies of the most current available detailed information on these key stations are in Tab 4.

Index to Station Descriptions

From U.S. Geological Survey Water-Data Report NM-90-1, Water Resources Data, New Mexico, Water Year 1990.

ARKANSAS RIVER BASIN

07226800 UTE RESERVOIR NEAR LOGAN, NM

LOCATION.--Lat 35°20'35", long 103°26'37", in NW¼ sec.21, T.13 N., R.33 E., Quay County, Hydrologic Unit 11080006, on face of Ute Dam on Canadian River, 2.5 mi southwest of Logan, 3.5 mi downstream from Ute Creek, and at mile 673.1.

DRAINAGE AREA.--11,140 mi², of which 1,110 mi² is probably noncontributing.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--May 1963 to September 1965 (monthend contents only), October 1965 to current year.

REVISED RECORDS.--WDR NM-78-1: 1977.

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Interstate Stream Commission). Prior to Feb. 25, 1974, nonrecording gage at same site and datum.

REMARKS.--Reservoir is formed by an earthfill dam 132 ft high above streambed, 2,050 ft long; an earthen dike section on north bank of Canadian River 3,640 ft long with a maximum height of 38 ft; a concrete labyrinth spillway section with an equivalent weir length of 3,360 ft is located upstream of an 840 ft long ogee section between the main embankment and dike. Original construction completed in May 1963, storage began Dec. 13, 1962; modification project to construct labyrinth spillway and increase height of dam and dike completed April 1984. Capacity, 246,620 acre-ft at elevation 3,787.0 ft, crest of labyrinth spillway. Top of dam is at elevation 3,812.0 ft. Maximum design capacity of 440,250 acre-ft at elevation 3,806.0 ft, 19.0 ft above crest of spillway, allows 193,600 acre-ft of capacity for protection of the structure. Dead storage, 10,900 acre-ft at elevation 3,725.0 ft, sill of outlet intake tower; inactive pool of 25,140 acre-ft between elevations 3,725.0 and 3,741.6 ft, maintained for sediment control and fish and wildlife. Figures given herein represent total contents. Reservoir storage is for municipal and industrial uses, recreational purposes, sediment control and some incidental flood control. Diversions upstream from station for irrigation about 90,000 acres.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents observed, 250,000 acre-ft, May 20, 21, 1987, elevation, 3,787.40 ft; minimum since reservoir first filled in September 1965, 31,320 acre-ft, June 6, 1984, elevation, 3,739.10 ft.

EXTREMES FOR CURRENT YEAR.--Maximum contents, 239,880 acre-ft, Oct. 1, elevation, 3,786.15 ft; minimum, 210,910 acre-ft, July 16, elevation, 3,782.26 ft.

Capacity table (elevation, in feet, and contents, in acre-feet)
(Based on survey by Geological Surveys and New Mexico Interstate Stream Commission 1983)

3,744	41,110	3,780	195,000
3,760	89,600	3,788	255,000

RESERVOIR STORAGE (ACRE-FEET), WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
OBSERVATION AT 24:00 VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	239880	235660	222610	221570	222020	222980	222680	220760	219200	213720	212930	229120
2	239730	235130	222610	221430	222170	223130	222680	221130	218900	213360	212860	228820
3	239650	234440	222680	221210	222240	223350	222910	221200	218900	213220	212860	228740
4	239570	233910	222680	221130	222310	223280	222830	221420	219350	212860	212710	228440
5	239250	233070	222680	221280	222310	223130	222540	221570	218460	212570	212860	228210
6	239250	232310	222540	221130	222390	223130	222460	221570	218090	212570	212860	228130
7	239170	231550	222460	221280	222390	222980	222680	221650	217950	212130	212860	228290
8	239250	230870	222540	221210	222390	223130	222760	221650	217430	211990	212710	228440
9	239170	230260	222460	221350	222390	223280	222540	221280	217350	211920	212570	228510
10	239250	229650	222090	221570	222390	223060	222310	221130	217210	211780	212360	228290
11	238940	228900	221940	221430	222390	223280	222310	221130	217130	211340	212280	228290
12	238850	228290	221870	221350	222390	223200	e222380	220980	216980	211200	212640	228210
13	238620	227450	222020	221430	222090	222980	222460	221050	216690	211060	215590	228130
14	238700	226610	222020	221280	221870	222760	222310	220980	216540	211410	220690	227830
15	238320	225630	221790	221430	222020	222830	222610	220980	216240	211270	225550	227750
16	237860	224710	221650	221720	222170	222830	222390	220610	215880	210910	227830	228820
17	237630	223880	221720	221500	222090	222910	222170	220540	215730	211410	228360	228970
18	237710	223650	221430	221940	222020	222610	221870	220680	215590	212350	228440	229120
19	237710	223570	221430	222020	223570	222680	222170	220540	215660	212350	228360	229050
20	237710	223650	221350	222090	222540	222830	222010	220310	215230	212420	228360	228900
21	237790	223420	221130	222090	222760	222830	222090	220240	215230	212200	229200	228670
22	237710	223280	221210	222240	222680	222680	222090	220240	215010	212500	229500	228740
23	237710	223350	221430	222170	222830	222240	222380	220160	214940	212930	229730	228740
24	237480	223500	221350	222020	222980	222090	221940	219940	214940	212780	229880	228670
25	237400	223130	221430	222170	222910	222090	221940	219870	214730	212710	229880	228740
26	237250	223420	221500	222460	223130	222390	221720	219570	214660	212420	229800	228670
27	237250	222760	221500	221940	222980	222540	221650	219280	214300	212420	229650	228670
28	237030	222680	221500	222020	222830	222390	221420	219200	214220	212280	229650	227960
29	236720	222610	221280	222240	---	222310	220910	219420	213940	212640	229580	228590
30	236570	222680	221130	222240	---	222540	220830	219350	213720	212710	229350	228900
31	236500	---	221350	222170	---	222680	---	219280	---	212930	229200	---
MAX	239880	235660	222680	222460	223570	223350	222910	221650	219350	213720	229880	229120
MIN	236500	222610	221130	221130	221870	222090	220830	219200	213720	210910	212280	227750
(†)	3785.71	3783.89	3783.71	3783.82	3783.91	3783.89	3783.66	3783.40	3782.43	3782.56	3784.75	3784.71
(††)	-3700	-13820	-1330	+820	+660	-150	-1850	-1550	-5560	-790	+16270	-300

CAL YR 1989 MAX 241230 MIN 216690 (††) -1780
WTR YR 1990 MAX 239880 MIN 210910 (††) -11300

(†) ELEVATION, IN FEET, AT END OF MONTH
(††) CHANGE IN CONTENTS, IN ACRE-FEET

e Estimated

From U.S. Geological Survey Water-Data Report NM-90-1, Water Resources Data, New Mexico, Water Year 1990.

ARKANSAS RIVER BASIN

07226800 UTE RESERVOIR NEAR LOGAN, NM -- Continued

WATER-QUALITY RECORDS

LOCATION.--Samples collected in Ute Reservoir impounded by Ute Dam on the Canadian River.

PERIOD OF RECORD.--Water years 1963 to current year.

REMARKS.--Samples for chemical analyses are collected annually at Site B which is located 0.6 mi upstream from Ute Dam. Samples are collected 5 feet from the bottom of the reservoir.

07226560 - UTE RE AT SITE B, 0.6 MILES AB UTE DAM, NM (LAT 35°20'32" LONG 103°27'16")

WATER QUALITY DATA, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990

DATE	TIME	SAMPLING DEPTH (FEET) (00003)	RESERVOIR DEPTH (FEET) (72025)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH (STANDARD UNITS) (00400)	TEMPERATURE AIR (DEG C) (00020)	TEMPERATURE WATER (DEG C) (00010)	OXYGEN, DISSOLVED (MG/L) (00300)	HARDNESS TOTAL (MG/L AS CACO3) (00900)	HARDNESS NONCARB DISSOLV FLD. AS CACO3 (MG/L) (00904)	CALCIUM DISSOLVED (MG/L AS CA) (00915)
JUN											
14...	0919	1.00	62.0	950	8.5	--	21.5	7.2	--	--	--
14...	0920	5.00	62.0	--	--	--	21.5	7.2	--	--	--
14...	0921	10.0	62.0	--	--	--	21.5	7.2	--	--	--
14...	0922	15.0	62.0	--	--	--	21.5	7.2	--	--	--
14...	0923	20.0	62.0	--	--	--	21.5	7.2	--	--	--
14...	0924	25.0	62.0	--	--	--	21.5	7.2	--	--	--
14...	0925	30.0	62.0	950	8.5	--	21.5	7.1	--	--	--
14...	0926	35.0	62.0	--	--	--	21.0	6.9	--	--	--
14...	0927	40.0	62.0	--	--	--	20.0	6.6	--	--	--
14...	0928	45.0	62.0	--	--	--	18.0	5.9	--	--	--
14...	0930	50.0	62.0	--	--	--	17.5	5.8	--	--	--
14...	0931	55.0	62.0	930	8.3	29.5	17.0	5.6	260	67	51
14...	0932	60.0	62.0	--	--	--	16.5	5.5	--	--	--

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)	SODIUM ADSORPTION RATIO (00931)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	BICARBONATE WATER DIS IT FIELD MG/L AS HCO3 (00453)	CARBONATE WATER DIS IT FIELD MG/L AS CO3 (00452)	ALKALINITY WAT DIS TOT IT FIELD MG/L AS CACO3 (39086)	ALKALINITY LAB (MG/L AS CACO3) (90410)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)
JUN											
14...	31	110	3	5.4	209	10	187	184	260	44	0.50

DATE	SILICA, DISSOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	NITROGEN, NO2+NO3 TOTAL (MG/L AS N) (00630)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N) (00631)	NITROGEN, AMMONIA TOTAL (MG/L AS N) (00610)	NITROGEN, ORGANIC TOTAL (MG/L AS N) (00605)	PHOSPHORUS TOTAL (MG/L AS P) (00665)	PHOSPHORUS ORTHO, DISSOLVED (MG/L AS P) (00671)	CARBON, ORGANIC TOTAL (MG/L AS C) (00680)	ARSENIC TOTAL (UG/L AS AS) (01002)	ARSENIC DISSOLVED (UG/L AS AS) (01000)
JUN											
14...	1.7	617	<0.100	<0.100	0.030	0.77	0.020	<0.010	4.6	1	1

DATE	BORON, DISSOLVED (UG/L AS B) (01020)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD) (01027)	CADMIUM DISSOLVED (UG/L AS CD) (01025)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR) (01034)	CHROMIUM, DISSOLVED (UG/L AS CR) (01030)	COPPER, TOTAL RECOVERABLE (UG/L AS CU) (01042)	COPPER, DISSOLVED (UG/L AS CU) (01040)	IRON, DISSOLVED (UG/L AS FE) (01046)	LEAD, TOTAL RECOVERABLE (UG/L AS PB) (01051)	LEAD, DISSOLVED (UG/L AS PB) (01049)	MERCURY TOTAL RECOVERABLE (UG/L AS HG) (71900)
JUN											
14...	150	<1	<1.0	3	<1	2	1	8	<1	<1	0.10

DATE	MERCURY DISSOLVED (UG/L AS HG) (71890)	SELENIUM, TOTAL (UG/L AS SE) (01147)	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN) (01092)	ZINC, DISSOLVED (UG/L AS ZN) (01090)	NITROGEN, NO2+NO3 TOT. IN BOT MAT (MG/KG AS N) (00633)	NITROGEN, NH4 TOTAL IN BOT. MAT. (MG/KG AS N) (00611)	PHOSPHORUS TOTAL IN BOT. MAT. (MG/KG AS P) (00668)	ARSENIC TOTAL IN BOTTOM MATERIAL (UG/G AS AS) (01003)	CADMIUM RECOV. FM BOTTOM MATERIAL (UG/G AS CD) (01028)	CHROMIUM, RECOV. FM BOTTOM MATERIAL (UG/G) (01029)
JUN											
14...	0.2	<1	<1	<10	10	<2.0	43	450	8	<1	6

DATE	COBALT, RECOV. FM BOTTOM MATERIAL (UG/G AS CO) (01038)	COPPER, RECOV. FM BOTTOM MATERIAL (UG/G AS CU) (01043)	IRON, RECOV. FM BOTTOM MATERIAL (UG/G AS FE) (01170)	LEAD, RECOV. FM BOTTOM MATERIAL (UG/G AS PB) (01052)	MANGANESE, RECOV. FM BOTTOM MATERIAL (UG/G) (01053)	MERCURY RECOV. FM BOTTOM MATERIAL (UG/G AS HG) (71921)	ZINC, RECOV. FM BOTTOM MATERIAL (UG/G AS ZN) (01093)	SEDIMENT, SUSPENDED (MG/L) (80154)	SED. SUSP. SIEVE DIAM. % FINER THAN .062 MM (70331)	COLIFORM, FECAL, 0.7 UM-MF (COLS./ 100 ML) (31625)	STREPTOCOCCI FECAL, KF AGAR (COLS. PER 100 ML) (31673)
JUN											
14...	10	20	4800	20	510	0.02	20	71	75	<1	<1

From U.S. Geological Survey Water-Data Report NM-90-1, Water Resources Data, New Mexico, Water Year 1990.

07227000 CANADIAN RIVER AT LOGAN, NM

LOCATION.--Lat 35°21'25", long 103°25'03", in NE¼NE¼ sec.15, T.13 N., R.33 E., Quay County, Hydrologic Unit 11080006, on left bank 1,100 ft upstream from bridge on U.S. Highway 54, 0.7 mi south of Logan, 1.4 mi upstream from Chicago, Rock Island & Pacific Railroad Co. bridge, 2.0 mi downstream from Ute Dam, 4.3 mi upstream from Revuelto Creek, and at mile 672.0.

DRAINAGE AREA.--11,141 mi^2, of which 1,100 mi^2 is probably noncontributing.

PERIOD OF RECORD.--June 1904 to November 1905 (gage heights and discharge measurements only), December 1908 to September 1909, February 1910, April to July 1910, August 1910 to September 1911 (gage heights and discharge measurements only), October 1911 to May 1914, January to May 1924, September 1924 to July 1925, January 1927 to April 1934, August 1934 to current year. Monthly discharge only for some periods, published in WSP 1311. Records for December 1909, January 1910, and May to July 1934, published in WSP 267, 287, and 762 are unreliable and should not be used. Published as "South Canadian River" June to September 1904.

REVISED RECORDS.--WSP 1087: 1935-36. WSP 1117: Drainage area. WSP 1281: 1912, 1932(M), 1934, 1945-47, 1949-50. WSP 1311: 1931(M). See also PERIOD OF RECORD.

GAGE.--Water-stage recorder. Datum of gage is 3,667.1 ft above National Geodetic Vertical Datum of 1929. Prior to Jan. 1, 1987 same site at datum 1.0 ft higher. See WSP 1311 or 1731 for history of changes prior to Oct. 1, 1934.

REMARKS.--Records poor. Flow regulated by Conchas Lake, 45 mi upstream (station 07223500) and Ute Reservoir, 2 mi upstream (station 07226800). Diversions for irrigation of about 90,000 acres upstream from station. Several observations of water temperature were made during the year.

AVERAGE DISCHARGE.--15 years (water years 1909, 1912-13, 1927-38), 392 ft^3/s, 284,000 acre-ft/yr, prior to completion of Conchas dam. 24 years (water years 1939-62), 257 ft^3/s, 186,200 acre-ft/yr, prior to completion of Ute Dam. 28 years (water years 1963-90), 36.4 ft^3/s, 26,370 acre-ft/yr.

EXTREMES FOR PERIOD OF RECORD (SINCE 1925).--Maximum discharge, 219,000 ft^3/s, Sept. 22, 1941, gage height, 29.3 ft, from floodmarks, from rating curve extended above 75,000 ft^3/s; no flow at times prior to completion of Ute Dam.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum discharge, 278,000 ft^3/s, Sept. 30, 1904, gage height, about 36.5 ft, site and datum used in 1909, from rating curve extended above 14,000 ft^3/s, from Ninth Biennial Report of New Mexico State Engineer.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 357 ft^3/s, Nov. 1, gage height, 3.72; minimum daily, 3.2 ft^3/s, Nov. 21.

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.6	171	3.7	4.2	4.6	5.2	4.9	4.3	3.5	3.5	3.4	3.9
2	3.7	347	3.7	4.1	4.6	5.2	4.9	4.3	3.5	3.5	3.5	3.9
3	3.7	341	3.7	5.3	4.6	5.2	4.8	4.6	3.6	3.5	3.5	4.0
4	3.8	341	3.7	4.2	4.5	5.4	4.6	4.5	3.6	3.5	3.6	3.9
5	4.1	336	3.7	4.3	4.6	5.5	4.6	4.1	3.6	3.5	3.4	3.9
6	4.5	332	3.7	4.3	4.5	5.8	4.6	4.0	3.6	3.5	3.4	3.9
7	4.2	328	3.7	4.3	4.5	6.1	4.5	3.9	3.6	3.5	3.5	4.0
8	4.3	309	3.7	4.3	4.6	5.8	4.4	3.9	3.7	3.6	3.5	4.0
9	4.4	323	3.7	4.3	4.6	5.8	4.4	3.9	3.6	3.5	3.4	3.8
10	4.6	320	3.7	4.4	4.7	5.8	4.3	3.8	3.5	3.5	3.5	3.9
11	4.6	317	3.7	4.4	4.7	6.7	4.1	3.8	3.5	3.6	3.6	4.1
12	4.0	314	3.7	4.4	5.1	6.5	4.1	3.9	3.5	3.5	3.6	4.1
13	4.0	311	3.7	4.4	4.8	6.5	4.1	3.8	3.5	3.5	3.9	4.2
14	4.0	326	3.7	4.4	4.6	6.2	4.1	3.8	3.5	3.5	4.5	4.3
15	4.2	342	3.7	4.5	4.7	5.8	4.1	3.8	3.5	3.5	5.7	4.7
16	4.0	341	3.7	4.5	4.7	5.8	4.0	3.8	3.5	3.5	3.9	7.4
17	4.0	340	3.7	4.5	4.6	5.7	4.0	3.8	3.6	3.4	3.6	4.9
18	4.1	209	3.7	4.6	4.7	5.6	4.0	3.8	3.5	4.2	3.8	3.7
19	4.2	4.5	3.7	4.6	4.7	5.6	4.2	3.8	3.5	3.6	4.0	3.7
20	4.1	3.3	3.7	4.7	5.6	5.6	4.3	3.8	3.5	3.4	4.0	3.6
21	4.3	3.2	3.8	4.7	4.9	5.5	4.1	3.8	3.6	3.5	4.0	3.6
22	4.3	3.3	3.9	4.7	4.9	5.3	4.1	3.7	3.5	3.5	3.8	3.6
23	4.3	3.4	4.0	4.7	4.9	5.3	4.2	3.5	3.5	3.4	3.9	3.7
24	4.6	3.5	4.0	4.7	4.9	5.3	4.3	3.5	3.5	3.6	3.9	4.0
25	4.7	3.6	3.8	4.6	5.1	5.3	4.2	3.5	3.5	3.5	3.8	4.0
26	9.0	3.7	4.0	4.6	5.2	5.3	4.2	3.5	3.5	3.4	3.9	3.9
27	5.4	3.7	4.0	4.5	5.2	5.3	4.2	3.5	3.5	3.5	3.9	3.7
28	6.0	3.7	4.0	4.5	5.1	5.0	4.0	3.5	3.5	3.5	3.9	3.6
29	4.8	3.7	4.0	4.7	---	5.2	4.1	4.5	3.5	4.0	3.9	3.7
30	4.1	3.7	4.0	4.7	---	5.0	4.6	3.9	3.5	3.5	4.0	3.6
31	4.4	---	4.1	4.7	---	5.0	---	3.9	---	3.4	3.9	---
TOTAL	138.0	5691.3	117.6	139.8	134.2	173.3	129.0	120.2	106.0	109.6	118.2	121.3
MEAN	4.45	190	3.79	4.51	4.79	5.59	4.30	3.88	3.53	3.54	3.81	4.04
MAX	9.0	347	4.1	5.3	5.6	6.7	4.9	4.6	3.7	4.2	5.7	7.4
MIN	3.6	3.2	3.7	4.1	4.5	5.0	4.0	3.5	3.5	3.4	3.4	3.6
AC-FT	274	11290	233	277	266	344	256	238	210	217	234	241

CAL YR 1989 TOTAL 7190.3 MEAN 19.7 MAX 347 MIN 2.2 AC-FT 14260
WTR YR 1990 TOTAL 7098.5 MEAN 19.4 MAX 347 MIN 3.2 AC-FT 14080

From U.S. Geological Survey, 1971 Water Resources Data For New Mexico, Part 2. Water Quality Records.

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1970 TO DECEMBER 1971

PART 7. LOWER MISSISSIPPI RIVER BASIN

ARKANSAS RIVER BASIN

07227000 CANADIAN RIVER AT LOGAN, N. MEX. (LAT 35°21'25", LONG 103°25'03"10)

DATE	TIME	DIS-CHARGE (CFS) (00060)	DIS-SOLVED SILICA (SiO_2) (MG/L) (00955)	DIS-SOLVED CAL-CIUM (CA) (MG/L) (00915)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L) (00925)	DIS-SOLVED SODIUM (NA) (MG/L) (00930)	DIS-SOLVED PO-TAS-SIUM (K) (MG/L) (00935)	BICAR-BONATE (HCO_3) (MG/L) (00440)	DIS-SOLVED SULFATE (SO_4) (MG/L) (00945)	DIS-SOLVED CHLO-RIDE (CL) (MG/L) (00940)	DIS-SOLVED FLUO-RIDE (F) (MG/L) (00950)	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L) (00631)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L) (70301)	HARD-NESS (CA,MG) (MG/L) (00900)	NON-CAR-BONATE HARD-NESS (MG/L) (00902)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) (00095)	PH (UNITS) (00400)	TEMPER-ATURE (DEG C) (00010)
JUNE, 1971																		
23...	1630	173	4.6	53	16	100	4.5	231	150	52	0.6	0.04	495	200	9	836	8.1	22.5
AUG.																		
31...	1645	149	3.7	36	16	120	4.4	226	160	67	.7	.00	519	160	0	860	8.1	25.0

OTHER VALUES

DATE	TIME	DIS-SOLVED IRON (FE) (UG/L) (01046)	TOTAL PHOS-PHORUS (P) (MG/L) (00665)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L) (00671)	DIS-SOLVED SOLIDS (RESI-DUE AT 180°C) (MG/L) (70300)	AIR TEMP-ERATURE (DEG C) (00020)	COLOR (PLAT-INUM-COBALT UNITS (00080)	TUR-BID-ITY (JTU) (00070)	DIS-SOLVED OXYGEN (MG/L) (00300)	CHEM-ICAL OXYGEN DEMAND (LOW LEVEL (MG/L) (00335)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L) (00310)	IMME-DIATE COLI-FORM (COL. PER 100 ML) (31501)	FECAL COLI-FORM (COL. PER 100 ML) (31616)	STREP-TOCOCCI (COL-ONIES PER 100 ML) (31679)	DIS-SOLVED BORON (B) (UG/L) (01020)	DIS-SOLVED LEAD (PB) (UG/L) (01049)	TOTAL MERCURY (HG) (UG/L) (71900)
JUNE, 1971																	
23...	1630	--	0.02	0.01	504	37.5	20	20	7.2	6	1.4	< 10	< 10	40	--	0	0.1
AUG.																	
31...	1645	20	--	--	--	--	--	--	--	--	--	--	--	--	180	--	--

From U.S. Geological Survey Water-Data Report NM-90-1, Water Resources Data, New Mexico, Water Year 1990.

07227100 REVUELTO CREEK NEAR LOGAN, NM

LOCATION.--Lat 35°20'29", long 103°23'37", in SW¼NW¼ sec.24, T.13 N., R.33 E., Quay County, Hydrologic Unit 11080008, on right bank 0.3 mi upstream from bridge on State Highway 469, 1.9 mi southeast of Logan, and at mile 2.3.

DRAINAGE AREA.--786 mi².

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--August 1959 to current year.

GAGE.--Water-stage recorder. Elevation of gage is 3,660 ft above National Geodetic Vertical Datum of 1929, from topographic map. Prior to Jan. 16, 1981, at site 320 ft upstream at datum 0.56 ft higher.

REMARKS.--Water-discharge records poor. Low flows supplemented by surface and ground-water return from irrigation in vicinity of Tucumcari. Several observations of water temperature were made during the year.

AVERAGE DISCHARGE.--31 years, 44.2 ft³/s, 32,020 acre-ft/yr.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 26,700 ft³/s, July 9, 1960, gage height, 14.3 ft, site and datum then in use; no flow at times most years.

EXTREMES OUTSIDE PERIOD OF RECORD (1941-47).--Maximum discharge determined, about 13,400 ft³/s, Sept. 18, 1946, gage height, 9.04 ft, at site 180 ft downstream at different datum, from unpublished records collected by U.S. Bureau of Reclamation. A peak of 26,100 ft³/s, date unknown, gage height, 12.9 ft at former site and datum, was measured by slope- area method in May 1957.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 3,500 ft³/s and maximum (*):

Date	Time	Discharge (ft³/s)	Gage height (ft)	Date	Time	Discharge (ft³/s)	Gage height (ft)
Sept. 29	0830	*4,970	*6.96	No other peak greater than base discharge.			

No flow part of each day June 29 - July 2.

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	4.5	e2.0	1.6	1.9	39	4.1	1.9	3.0	3.2	.00	e20	e16
2	2.6	e2.0	1.7	2.4	22	4.1	1.6	4.1	1.9	.56	e13	e16
3	4.4	e2.0	1.3	2.3	28	3.1	1.3	27	1.1	.80	e20	e16
4	4.8	e2.0	1.4	1.8	11	2.7	1.0	130	.79	2.6	e11	e16
5	8.5	e2.0	1.5	1.8	8.4	2.6	.76	47	.64	3.1	e8.0	e16
6	15	e2.0	1.4	1.7	8.5	2.3	.66	31	.44	2.2	35	e16
7	14	e2.0	1.6	3.0	11	1.5	.71	22	.25	.70	219	11
8	15	e2.0	1.8	1.9	10	1.4	.58	15	.24	1.3	e112	e45
9	13	e2.0	1.7	2.4	8.2	1.4	.49	14	.38	4.0	e90	e80
10	12	e2.0	1.5	1.9	6.5	1.6	.40	10	.26	4.7	e80	e50
11	12	e2.0	1.5	1.6	6.4	3.2	.32	9.0	.17	5.1	e70	e20
12	7.0	e2.0	1.8	1.3	3.6	14	.37	10	.07	5.6	e60	e15
13	3.4	e4.0	2.4	1.5	.93	3.7	.47	10	1.2	3.9	e300	8.5
14	3.3	5.0	3.1	1.5	.75	1.8	.45	13	2.5	4.3	e400	4.6
15	7.6	5.8	3.0	1.5	1.1	1.6	.48	9.2	1.8	3.8	e100	4.3
16	8.7	4.0	1.9	1.3	1.8	1.6	.39	7.4	1.6	2.3	e90	96
17	9.5	2.7	2.8	1.4	1.7	1.4	.32	3.8	1.1	1.5	e70	1070
18	15	2.5	4.8	3.3	1.4	1.2	.28	4.6	.60	30	e60	754
19	e10	2.0	3.7	8.2	1.2	.95	.87	4.6	.18	13	e50	146
20	e5.0	1.9	4.2	11	264	.88	24	3.3	.55	7.6	e40	17
21	e3.5	1.8	4.7	18	149	.81	9.2	3.7	1.7	58	e30	146
22	e2.5	1.5	4.8	21	111	.79	3.0	3.8	1.1	169	e28	238
23	e2.5	1.4	13	111	58	.71	6.2	5.0	1.1	77	e25	121
24	e2.5	1.4	12	230	12	.98	1.6	2.8	2.4	28	e22	16
25	e2.5	1.2	11	110	7.7	1.2	4.5	2.4	.83	13	e20	5.3
26	e2.5	1.2	12	79	5.6	1.4	2.0	1.7	.32	7.8	e20	2.4
27	e2.5	1.2	9.1	98	4.7	1.4	1.9	1.4	.19	5.1	e19	1.3
28	e2.5	1.1	4.2	60	4.9	1.2	2.6	1.8	.16	78	e18	.82
29	e2.5	1.1	2.5	29	---	2.9	2.4	3.7	.02	59	e17	1200
30	e2.5	1.4	2.1	32	---	5.0	2.4	2.6	.00	e45	e17	286
31	e2.5	---	2.2	23	---	3.2	---	3.3	---	e30	e16	---
TOTAL	203.8	65.2	122.3	864.7	788.38	74.72	73.15	410.2	26.79	666.96	2080.0	4434.22
MEAN	6.57	2.17	3.95	27.9	28.2	2.41	2.44	13.2	.89	21.5	67.1	148
MAX	15	5.8	13	230	264	14	24	130	3.2	169	400	1200
MIN	2.5	1.1	1.3	1.3	.75	.71	.28	1.4	.00	.00	8.0	.82
AC-FT	404	129	243	1720	1560	148	145	814	53	1320	4130	8800

CAL YR 1989 TOTAL 14419.52 MEAN 39.5 MAX 1310 MIN .05 AC-FT 28600
WTR YR 1990 TOTAL 9810.42 MEAN 26.9 MAX 1200 MIN .00 AC-FT 19460

e Estimated

From U.S. Geological Survey Water-Data Report NM-90-1, Water Resources Data, New Mexico, Water Year 1990.

ARKANSAS RIVER BASIN

07227100 REVUELTO CREEK NEAR LOGAN, NM -- Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Water years 1959 to current year.

WATER QUALITY DATA, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990

DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	PH (STAND-ARD UNITS) (00400)	TEMPER-ATURE AIR (DEG C) (00020)	TEMPER-ATURE WATER (DEG C) (00010)	OXYGEN, DIS-SOLVED (MG/L) (00300)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)
NOV 13...	1600	4.0	1550	--	8.5	21.0	17.0	8.5	350	70	42
JAN 17...	1600	1.4	2380	--	8.1	14.0	11.5	9.5	--	--	--
MAR 29...	1600	3.4	2100	--	8.2	10.0	9.5	10.4	360	62	49
APR 18...	1530	2.8	2890	--	9.0	10.0	6.0	9.4	350	63	46
JUN 13...	1430	2.4	--	1180	8.7	34.0	34.0	6.0	440	85	55
SEP 12...	1600	38	1100	--	8.4	32.0	30.0	6.3	--	--	--

DATE	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	ALKA-LINITY LAB (MG/L AS CACO3) (90410)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	BORON, DIS-SOLVED (UG/L AS B) (01020)	IRON, DIS-SOLVED (UG/L AS FE) (01046)
NOV 13...	230	5	4.6	206	500	120	0.60	8.1	1100	300	7
JAN 17...	--	--	--	--	--	--	--	--	--	--	--
MAR 29...	330	8	3.7	213	660	160	0.50	6.9	1400	340	20
APR 18...	520	12	4.0	262	520	480	0.30	9.5	1800	440	30
JUN 13...	98	2	3.8	156	460	22	0.20	7.5	825	100	16
SEP 12...	--	--	--	--	--	--	--	--	--	--	--

From U.S. Geological Survey, 1966 Water Resources Data For New Mexico, Part 2. Water Quality Records.

7-2271.25. CANADIAN RIVER NEAR GLENRIO, N. MEX.

LOCATION.--Lat 35°21'12", long 103°06'15", at gaging station 300 feet downstream from Martin Draw, 0.5 mile downstream from Rana Canyon, approximately 6 miles upstream from New Mexico-Texas State line, and 13 miles north of Glenrio, Quay County.
RECORDS AVAILABLE.--Chemical analyses: July 1964 to January 1966 (discontinued).
Water temperatures: October 1964 to September 1965.

Chemical analyses, in parts per million, October 1965 to January 1966

Date of collection	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)			Hardness as $CaCO_3$		Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
															Parts per million	Tons per acre-foot	Tons per day	Calcium, Magnesium	Noncarbonate			
Oct. 4, 1965.....	336	5.4	0.01	48	16	157	5.0	214	0	158	130	0.8	0.2	0.17	626			185	10	5.0	1060	7.7
Oct. 11..........	326	--	--	--	--	--	--	221	0	--	138	--	--	--	--			202	21	--	1110	7.6
Oct. 25..........	300	--	--	--	--	--	--	204	0	--	130	--	--	--	--			187	20	--	1050	7.7
Nov. 3...........	307	--	--	--	--	--	--	209	0	--	138	--	--	--	--			195	24	--	1080	7.6
Nov. 10..........	17.4	10	.01	113	46	768	7.6	301	0	274	1110	.6	.5	.23	2480			470	224	15	4340	8.0
Nov. 17..........	9.5	--	--	--	--	--	--	313	0	--	1730	--	--	--	--			570	314	--	6200	7.9
Nov. 26..........	7.9	--	--	--	--	--	--	312	0	--	2020	--	--	--	--			600	344	--	7100	7.8
Dec. 11..........	10.2	--	--	--	--	--	--	307	0	--	2180	--	--	--	--			615	364	--	7530	8.0
Dec. 20..........	24.7	--	--	--	--	--	--	300	0	--	1350	--	--	--	--			510	264	--	5270	8.0
Jan. 4, 1966.....	21.7	--	--	--	--	--	--	352	0	--	2390	--	--	--	--			665	378	--	8240	7.9

From U.S. Geological Survey Water-Data Report NM-86-1, Water Resources Data, New Mexico, Water Year 1986.

ARKANSAS RIVER BASIN

07227140 CANADIAN RIVER ABOVE NEW MEXICO-TEXAS STATE LINE, NM
(National stream-quality accounting network station)

WATER-QUALITY RECORDS

LOCATION.--Lat 35°23'35", long 103°02'30", in SW¼ sec.32, T.14 N., R.37 E., Quay County, Hydrologic Unit 11080006, 0.1 mi upstream from New Mexico-Texas State line, 5.5 mi downstream from Rana Canyon, and 14.7 mi north of Glenrio.

DRAINAGE AREA.--12,616 mi².

PERIOD OF RECORD.--Water years 1969-73, 1975 to March 1986 (discontinued).

REMARKS.--Water-discharge measurements were made at the time water-quality samples were collected.

WATER QUALITY DATA, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS) (00061)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	PH (STAND-ARD UNITS) (00400)	PH LAB (STAND-ARD UNITS) (00403)	TEMPER-ATURE, AIR (DEG C) (00020)	TEMPER-ATURE (DEG C) (00010)	TUR-BID-ITY (NTU) (00076)	OXYGEN, DIS-SOLVED (MG/L) (00300)	HARD-NESS (MG/L AS CACO3) (00900)
DEC 12...	1130	1.5	10900	8630	8.20	7.70	-12.0	2.0	20	12.0	700
MAR 12...	0900	8.6	8000	9140	--	7.80	12.0	9.0	21	--	670

DATE	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	ALKA-LINITY LAB (MG/L AS CACO3) (90410)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)
DEC 12...	420	150	79	1700	29	7.7	286	400	2600	0.60	13
MAR 12...	420	130	83	1800	31	8.5	248	530	2700	0.60	13

DATE	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N) (00613)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N) (00610)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N) (00608)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N) (00605)	PHOS-PHORUS, TOTAL (MG/L AS P) (00665)	PHOS-PHORUS, ORTHO, DIS-SOLVED (MG/L AS P) (00671)	ALUM-INUM, DIS-SOLVED (UG/L AS AL) (01106)
DEC 12...	5090	5100	0.380	0.010	0.390	0.120	0.120	0.28	0.010	0.010	10
MAR 12...	5370	5400	0.440	0.010	0.450	0.030	0.080	0.27	0.020	<0.010	--

DATE	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BARIUM, DIS-SOLVED (UG/L AS BA) (01005)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE) (01010)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COBALT, DIS-SOLVED (UG/L AS CO) (01035)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LITHIUM DIS-SOLVED (UG/L AS LI) (01130)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)
DEC 12...	1	200	<10	1	<1	2	3	20	<1	210	260
MAR 12...	--	--	--	--	--	--	--	--	--	--	--

DATE	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	SELE-NIUM, DIS-SOLVED (UG/L AS SE) (01145)	SILVER, DIS-SOLVED (UG/L AS AG) (01075)	STRON-TIUM, DIS-SOLVED (UG/L AS SR) (01080)	VANA-DIUM, DIS-SOLVED (UG/L AS V) (01085)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)	SEDI-MENT, SUS-PENDED (MG/L) (80154)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY) (80155)	SED. SUSP. SIEVE DIAM. % FINER THAN .062 MM (70331)
DEC 12...	0.9	2	2	<1	<1	3000	36	20	--	--	--
MAR 12...	--	--	--	--	--	--	--	--	310	7.2	20

From U.S. Geological Survey, 1973 Water Resources Data For Texas, Part 1. Surface Water Records.

07227448 Punta de Agua Creek near Channing, Tex.

LOCATION.--Lat 35°40'03", long 102°28'48", Hartley County, on left bank at downstream side of bridge on Farm Road 767, 8.5 miles (13.7 km) west of Channing, and 10.3 miles (16.6 km) upstream from mouth.

DRAINAGE AREA.--3,568 mi² (9,241 km²), of which 2,068 mi² (5,356 km²) is probably noncontributing.

PERIOD OF RECORD.--October (revised) 1967 to September 1973 (discontinued).

GAGE.--Water-stage recorder. Datum of gage is 3,390.87 ft (1,033.54 m) above mean sea level.

AVERAGE DISCHARGE.--6 years, 15.7 ft³/s (0.445 m³/s), 11,370 acre-ft/yr (14.0 hm³/yr).

EXTREMES.--Current year: Maximum discharge, 51 ft³/s (1.44 m³/s) Oct. 20, gage height, 4.43 ft (1.35 m); no flow for many days.
Period of record: Maximum discharge, 24,200 ft³/s (685 m³/s) Aug. 28, 1972, gage height, 6.00 ft (1.83 m); no flow for many days each year.

REMARKS.--Records poor. Flow is partly regulated by Lake Rita Blanca on Rita Blanca Creek, capacity 12,100 acre-ft (14.9 hm³), 23 miles (37 km) upstream. Small diversions from Lake Rita Blanca.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	17	11	21	21	7.2	14	7.1				
2	0	11	11	22	13	6.7	41	.81				
3	0	8.2	11	22	12	5.9	28	6.4				
4	0	6.6	5.9	8.7	9.0	5.7	8.3	.81				
5	0	5.6	6.8	26	7.8	5.2	8.2	.47				
6	0	3.4	4.5	22	9.9	4.8	6.9	.19				
7	0	3.1	4.5	14	11	4.9	6.6	.25				
8	0	3.6	7.6	9.3	11	7.6	5.2	.16				
9	0	3.7	5.5	6.1	10	9.1	5.2	.10				
10	0	3.4	6.5	4.0	12	19	5.7	0				
11	0	3.1	5.5	4.0	13	13	9.5	0				
12	0	3.9	6.5	5.0	18	7.8	15	0				
13	0	9.5	8.0	7.5	9.7	8.1	13	0				
14	0	8.7	9.5	8.7	8.0	7.3	13	22				
15	0	8.2	6.0	10	8.0	4.3	13	11				
16	0	5.6	7.0	13	8.8	4.5	12	3.3				
17	0	8.0	8.0	16	9.6	3.7	10	3.3				
18	0	8.1	9.0	16	8.9	3.0	8.5	.81				
19	2.6	7.7	10	13	9.0	2.9	.47	.53				
20	48	9.0	11	13	8.5	3.7	.42	.25				
21	30	9.5	11	9.5	5.8	3.0	.37	0				
22	8.9	8.0	14	7.8	5.5	6.9	.37	0				
23	11	6.0	13	13	8.0	28	.47	0				
24	9.4	8.0	12	13	9.5	23	.69	0				
25	8.6	12	11	12	12	13	22	0				
26	6.1	11	10	13	10	11	13	0				
27	5.4	10	10	9.9	10	14	13	0				
28	4.9	11	17	6.4	10	23	12	0				
29	4.0	12	10	6.4	------	18	9.8	0				
30	6.4	11	9.4	24	------	27	7.4	0				
31	8.9	------	9.4	28	------	15	------	0	------			------
TOTAL	154.2	235.9	281.6	404.3	289.0	316.3	302.09	57.48	0	0	0	0
MEAN	4.97	7.86	9.08	13.0	10.3	10.2	10.1	1.85	0	0	0	0
MAX	48	17	17	28	21	28	41	22	0	0	0	0
MIN	0	3.1	4.5	4.0	5.5	2.9	.37	0	0	0	0	0
AC-FT	306	468	559	802	573	627	599	114	0	0	0	0

CAL YR 1972 TOTAL 28,183.36 MEAN 77.0 MAX 5,680 MIN 0 AC-FT 55,900
WTR YR 1973 TOTAL 2,040.87 MEAN 5.59 MAX 48 MIN 0 AC-FT 4,050

PEAK DISCHARGE (BASE, 1,000 FT³/S).--No peak above base.

From U.S. Geological Survey Water-Data Report TX-77-1, Water Resources Data For Texas, Water Year 1977, Volume 1.

07227470 CANADIAN RIVER AT TASCOSA, TX--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Chemical and biochemical analyses: October 1968 to curent year.

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 1968 to current year.
WATER TEMPERATURES: October 1968 to current year.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: Maximum daily, 6,520 micromhos Mar. 3, 1971; minimum daily, 252 micromhos July 21, 1972.
WATER TEMPERATURE: Maximum daily, 36.0°C July 31, 1977; minimum aily, 0.0°C on many days during winter months.

EXTREMES FOR CURRENT YEAR.--
SPECIFIC CONDUCTANCE: Maximum daily, 4,850 micromhos Dec. 11, May 8; minimum daily, 478 micromhos June 19.
WATER TEMPERATURES: Maximum daily, 36.0°C July 31; minimum daily, 0.0°C on many days during winter months.

WATER QUALITY DATA, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	DISSOLVED OXYGEN (MG/L)	PERCENT SATURATION	BIOCHEMICAL OXYGEN DEMAND 5 DAY (MG/L)	HARDNESS (CA,MG) (MG/L)
OCT 06...	1430	40	2610	8.5	19.0	9.0	101	1.1	330
DEC 08...	1330	21	3410	8.2	6.5	11.1	94	.5	480
FEB 09...	1330	10	4240	8.1	12.0	10.4	101	1.2	510
MAR 01...	1400	4.5	4700	8.2	14.0	--	--	--	510
APR 06...	1400	2.0	4030	8.4	24.5	8.3	102	1.2	460
MAY 19...	1320	14	2460	7.7	23.5	--	--	--	270
JUN 30...	0850	.53	2140	8.2	22.0	--	--	--	210
AUG 10...	1345	1000	1520	8.3	28.0	6.0	78	16	160
SEP 01...	1130	500	613	8.4	23.0	--	--	--	170

DATE	NONCARBONATE HARDNESS (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	SODIUM ADSORPTION RATIO	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)
OCT 06...	110	80	31	420	10	5.6	244	8	260
DEC 08...	270	110	51	700	14	6.7	258	0	360
FEB 09...	280	110	57	740	14	7.2	285	0	440
MAR 01...	330	92	67	830	16	7.4	210	0	530
APR 06...	210	87	58	750	15	7.4	284	8	460
MAY 19...	39	63	27	430	11	6.1	280	0	250
JUN 30...	0	53	18	370	11	5.4	310	0	230
AUG 10...	0	38	16	270	9.3	5.4	220	0	250
SEP 01...	0	40	16	65	2.2	5.4	200	4	75

DATE	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	TOTAL NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	TOTAL AMMONIA NITROGEN (N) (MG/L)	TOTAL ORGANIC NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)
OCT 06...	560	.5	11	1500	.08	.01	.02	.50	.40
DEC 08...	990	.6	11	2360	.08	.01	.04	.24	.02
FEB 09...	1100	.6	9.1	2600	.00	.00	.00	.26	.01
MAR 01...	1100	.6	10	2740	--	--	--	--	--
APR 06...	950	.6	9.9	2470	.00	.00	.01	.58	.02
MAY 19...	500	.8	16	1430	--	--	--	--	--
JUN 30...	390	.6	14	1230	--	--	--	--	--
AUG 10...	230	.9	7.3	927	.29	.01	.08	25	5.1
SEP [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--	--	--	--	--

From U.S. Geological Survey, 1973 Water Resources Data For Texas, Part 2. Water Quality Records.

07227448 PUNTA de AGUA CREEK NEAR CHANNING, TEX.

LOCATION.--Lat 35°40'03", long 102°28'48", Hartley County, at gaging station at bridge 0.5 mile (0.8 km) downstream from Rita Blanca Creek and 8.5 miles (13.7 km) southwest of Channing on Farm Road 767.

DRAINAGE AREA.--3,568 mi² (9,241 km²) of which 2,068 mi² (5,356 km²) is probably noncontributing.

PERIOD OF RECORD.--Chemical analyses: February 1968 to September 1973 (Discontinued).

REMARKS.--See Part 1 of this report for remarks on diversions and return flows.

WATER QUALITY DATA, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED CALCIUM (CA) (MG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM PLUS POTASSIUM (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)
NOV. 08...	1440	2.9	35	28	77	100	460	32	83	64
DEC. 13...	1225	2.0	36	26	83	98	484	33	84	49
JAN. 17...	1520	16	35	26	68	74	418	18	66	39
FEB. 22...	1055	6.5	30	41	60	66	444	0	66	36
MAR. 28...	1400	23	26	42	37	72	356	0	65	32
MAY 02...	1120	.87	24	62	86	100	652	0	98	56

DATE	DISSOLVED FLUORIDE (F) (MG/L)	TOTAL NITRATE (N) (MG/L)	DISSOLVED SOLIDS (SUM OF CONSTITUENTS) (MG/L)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)
NOV. 08...	3.0	--	653	380	0	--	1040	8.7	16.0
DEC. 13...	4.0	--	652	400	0	2.1	1040	8.7	1.0
JAN. 17...	3.8	.2	537	340	0	1.7	860	8.5	10.0
FEB. 22...	3.7	.03	521	350	0	1.5	851	8.3	2.0
MAR. 28...	3.7	.1	453	260	0	2.0	740	8.3	13.5
MAY 02...	5.8	.00	756	510	0	2.0	1210	8.1	13.0

From U.S. Geological Survey Water-Data Report TX-77-1, Water Resources Data For Texas, Water Year 1977, Volume 1.

07227470 CANADIAN RIVER AT TASCOSA, TX

LOCATION.--Lat 35°31'08", long 102°15'35", Oldham County, Hydrologic Unit 11090101, on right bank at downstream side of bridge on U.S. Highway 385, 0.3 mi (1.3 km) northwest of Tascosa, and 1.0 mi (1.6 km) southwest of Boys Ranch.

DRAINAGE AREA.--18,536 mi² (48,008 km²), of which approximately 3,823 mi² (9,902 km²) probably is noncontributing.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--October 1968 to September 1977 (discontinued).

GAGE.--Water-stage recorder. Datum of gage is 3,169.25 ft (965.987 m) above mean sea level.

REMARKS.--Water-discharge records poor. Some regulation by Ute Reservoir in New Mexico, capacity, 109,600 acre-ft (135 hm³). Conchas and Bell Ranch Canals divert from Conchas Lake for irrigation of about 36,000 acres (150 km²) in New Mexico.

AVERAGE DISCHARGE.--9 years, 168 ft³/s (4.758 m³/s), 121,700 acre-ft/yr (150 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 27,500 ft³/s (779 m³/s) July 27, 1971, gage height, 8.50 ft (2.591 m), from rating curve extended above 12,000 ft³/s (340 m³/s); no flow at times each year.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum stage probably occurred October 1904; other major floods occurred in May 1914, October 1937, and July 1941, from information by local residents.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 19,800 ft³/s (561 m³/s) Sept. 5, gage height, 7.62 ft (2.323 m), from rating curve extended as explained above, no other peak above base of 10,000 ft³/s (283 m³/s); no flow at times.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	167	16	12	10	10	8.8	2.3	10	2.4	3.7	170	1190
2	95	15	14	10	11	9.4	1.1	8.8	1.8	20	190	298
3	66	13	15	15	12	11	2.1	7.0	1.2	10	194	916
4	43	14	15	18	11	12	3.2	5.0	.50	1.6	75	441
5	36	13	17	17	9.8	13	1.6	4.0	.18	22	39	2720
6	35	13	18	10	9.4	14	1.6	3.8	.07	96	106	400
7	33	12	14	9.0	8.4	14	.79	3.2	.02	72	260	349
8	29	11	13	10	8.4	14	.66	2.0	.00	178	248	302
9	29	11	12	7.0	8.0	14	.51	3.6	.00	29	350	276
10	28	11	11	5.0	8.0	13	.32	52	.00	22	329	255
11	26	11	12	5.0	8.0	7.8	.34	28	.00	17	394	267
12	29	10	12	7.0	8.0	2.6	.31	36	.00	21	1720	341
13	27	9.0	13	9.0	7.6	3.1	.45	31	.00	28	699	356
14	22	9.0	14	9.0	7.1	1.8	5.6	30	.00	49	499	537
15	24	15	13	9.0	6.4	1.7	25	80	.00	62	457	427
16	20	18	13	8.0	6.0	1.8	9.5	284	.00	86	558	150
17	17	16	13	8.0	6.0	1.7	50	71	.00	143	510	90
18	16	16	12	10	5.7	.84	126	24	.00	92	1350	54
19	16	16	13	15	5.7	.87	23	13	8.9	35	2770	40
20	16	15	11	18	6.0	.66	1500	1500	.20	14	1530	25
21	15	14	11	20	6.4	.53	169	305	.00	75	2540	21
22	15	13	11	26	6.4	.71	91	44	.00	67	1220	20
23	14	13	10	22	6.8	.67	112	20	2.1	13	809	28
24	13	12	13	19	6.0	.63	88	289	1770	6.3	897	15
25	13	12	12	17	5.4	.47	49	106	82	15	968	12
26	13	11	11	15	6.9	.50	275	77	2.5	15	492	13
27	12	10	14	14	7.3	4.5	46	31	1.0	53	436	10
28	14	9.0	12	13	7.8	2.9	25	15	.54	23	434	11
29	20	9.0	12	12	---	1.6	15	6.5	.33	7.5	454	9.1
30	19	10	12	10	---	1.2	15	4.7	.30	43	1040	8.8
31	16	---	11	10	---	1.4	---	3.4	---	82	345	---
TOTAL	938	377.0	396	387.0	215.5	161.18	2639.38	3098.0	1874.04	1401.1	22292	9591.9
MEAN	30.3	12.6	12.8	12.5	7.70	5.20	88.0	99.9	62.5	45.2	719	320
MAX	167	18	18	26	12	14	1500	1500	1770	178	2770	2720
MIN	12	9.0	10	5.0	5.4	.47	.31	2.0	.00	1.6	39	8.8
AC-FT	1860	748	785	768	427	320	5240	6140	3720	2780	44220	19030

CAL YR 1976 TOTAL 34108.35 MEAN 93.2 MAX 4710 MIN .00 AC-FT 67650
WTR YR 1977 TOTAL 43371.10 MEAN 119 MAX 2770 MIN .00 AC-FT 86030

From U.S. Geological Survey Water-Data Report TX-90-1, Water Resources Data, Texas, Water Year 1990, Volume 1.

07227500 CANADIAN RIVER NEAR AMARILLO, TX

LOCATION.--Lat 35°28'13", long 101°52'45", Potter County, Hydrologic Unit 11090105, on left bank at downstream side of southbound lane of bridge on U.S. Highways 87 and 287, 1,500 ft downstream from Pitcher Creek, 1.4 mi downstream from East Amarillo Creek, 1.7 mi downstream from Panhandle and Santa Fe Railway Co. bridge, 19 mi north of Amarillo, and 537.7 mi upstream from mouth.

DRAINAGE AREA.--19,445 mi², of which 4,069 mi² probably is noncontributing.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--January 1924 to December 1925, January 1938 to current year. Monthly discharge only for some periods, published in WSP 1311.

REVISED RECORDS.--WSP 1341: Drainage area.

GAGE.--Water-stage recorder. Datum of gage is 2,989.16 ft above National Geodetic Vertical Datum of 1929. Jan. 16, 1924, to Dec. 31, 1925, and Apr. 3 to June 1, 1938, nonrecording gage at site of old bridge 20 ft upstream at same datum. June 2 to Dec. 5, 1938, nonrecording gage at present site and datum.

REMARKS.--Records fair except those for periods of estimated daily discharges which are poor. There is some regulation by Conchas and Ute Reservoirs in New Mexico, total capacity 439,000 acre-feet. Conchas and Bell Ranch Canals divert water from Conchas Reservoir upstream for irrigation.

AVERAGE DISCHARGE.--53 years (water years 1925, 1939-90), 305 ft³/s (221,000 acre-ft/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 135,000 ft³/s July 25, 1941 (gage height, 15.7 ft), from rating curve extended above 100,000 ft³/s; no flow at times.

EXTREMES OUTSIDE PERIOD OF RECORD.--Flood in May 1914 reached a stage of 24 ft; a higher stage probably occurred during flood in October 1904, from information by local resident.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 14,000 ft³/s and maximum (*):

Date	Time	Discharge (ft³/s)	Gage height (ft)	Date	Time	Discharge (ft³/s)	Gage height (ft)
Sept. 29	0630	*13,700	*6.98				

Minimum discharge, no flow June 24 to July 20.

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	37	16	60	31	110	173	63	26	14	.00	.18	1.7
2	34	19	56	28	94	135	54	40	4.6	.00	.16	1.6
3	30	21	44	29	92	132	49	174	2.2	.00	.17	1.3
4	26	20	46	30	89	107	46	106	1.6	.00	.18	1.1
5	32	101	39	27	75	92	42	70	1.2	.00	.12	.83
6	97	287	33	27	60	80	38	52	1.1	.00	.11	1.7
7	69	356	50	e26	61	64	36	36	.80	.00	.10	8.6
8	55	431	40	27	49	53	25	37	.52	.00	.09	2.0
9	49	480	36	30	43	49	27	37	.35	.00	.13	1.6
10	35	493	31	27	39	60	20	32	.29	.00	.12	1.4
11	26	479	22	26	34	80	19	26	.26	.00	.12	1.4
12	24	515	15	23	30	85	19	20	.24	.00	.15	1.1
13	22	526	e13	22	25	68	20	16	.24	.00	113	.81
14	20	548	17	21	21	57	22	14	.21	.00	23	.54
15	18	541	e16	21	e20	48	19	12	.19	.00	91	.31
16	16	511	e15	21	e20	46	17	9.3	.17	.00	100	.42
17	17	497	e15	21	23	45	15	6.8	.13	.00	202	.41
18	19	530	e15	28	21	47	17	6.0	.10	.00	205	.32
19	20	461	e15	e27	20	46	20	4.9	.05	.00	91	487
20	23	468	e16	e26	44	37	24	4.2	.06	179	162	449
21	20	405	e14	e30	141	32	28	3.7	.04	105	98	1750
22	19	251	e13	e35	149	26	25	3.3	.02	40	40	465
23	19	174	28	57	227	22	29	2.7	.01	6.9	22	200
24	19	119	41	106	281	24	30	2.5	.00	1.4	14	94
25	21	104	39	127	281	24	366	2.4	.00	.75	8.9	84
26	25	83	34	91	244	28	193	2.3	.00	1.6	4.7	127
27	21	72	35	100	218	35	97	2.3	.00	492	3.6	90
28	19	62	41	164	185	25	61	2.1	.00	9.9	2.8	64
29	17	56	46	125	---	46	36	2.0	.00	2.0	2.3	6800
30	16	57	50	120	---	102	31	69	.00	1.1	2.0	683
31	15	---	40	112	---	65	---	58	---	.24	1.7	---
TOTAL	880	8683	975	1585	2696	1933	1488	879.5	28.38	839.89	1188.63	11320.14
MEAN	28.4	289	31.5	51.1	96.3	62.4	49.6	28.4	.95	27.1	38.3	377
MAX	97	548	60	164	281	173	366	174	14	492	205	6800
MIN	15	16	13	21	20	22	15	2.0	.00	.00	.09	.31
AC-FT	1750	17220	1930	3140	5350	3830	2950	1740	56	1670	2360	22450

CAL YR 1989 TOTAL 55256.5 MEAN 151 MAX 3940 MIN 5.3 AC-FT 109600
WTR YR 1990 TOTAL 32496.54 MEAN 89.0 MAX 6800 MIN .00 AC-FT 64460

e Estimated

From U.S. Geological Survey Water-Data Report TX-90-1, Water Resources Data, Texas, Water Year 1990, Volume 1.

07227500 CANADIAN RIVER NEAR AMARILLO, TX--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Chemical analyses: July 1948 to October 1949, February 1950 to current year. Chemical and biochemical analyses: March 1968 to current year. Pesticide analyses: March 1968 to June 1981.

PERIOD OF RECORD.--
SPECIFIC CONDUCTANCE: October 1950 to current year.
WATER TEMPERATURE: August 1949 to current year.
SUSPENDED SEDIMENT DISCHARGE: August 1949 to September 1952.

REMARKS.--Mean monthly and annual concentrations and loads for selected chemical constituents have been computed using the daily (or continuous) records of specific conductance and regression relationships between each chemical constituent and specific conductance. Regression equations developed for this station may be obtained from the Geological Survey District office upon request.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: Maximum daily, 9,180 microsiemens June 8, 1990; minimum daily, 346 microsiemens Oct. 29, 1964.
WATER TEMPERATURE (1949-76, 1988 to current year): Maximum daily, 39.0°C July 7, 1973; minimum daily, 0.0°C on many days during winter months.

EXTREMES FOR CURRENT YEAR.--
SPECIFIC CONDUCTANCE: Maximum daily, 9,180 microsiemens June 8; minimum daily, 360 microsiemens July 21.
WATER TEMPERATURE; Maximum daily, 34.0°C June 7, Aug. 29; minimum daily, 0.0°C Dec. 21-23.

WATER QUALITY DATA, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990

DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE WATER (DEG C)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	HARD-NESS TOTAL (MG/L AS CACO3)	HARD-NESS NONCARB DISSOLV FLD. AS CACO3 (MG/L)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)
NOV 14...	0915	546	1510	8.2	6.5	14.8	137	1.7	260	130	56	29
JAN 23...	0910	65	3260	8.3	1.5	14.9	121	0.4	490	290	120	46
MAR 13...	0930	68	3320	8.3	16.5	9.4	110	2.5	400	180	91	43
MAY 15...	0930	14	4900	8.1	20.0	11.0	139	1.5	570	410	120	66
AUG 21...	0920	192	1400	8.1	23.5	9.3	123	5.7	100	0	23	11

DATE	SODIUM, DIS-SOLVED (MG/L AS NA)	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY WAT DIS FIX END FIELD CACO3 (MG/L)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NITRATE TOTAL (MG/L AS N)	NITRO-GEN, NITRITE TOTAL (MG/L AS N)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)
NOV 14...	210	6	4.4	130	310	190	0.60	5.7	888	0.00	0.150	0.100
JAN 23...	520	10	5.0	200	410	720	0.60	12	1960	0.240	0.060	0.300
MAR 13...	510	11	13	220	370	780	0.20	12	1950	0.00	0.300	0.200
MAY 15...	750	14	6.4	170	630	1100	0.80	15	2790	--	0.040	<0.100
AUG 21...	240	10	4.4	140	170	240	0.90	8.9	785	0.690	0.010	0.700

DATE	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN,AM-MONIA + ORGANIC TOTAL (MG/L AS N)	PHOS-PHORUS TOTAL (MG/L AS P)	ARSENIC DIS-SOLVED (UG/L AS AS)	BARIUM, DIS-SOLVED (UG/L AS BA)	BERYL-LIUM, DIS-SOLVED (UG/L AS BE)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, DIS-SOLVED (UG/L AS FE)
NOV 14...	0.380	0.62	1.0	0.650	5	91	<0.5	<1.0	<5	<3	<10	41
JAN 23...	0.110	0.29	0.40	0.190	--	--	--	--	--	--	--	--
MAR 13...	0.150	0.35	0.50	0.170	--	--	--	--	--	--	--	--
MAY 15...	0.070	0.63	0.70	0.080	--	--	--	--	--	--	--	--
AUG 21...	0.060	0.74	0.80	0.070	--	--	--	--	--	--	--	--

DATE	LEAD, DIS-SOLVED (UG/L AS PB)	LITHIUM DIS-SOLVED (UG/L AS LI)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY DIS-SOLVED (UG/L AS HG)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	NICKEL, DIS-SOLVED (UG/L AS NI)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	SILVER, DIS-SOLVED (UG/L AS AG)	STRON-TIUM, DIS-SOLVED (UG/L AS SR)	VANA-DIUM, DIS-SOLVED (UG/L AS V)	ZINC, DIS-SOLVED (UG/L AS ZN)
NOV 14...	<10	55	4	3.6	<10	<10	<1	<1.0	1400	7	4
JAN 23...	--	--	--	--	--	--	--	--	--	--	--
MAR 13...	--	--	--	--	--	--	--	--	--	--	--
MAY 15...	--	--	--	--	--	--	--	--	--	--	--
AUG 21...	--	--	--	--	--	--	--	--	--	--	--

From U.S. Geological Survey Water-Data Report TX-84-1, Water Resources Data, Texas, Water Year 1984.

07227900 LAKE MEREDITH NEAR SANFORD, TX

LOCATION.--Lat 35°42'38", long 101°33'03", Hutchinson County, Hydrologic Unit 11090106, in outlet tower near right end of dam on Canadian River, 1.2 mi northwest of Sanford, and 508.5 mi upstream from mouth.

DRAINAGE AREA.--20,220 mi², of which 4,172 mi² probably is noncontributing.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--October 1964 to current year.

GAGE.--Water-stage recorder. Datum of gage is National Geodetic Vertical Datum of 1929 (levels by Bureau of Reclamation). Prior to Aug. 16, 1965, nonrecording gage read daily at same site and datum.

REMARKS.--The lake is formed by a rolled earthfill dam 6,410 ft long. The dam was completed and storage began in October 1964. The service spillway is an uncontrolled concrete drop inlet located near the left end of dam. The spillway discharges into a 22-foot-diameter conduit that is designed to discharge 19,300 ft³/s at an elevation of 3,004.9 ft. The flood-control outlet works consist of three 12- by 15-foot gates that open into three 15.5-foot concrete conduits. The flood-control works are located just to the left of the service spillway near the left end of dam. The dam was built by the U.S. Bureau of Reclamation for the Canadian River Municipal Water Authority for flood control, municipal, and industrial supply for the cities of Amarillo, Borger, Brownfield, Lamesa, Levelland, Lubbock, O'Donnell, Pampa, Plainview, Slaton, and Tahoka. The area-capacity curves are based on sediment resurvey in May 1980 by U.S. Bureau of Reclamation. Figures given herein represent total contents. Data regarding the dam and lake are given in the following table:

	Elevation (feet)	Capacity (acre-feet)
Top of dam	3,011.0	-
Design flood	3,004.9	2,409,900
Crest of drop inlet	2,965.0	1,382,500
Top of conservation pool	2,936.5	839,200
Crest of flood-control outlet works (invert)	2,894.0	300,400
Lowest gated outlet (invert)	2,850.0	42,320

COOPERATION.--Record of elevations and diversions furnished by the Canadian River Municipal Water Authority. The area-capacity curves were furnished by the U.S. Bureau of Reclamation.

EXTREMES FOR PERIOD OF RECORD.--Maximum contents, 546,100 acre-ft Apr. 28, 1973 (elevation, 2,914.91 ft); minimum since first appreciable storage, 165,500 acre-ft May 27, 1981 (elevation, 2,876.17 ft).

EXTREMES FOR CURRENT YEAR.--Maximum contents, 404,300 acre-ft Oct. 1 at 2400 hours (elevation, 2,904.73 ft); minimum, 325,100 acre-ft Sept. 30 (elevation, 2,896.73 ft).

Capacity table (elevation, in feet, and total contents, in acre-feet)

2,896.0	318,400	2,902.0	376,000
2,898.0	337,000	2,904.0	396,600
2,900.0	356,100	2,906.0	418,000

CONTENTS, IN ACRE-FEET, WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984
INSTANTANEOUS OBSERVATIONS AT 2400

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	404300	395900	387400	379900	374100	367900	363300	357600	347400	346500	332100	339300
2	404100	395800	386900	379900	373700	367600	362800	357700	346500	346200	331600	339000
3	404100	395700	386900	379600	373700	367400	362800	357300	346300	345800	331200	338700
4	403000	395400	386700	379600	373700	367200	362800	357000	346100	345400	330900	336500
5	402700	395300	386400	379300	373300	367000	362800	356700	345500	345400	330800	338000
6	402300	394900	386600	379200	373200	366800	363800	356600	345200	345300	330500	337500
7	402000	394900	386200	379000	372800	366400	363900	356400	345600	344900	330200	336400
8	401600	394100	386000	378800	373000	366300	363700	356100	344200	343900	329900	335800
9	401600	393900	385900	378600	372900	365800	363600	355800	343400	343200	329500	335300
10	401600	393700	385600	378600	372800	365700	363500	355400	345700	343400	330800	335000
11	400400	393400	385200	379600	372400	365600	363500	355100	350000	342000	332100	334400
12	400200	392900	384700	378200	372400	365100	363400	354600	350500	341600	332200	333800
13	400200	392600	384800	377900	372200	365000	363200	354400	350600	341100	332600	333200
14	399600	392300	384400	377700	371800	364700	362800	354000	350400	340500	332700	332200
15	399200	392000	384000	377500	371600	364500	362300	353700	350300	339900	334400	332200
16	398700	391700	384000	377300	371300	364500	361900	353300	350400	339600	334800	331800
17	398500	391300	383600	376900	371600	364300	361600	352900	350100	338900	334800	331300
18	398100	391200	383400	377000	370700	364300	361000	352600	350000	338600	334500	330800
19	398300	390500	383600	376600	370300	363900	360800	352300	349800	338100	334300	330400
20	398800	390500	382300	376600	370200	363500	360600	352000	349800	337700	334100	329700
21	398700	390400	382100	376600	369900	363100	360300	351800	349600	337300	333700	329200
22	398500	390000	382000	376600	369500	363100	359900	351200	349400	336800	334000	328500
23	398100	390000	381800	376600	369200	363500	359700	351200	348900	336300	336600	328100
24	397700	390000	381600	376600	369200	363100	359400	350600	349000	335600	337100	327700
25	397600	389800	381400	375700	368900	362800	359400	350100	348800	335300	338400	326800
26	397100	389900	381300	375200	369200	362600	359000	350000	348500	335700	340300	326400
27	397000	389900	381100	375000	369200	363300	358000	349400	348200	334600	340600	325800
28	396900	368400	381100	374800	368400	362900	357400	349000	347700	334100	340600	325600
29	396400	387800	380800	374500	368100	363000	358000	348700	347300	333700	340600	325400
30	396300	387600	380000	374400	---	363200	358000	348100	346800	333200	340400	325100
31	396000	---	380000	374300	---	363000	---	347600	---	332600	339900	---
MAX	404300	395900	387400	379900	374100	367900	363900	357700	350600	346500	340600	339300
MIN	396000	387600	380000	374300	368100	362600	357400	347600	343400	332600	329500	325100
(†)	2903.94	2903.14	2902.40	2901.83	2901.22	2900.70	2900.19	2899.12	2899.03	2897.54	2898.31	2896.73
(‡)	-8700	-8400	-7600	-5700	-6200	-5100	-5000	-10400	-800	-14200	+7300	-14800
(††)	4816	3880	5002	5863	4900	5585	6197	80098	6675	8975	7433	7716

CAL YR 1983 MAX 464000 MIN 380000 ‡ -68900 †† 73022
WTR YR 1984 MAX 404300 MIN 325100 ‡ -79600 †† 75051

† Elevation, in feet, at end of month.
‡ Change in contents, in acre-feet.
†† Diversions, in acre-feet, for municipal and industrial uses.

From U.S. Geological Survey Water-Data Report TX-84-1, Water Resources Data, Texas, Water Year 1984.

07227900 LAKE MEREDITH NEAR SANFORD, TX--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Chemical analyses: October 1968 to September 1984 (discontinued).

WATER QUALITY DATA, WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984

DATE	TIME	SPE- CIFIC CON- DUCT- ANCE (UMHOS)	TEMPER- ATURE (DEG C)	HARD- NESS (MG/L AS CACO3)	HARD- NESS, NONCAR- BONATE (MG/L CACO3)	CALCIUM DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)
JAN								
03...	1100	1640	3.0	230	47	53	23	250

DATE	SODIUM AD- SORP- TION RATIO	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	ALKA- LINITY FIELD (MG/L AS CACO3)	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SILICA, DIS- SOLVED (MG/L AS SIO2)	SOLIDS, SUM OF CONSTI- TUENTS, DIS- SOLVED (MG/L)
JAN								
03...	7	5.8	180	220	280	.80	5.1	950

Programs and files related to USGS data base

The following is a list of program files, data files, tables and worksheets for the Canadian River project held on electronic media in the Albuquerque office of Lee Wilson and Associates. The programs, data files and worksheets comprise a method for accessing the data base, storing abstracted data, examing or interpreting the data and producing tables and figures as final products. The system, once constructed, was used to examine and characterize the data. Interpretation and production of final products has not been attempted.

USGS files

Water quality, discharge and lake storage data were obtained from USGS and are maintained on computer files.

QW.1	Water quality data base, part 1
QW.2	Water quality data base, part 2
QW.3	Water quality data base, part 3
QW.4	Water quality data base, part 4
DV.1	Discharge and storage data base, part 1
DV.2	Discharge and storage data base, part 2

Programs

Several FORTRAN programs were written to access and process the data for data base characterization.

QWDATA.F	Reads water quality data base and produces tables of water quality data for operator-specified stations, constituents and dates.
QWCATS.F	Reads water quality data base and tables the number of analyses at operator-specified stations and dates for constituents in defined categories.
CODE.F	Reads water quality data base and compiles a list of constituent codes.
MEDIA.F	Reads water quality data base and compiles a list of sample media codes.

QDDATA.F Reads discharge and storage data base and produces tables of water discharge and storage data for operator-specified stations and dates.

QSTATS.F Reads discharge and storage data base and produces histograms and cumulative frequency diagrams of discharge for operator-specified stations and dates.

Data extracts from Fortran programs: general

The programs listed above produce tables and column-formatted files used in construction of several worksheets. The data files now resident are:

AMTX.DAT	Daily discharge table for the Amarillo, TX gauge on the Canadian River.
AMTX2.DAT	Daily discharge table for the Amarillo, TX gauge on the Canadian River, water year ending in September, 1972.
AMTXCL.DAT	Discharge and chloride concentrations at the Amarillo, TX gauge on the Canadian River.
AMTXCL2.DAT	Discharge and chloride concentrations at the Amarillo, TX gauge on the Canadian River water year ending in September, 1972.
CHANNING.DAT	Daily discharge table for the Channing, TX gauge on Punta de Aqua Creek.
CHAN2.DAT	Daily discharge table for the Channing, TX gauge on Punta de Aqua Creek, water year ending in September, 1972.
CODES.OUT	List of all parameter codes in the water quality data base.
LOGAN.DAT	Daily discharge table for the Logan, NM gauge on the Canadian River.
MEDIA.OUT	List of all media codes in the water quality data base.
MLTX.DAT	Daily storage table for Meredith Lake, TX.

PPR500.DAT	Major constituent concentrations by discharge at the Amarillo, TX gauge on the Canadian River. These data are formatted for input to a Piper diagram graphics program.
PPR470.DAT	Major constituent concentrations by discharge at the Tascosa, TX gauge on the Canadian River. These data are formatted for input to a Piper diagram graphics program.
Q000.OUT	Daily discharge data table (column format) for the Logan, NM gauge on the Canadian River, water years 1968-1977.
Q72-500.DAT	Daily discharge data file (column format) for the Amarillo, TX gauge on the Canadian River, water year ending in September, 1972.
Q72-470.DAT	Daily discharge data file (column format) for the Tascosa, TX gauge on the Canadian River, water year ending in September, 1972.
Q100.OUT	Daily discharge data table (column format) for the Revuelto Creek, NM gauge above the Canadian River, water years 1968-1977.
Q140.OUT	Occasional discharge data table (column format) for the State Line, NM gauge on the Canadian River, 1969-1977.
Q448.OUT	Daily discharge data table (column format) for the Channing, TX gauge on Punta de Agua Creek, water years 1968-1973.
Q470.OUT	Daily discharge data table (column format) for the Tascosa, TX gauge on the Canadian River, water years 1968-1977.
Q500.OUT	Daily discharge data table (column format) for the Amarillo, TX gauge on the Canadian River, water years 1964-1977.
Q500P1.OUT	Similar to Q500, water years 1964-1974.
Q500P2.OUT	Similar to Q500, water years 1975-current.
QD500.DAT	Daily discharge frequency data (column format) for the Amarillo, TX gauge on the Canadian River.
TASCOSA.DAT	Daily discharge table for the Tascosa, TX gauge on the Canadian River.

TASCOSA2.DAT	Daily discharge table for the Tascosa, TX gauge on the Canadian River, water year ending in September, 1972.

Data extracts: major ions

The programs have been used to prepare 41 column-formatted data files of major-ion analyses and concurrent discharge data. The files are for each of the Canadian River stations and major tributaries downstream from Ute Reservoir since 1964. Each file name has the subscript ".DAT". "Alk" on the table indicates total field alkalinity used for HCO_3 and CO_3. All data are for water years 1964 through the end of the record, or the period of record for the station. Data for potassium not available at the Channing, TX gauge on Punta de Aqua Creek.

The file names are summarized as follows (e.g. file CA000.DAT contains the calcium and discharge data for the Logan gage).

Constituent:	Ca	Mg	Na	K	Alk	SO_4	Cl
Station Name							
Logan, NM	CA000	MG000	NA000	K000	CO000	SO000	CL000
Revuelto Ck, NM	CA100	MG100	NA100	K100	CO100	SO100	CL100
State Line, NM	CA140	MG140	NA140	K140	CO140	SO140	CL140
Channing, TX	CA448	MG448	NA448	--	CO448	SO448	CL448
Tascosa, TX	CA470	MG470	NA470	K470	CO470	SO470	CL470
Amarillo, TX	CA500	MG500	NA500	K500	CO500	SO500	CL500

Data counts

We have used the programs to prepare 27 tables listing the number of major contituent analyses at each water quality station from Bell Ranch Canal, NM to Meredith Lake, TX.

CAT3000.OUT	Bell Ranch Canal, Station 07223000
CAT3300.OUT	Conchas Canal, Station 07223300
CAT3500.OUT	Conchas Lake, Station 07223500

CAT4500.OUT	Canadian River below Conchas Lake, Station 07224500
CAT5500.OUT	Ute Creek near Gladstone, Station 07225500
CAT6500.OUT	Ute Creek near Logan, Station 07226500
CAT6510.OUT	Ute Reservoir, site F, Station 07226510
CAT6515.OUT	Ute Reservoir, site I, Station 07226515
CAT6520.OUT	Ute Reservoir, site G, Station 07226520
CAT6530.OUT	Ute Reservoir, site D, Station 07226530
CAT6540.OUT	Ute Reservoir, Site E, Station 07226540
CAT6560.OUT	Ute Reservoir, Site B, Station 07226560
CAT6800.OUT	Ute Reservoir near Logan, Station 07226800
CAT6810.OUT	Ute Reservoir, north spillway, Station 07226810
CAT6820.OUT	Ute Reservoir, north drain outlet, Station 07226820
CAT6830.OUT	Canadian River below Ute dam, Station 07226830
CAT7000.OUT	Canadian River at Logan, Station 07227000
CAT7070.OUT	Plaza Larga Crk above Barranca Crk, Station 07227070
CAT7073.OUT	Plaza Larga Crk below Barranca Crk, Station 07227073
CAT7080.OUT	Revuelto Creek below Plaza Larga Crk, Station 07227080
CAT7100.OUT	Revuelto Creek near Logan, Station 07227100
CAT7125.OUT	Canadian River near Glenrio, Station 07227125
CAT7140.OUT	Canadian River above state line, Station 07227140
CAT7448.OUT	Punta de Aqua Creek at Channing, Station 07227448
CAT7470.OUT	Canadian River at Tascosa, Station 07227470
CAT7500.OUT	Canadian River at Amarillo, Station 07227500
CAT7900.OUT	Lake Meredith near Sanford, Station 07227900

Lotus worksheets: double-mass curves

Forty one worksheets containing data for double mass-curves (cumulative mass of constituent plotted against cumulative volume of water) and regression data for determining constituent concentrations as functions of discharge. Each file name carries the subscript ".WK1". All data are for water years 1964 through the end of the record, or the period of record for the station. Data for potassium not available at the Channing, TX gauge on Punta de Aqua Creek.

The file names are summarized as follows (e.g. file 2MCA000.WK1 contains the data to be used for calcium at the Logan gage).

Constituent:	Ca	Mg	Na	K	Alk	SO_4	Cl
Station Name							
Logan, NM	2MCA000	2MMG000	2MNA000	2MK000	2MC0000	2MS0000	2MCL000
Revuelto Ck, NM	2MCA100	2MMG100	2MNA100	2MK100	2MC0100	2MS0100	2MCL100
State Line, NM	2MCA140	2MMG140	2MNA140	2MK140	2MC0140	2MS0140	2MCL140
Channing, TX	2MCA448	2MMG448	2MNA448	--	2MC0448	2MS0448	2MCL448
Tascosa, TX	2MCA470	2MMG470	2MNA470	2MK470	2MC0470	2MS0470	2MCL470
Amarillo, TX	2MCA500	2MMG500	2MNA500	2MK500	2MC0500	2MS0500	2MCL500

Lotus worksheets: general

Many of the data files were used in worksheets. Two of the worksheets are templates for graphs and calculations.

WHAT.WK1 — Template for chloride load calculations. Currently loaded with data from the Amarillo, TX gauge on the Canadian River.

SUPPLY.WK1 — Template for discharge frequency histograms and cumulative frequency curves. Currently loaded with data from the Amarillo, TX gauge on the Canadian River.

A third workshet, CODES.WK1, is an organized list of parameter codes appearing in the water quality data base. As with the two templates, this worksheet allows wide access to the basic USGS data. The following list of codes from CODES.WK1 indicates the scope of the data base.

ADMINISTRATIVE CODES, QA AND QC

Agency analyzing sample, code number
Agency collecting sample, code number
Conversion factor
Lab ID number, units
Samples, number taken
Sampling method, codes

METEOROLOGICAL CONDITIONS

Barometric pressure, mm of Hg
Light incid., 400-700 mm, intens., seins/sqm/sl
Temperature, air, deg C

SITE DESCRIPTIONS

Depth to bottom of water-bearing zone, ft
Depth to bottom of water-bearing zone, ft
Depth to top of sample interval, ft
Discharge, in cfs
Discharge, instantaneous, cfs
Elevation above NGVD, feet
Elevation of land surface datum, feet above NGVD
Length of exposure, days
Reservoir depth, feet
Reservoir storage, AF
Sampling depth, feet
Stream stage, feet above datum
Surface area, sq mi
Water level, depth below land surface, feet

QUALITATIVE OBSERVATIONS

Algae, floating mats, severity
Debris, floating, severity
Detergent suds, severity
Fish, dead, severity
Ice cover, severity
Odor, atmospheric, severity
Oil-grease, severity
Turbidity, severity

PHYSICAL DESCRIPTIONS

Density, gm/ml at 20 deg C
Temperature, deg C

Color, platinum-cobalt units
Transparency, Secchi disk, m
Turbidity, JTU
Turbidity, NTU
Turbidity, mg/l as SiO2

WATER ANALYSES

Non-synthetic, dissolved and total chemical and radiological constituents

Alkalinity, carbonate, field, inc. t., mg/l as CaCO3
Alkalinity, carbonate, IT-fld, mg/l as CaCO3
Alkalinity, lab, mg/l as CaCO3
Alkalinity, total, field, FET, mg/l as CaCO3
Alkalinity, wat dis, fix end, field, CaCO3, mg/l
Alkalinity, wat. dissolved, field, inc. t., mg/l as Ca
Alkalinity, wat. wh., gran t., field, CaCO3, mg/l
Alkalinity, whole, field, FET, mg/l CaCO3
Aluminum, dissolved, ug/l as Al
Aluminum, total, recoverable, ug/l as Al
Arsenic, dissolved, ug/l as As
Arsenic, total, ug/l

Barium, dissolved, ug/l as Ba
Barium, total, recoverable, ug/l as Ba
Beryllium, dissolved, ug/l as Be
Bicarbonate, IT-fld, mg/l as HCO3
Bicarbonate, wat. dissolved, field, inc. t., mg/l as H
Bicarbonate, whole, field, FET, mg/l HCO3
Bicarbonate, whole, field, inc. t., mg/l as HCO3
Bismuth, dissolved, ug/l as Bi
Boron, dissolved, ug/l as B
Bromide, dissolved, mg/l as Br

Cadmium, dissolved, ug/l as Cd
Cadmium, total, recoverable, ug/l as Cd
Calcium, dissolved, mg/l as Ca
Carbon, organic, dissolved, mg/l as C
Carbon, organic, total, mg/l as C
Carbon dioxide, dissolved, mg/l as CO
Carbonate, IT-fld, mg/l as CO3
Carbonate, wat. dissolved, field, inc. t., mg/l as CO3
Carbonate, whole, field, FET, mg/l as CO3
Carbonate, whole, field, inc. t., mg/l as CO3
Chloride, dissolved, mg/l as Cl
Chromium, dissolved, ug/l as Cr
Chromium, hexavalent, dissolved, ug/l as Cr
Chromium, total, recoverable, ug/l as Cr
Cobalt, dissolved, ug/l as Co

Cobalt, total, recoverable, ug/l as Co
Copper, dissolved, ug/l as Cu
Copper, total, recoverable, ug/l as Cu

Fluoride, dissolved, mg/l as F
Gallium, dissolved, ug/l as Ga
Germanium, dissolved, ug/l as Ge
Gross Alpha, dissolved, pCi/l as U-nat
Gross Alpha, dissolved, ug/l as U-nat
Gross Beta, dissolved, pCi/l as Cs-137
Gross Beta, dissolved, pCi/l as Sr/Yt-90

Hardness, mg/l as CaCO3
Hardness, noncarb F. WH. W., FET, mg/l CaCO3
Hardness, noncarbonate, mg/l as CaCO3
Iron, dissolved, ug/l as Fe
Iron, total recoverable, ug/l as Fe
Iron, ug/l as Fe 71885

Lead, dissolved, ug/l as Pb
Lead, total recoverable, ug/l as Pb
Lithium, dissolved, ug/l as Li
Magnesium, dissolved, mg/l as Mg
Manganese, dissolved, ug/l as Mn
Manganese, total, recoverable, ug/l as Mn
Mercury, dissolved, ug/l as Hg
Mercury, total recoverable, ug/l as Hg
Molybdenum, dissolved, ug/l as Mo

Nickel, dissolved, ug/l as Ni
Nickel, total, recoverable, ug/l as Ni
Nitrogen, ammonia, dissolved, mg/l as NH4
Nitrogen, ammonia, total, mg/l as N
Nitrogen, ammonia, total, mg/l as NH4
Nitrogen, ammonia + organic, total, mg/l as N
Nitrogen, dissolved, mg/l as N
Nitrogen, NH4, water, dissolved, mg/l as N
Nitrogen, NH4 + org. water, wh. tot., mg/l as N
Nitrogen, nitrate, dissolved, mg/l as N
Nitrogen, nitrate, dissolved, mg/l as NO3
Nitrogen, nitrate, total, mg/l as N
Nitrogen, nitrate, total, mg/l as NO3
Nitrogen, nitrite, dissolved, mg/l as N
Nitrogen, nitrite, dissolved, mg/l as NO2
Nitrogen, nitrite, total, mg/l as N
Nitrogen, NO2 + NO3, total, mg/l as N
Nitrogen, NO2 + NO3 dissolved, mg/l as N
Nitrogen, organic, dissolved, mg/l as N

Nitrogen, organic, total, mg/l as N
Nitrogen, total, mg/l as N
Nitrogen, total, mg/l as NO3

Oxygen, dissolved, mg/l
Oxygen, dissolved, % saturation
Oxygen demand, biochemical, 5 day, mg/l
Oxygen demand, chemical, high level, mg/l
Oxygen demand, chemical, low level, mg/l

pH, lab, standard unit
pH, standard unit
Phosphate, ortho, dissolved, mg/l as PO4
Phosphate, total, mg/l as PO4
Phosphorus, dissolved, mg/l as P
Phosphorus, ortho, dissolved, mg/l as P
Phosphorus, total, mg/l as P
Phosphorus, total, mg/l as PO4
Potassium, dissolved, mg/l as K
Potassium 40, dissolved, pCi/l as K40

Radium 226, dissolved, radon method, pCi/l
Selenium, dissolved, ug/l as Se
Selenium, total, ug/l as Se
Silica, dissolved, mg/l as SiO2
Silver, dissolved, ug/l as Ag
Silver, total, recoverable, ug/l as Ag
Sodium, dissolved, Mg/l as Na
Sodium, per cent
Sodium adsorption ratio
Sodium + potassium, dissolved, mg/l as Na
Solids, dissolved, tons per AF
Solids, dissolved, tons per day
Solids, residue at 105 deg C, dissolved, mg/l
Solids, residue at 180 deg C, dissolved, mg/l
Solids, sum of constituents, dissolved, mg/l
Solids, volatile on ignition, total, mg/l
Specific conductance, field, us/cm
Specific conductance, lab, us/cm
Specific conductance, us/cm
Strontium, dissolved, ug/l as Sr
Sulfate, dissolved, mg/l as SO4

Tin, dissolved, ug/l as Sn, A.A.S. direct
Titanium, dissolved, ug/l as Ti
Uranium, dissolved, direct fluorimetric, pCi/l
Uranium, dissolved, extraction, ug/l
Uranium, natural, dissolved, ug/l as U

Vanadium, dissolved, ug/l as V
Zinc, dissolved, ug/l as Zn
Zinc, total, recoverable, ug/l as Zn
Zirconium, dissolved, ug/l as Zr

Synthetic, dissolved and total chemical constituents

2,4,5-T, total, ug/l
2,4-D, total, ug/l
2,4-DP, total, ug/l
Aldrin, total, ug/l
Chlordane, total, ug/l
DDD, total, ug/l
DDE, total, ug/l
DDT, total, ug/l
Diazinon, total, ug/l
Dieldrin, total, ug/l

Endosulfan, total, ug/l
Endrin, total, ug/l
Ethion, total, ug/l
Heptachlor, total, ug/l
Heptachlor epoxide, total, ug/l
Isodrin, total, ug/l

Lindane, total, ug/l
Malathion, water whole, total, ug/l
Methoxychlor, total, ug/l
Methyl parathion, total, ug/l
Methyl trithion, total, ug/l
Methylene blue active substance, mg/l
Mirex, total, ug/l

Napthalenes, polychlor., total, ug/l
Parathion, total, ug/l
PCB, total, ug/l
Perthane, total, ug/
Phenols, total, ug/l

Silvex, total, ug/l
Total trithion, ug/l
Toxaphene, total, ug/l

SUSPENDED SEDIMENTS AND BED MATERIAL

Physical characteristics

Bed material, sieve diameter, % finer than 0.062 mm
Sediment, suspended, fall diameter, % finer than 0.002

Sediment, suspended, fall diameter, % finer than 0.004
Sediment, suspended, fall diameter, % finer than 0.008
Sediment, suspended, fall diameter, % finer than 0.016
Sediment, suspended, fall diameter, % finer than 0.031
Sediment, suspended, fall diameter, % finer than 0.062
Sediment, suspended, fall diameter, % finer than 0.125
Sediment, suspended, fall diameter, % finer than 0.250
Sediment, suspended, fall diameter, % finer than 0.500
Sediment, suspended, mg/l
Sediment, suspended, sieve diameter, % finer than 0.062
Sediment, suspended, sieve diameter, % finer than 0.125
Sediment, suspended, sieve diameter, % finer than 0.250
Sediment, suspended, sieve diameter, % finer than 0.500
Sediment discharge, suspended, tons/day

Non-synthetic chemical constituents

Arsenic, suspended, total, ug/l as As
Arsenic, total in bottom material, ug/g as As
Barium, suspended, recoverable, ug/l as Ba

Cadmium, recov. from bottom material, ug/g as Cd
Cadmium, suspended, recoverable, ug/l as Cd
Carbon, organic, suspended, total, mg/l as C
Chromium, recov. from bottom material, ug/g as C
Chromium, suspended, recoverable, ug/l as Cr
Cobalt, recov. from bottom material, ug/g as Co
Cobalt, suspended, recoverable, ug/l as Co
Copper, recov. from bottom material, ug/g as Cu
Copper, suspended, recoverable, ug/l as Cu

Gross Alpha, suspended, total, pCi/l as U-nat
Gross Alpha, suspended, total, ug/l as U-nat
Gross Beta, suspended, total, pCi/l as Cs-137
Gross Beta, suspended, total, pCi/l as Sr/Yt-90

Iron, recov. from bottom material, ug/g as Fe
Iron, suspended, recoverable, ug/l as Fe
Lead, recov. from bottom material, ug/g as Pb
Lead, suspended, recovearble, ug/l as Pb

Manganese, recov. from bottom material, ug/g as Mn
Manganese, suspended, recoverable, ug/l as Mn
Mercury, suspended, recoverable, ug/l as Hg
Mercury, total, recov. from bottom material, ug/g as H

Nickel, suspended, recoverable, ug/l as Ni
Nitrogen, NH4, total in bottom material, mg/kg as N
Nitrogen, NH4 + organic, total in bottom material, mg/l
Nitrogen, NH4 + org., suspended, total, mg/l as N
Nitrogen, NO2 + NO3, total in bottom material, mg/kg

Phosphorus, total in bottom material, mg/kg as P
Selenium, suspended, total, ug/l as Se
Silver, suspended, recoverable, ug/l as Ag
Solids, nonvolatile, suspended, mg/l
Solids, residue at 105 deg C, suspended, mg/l
Solids, suspended, total, residue at 110 deg C, mg/l
Solids, volatile, suspended, mg/l

Zinc, recov. from bottom material, ug/g as Zn
Zinc, suspended, recoverable, ug/l as Zn

Synthetic chemical constituents

2,4,5-T, total in bottom material, ug/kg
2,4-D, total in bottom material, ug/kg
Aldrin, total in bottom material, ug/kg
Chlordane, total in bottom material, ug/kg
DDD, total in bottom material, ug/kg
DDE, total in bottom material, ug/kg
DDT, total in bottom material, ug/kg
Dieldrin, total in bottom material, ug/kg

Endosulfan, total in bottom material, ug/kg
Endrin, total in bottom material, ug/kg
Heptachlor, total in bottom material, ug/kg
Heptachlor epoxide, total in bottom material, ug/kg

Lindane, total in bottom material, ug/kg
Malathion, total in bottom material, ug/kg
Methoxychlor, total in bottom material, ug/kg
Methyl parathion, total in bottom material, ug/kg
Mirex, total in bottom material, ug/kg

Parathion, total in bottom material, ug/kg
PCB, total in bottom material, ug/kg
PCN, total in bottom material, ug/kg
Perthane, in bottom material, ug/kg
Silvex, total in bottom material, ug/kg
Toxaphene, total in bottom material, ug/kg

BIOLOGICAL CONSTITUENTS

Achnanthes
Actinastrum
Agmenellum
Amphora
Anabaena
Anabaenopsis
Anacystis
Ankistrodes mus
Aphanizomenon
Asterionella

Biomass chlorophyll ratio, periphyton, units
Caloneis
Ceratium
Chlamydomonadaceae
Chlamydomonas
Chlorella
Chlorococcum
Chlorophyll A periphyton, uncorr., mg/sq m
Chlorophyll B periphyton, uncorr., mg/sq m
Chlor-A, periphyton, chromographic fluorom, mg/m
Chlor-A, periphyton, chromrospectmetric, mg/m
Chlor-B, periphyton, chromographic fluorom, mg/m
Chlor-B, periphyton, chromrospectmetric, mg/m
Chodatella
Chroomonas
Chroomonas
Closteriopsis
Closterium
Cocconeis
Cocystis
Coelastrum
Coliform, fecal, 0.45 um-mf, cols./ 100 ml
Coliform, fecal, 0.7 um-mf, cols./ 100 ml
Coliform, total, immed., cols./ 100 ml
Cosmarium
Crucigenia
Cryptomonas
Cryptomonas
Cyclotella
Cymbella

Denticula
Diatoma
Dictyosphaerium
Dinobyron
Diploneis

Elakatothrix
Entomoneis
Epithemia
Euglena
Eunotia
Fragilaria

Glenodinium
Golenkinia
Gomphonema
Gymnodinium
Gyrosigma
Hantzschia
Kirchneriella

Mastogloia
Melosira
Micractinium
Navicula
Nephrocytium
Nitzschia
Opephora
Ophiocytium
Oscillatoria

Pandorina
Pediastrum
Periphyton biomass, ash weight, g/sq m
Periphyton biomass, total dry weight, g/sq m
Phacotus
Phacus
Phytoplankton, total, cells per ml
Pinnularia
Rhocosphenia

Scenedesmus
Schroederia
Selenastrum
Sphaerocystis
Spirulina
Staurastrum
Stauroneis
Stephanodiscus
Streptococci, fecal, cols./ 100 ml
Streptococci, fecal, KF agar, cols./ 100 ml
Surirella
Synedra

Tabellaria
Tetraedron
Total count, cells/ml
Trachelononas
Treubaria

Station 07223000
Total analyses: 10 From 04/15/63 to 08/03/64

Category	Occurences
Discharge, CFS	10
Temperature	0
pH	10
Specific conductance	10
Calcium mg/l	0
Magnesium mg/l	0
Potassium mg/l	0
Sodium mg/l	0
Bicarbonate mg/l	10
Carbonate mg/l	10
Chloride mg/l	10
Sulfate mg/l	0
Alkalinity mg/l	0
Total dissolved solids	0
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	10
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07223300
Total analyses: 218 From 08/22/08 at 15:35 to 06/30/77 at 17:00

Category	Occurences
Discharge, CFS	142
Temperature	194
pH	128
Specific conductance	211
Calcium mg/l	102
Magnesium mg/l	100
Potassium mg/l	60
Sodium mg/l	78
Bicarbonate mg/l	111
Carbonate mg/l	106
Chloride mg/l	111
Sulfate mg/l	103
Alkalinity mg/l	78
Total dissolved solids	102
Other:	
Administrative	0
Meteorological	22
Site descriptions	0
Qualitative	0
Physical, water	100
Dissolved inorganic	1684
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	9
Biological	0
Unidentified codes	0

Station 07223500
Total analyses: 1 From 06/24/75 at 12:35 to 06/24/75 at 12:35

Category	Occurences
Discharge, CFS	0
Temperature	1
pH	1
Specific conductance	1
Calcium mg/l	0
Magnesium mg/l	0
Potassium mg/l	0
Sodium mg/l	0
Bicarbonate mg/l	0
Carbonate mg/l	0
Chloride mg/l	0
Sulfate mg/l	0
Alkalinity mg/l	0
Total dissolved solids	0
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	0
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	1
Unidentified codes	0

Station 07224500
Total analyses: 14 From 04/15/63 to 08/03/64

Category	Occurences
Discharge, CFS	14
Temperature	0
pH	14
Specific conductance	14
Calcium mg/l	0
Magnesium mg/l	0
Potassium mg/l	0
Sodium mg/l	0
Bicarbonate mg/l	14
Carbonate mg/l	8
Chloride mg/l	14
Sulfate mg/l	0
Alkalinity mg/l	0
Total dissolved solids	0
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	0
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07225500
Total analyses: 68 From 10/01/53 to 09/05/81 at 18:00

Category	Occurences
Discharge, CFS	67
Temperature	1
pH	68
Specific conductance	68
Calcium mg/l	68
Magnesium mg/l	68
Potassium mg/l	2
Sodium mg/l	67
Bicarbonate mg/l	67
Carbonate mg/l	67
Chloride mg/l	68
Sulfate mg/l	68
Alkalinity mg/l	68
Total dissolved solids	68
Other:	
Administrative	1
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	547
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07226500
Total analyses: 24 From 04/08/63 to 04/21/73 at 16:20

Category	Occurences
Discharge, CFS	23
Temperature	0
pH	24
Specific conductance	24
Calcium mg/l	3
Magnesium mg/l	3
Potassium mg/l	3
Sodium mg/l	5
Bicarbonate mg/l	24
Carbonate mg/l	19
Chloride mg/l	24
Sulfate mg/l	5
Alkalinity mg/l	1
Total dissolved solids	3
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	64
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07226510
Total analyses: 98 From 10/14/68 to 08/07/86 at 10:05

Category	Occurences
Discharge, CFS	0
Temperature	79
pH	51
Specific conductance	66
Calcium mg/l	43
Magnesium mg/l	43
Potassium mg/l	29
Sodium mg/l	29
Bicarbonate mg/l	38
Carbonate mg/l	38
Chloride mg/l	58
Sulfate mg/l	58
Alkalinity mg/l	43
Total dissolved solids	29
Other:	
Administrative	31
Meteorological	57
Site descriptions	174
Qualitative	7
Physical, water	0
Dissolved inorganic	409
Total organic, water	0
Physical, sediment	1
Inorganic, sediment	0
Organic, sediment	0
Biological	26
Unidentified codes	0

Station 07226515
Total analyses: 77 From 10/14/68 to 08/07/86 at 10:32

Category	Occurences
Discharge, CFS	0
Temperature	70
pH	28
Specific conductance	28
Calcium mg/l	18
Magnesium mg/l	18
Potassium mg/l	18
Sodium mg/l	18
Bicarbonate mg/l	13
Carbonate mg/l	13
Chloride mg/l	18
Sulfate mg/l	18
Alkalinity mg/l	18
Total dissolved solids	18
Other:	
Administrative	49
Meteorological	57
Site descriptions	150
Qualitative	0
Physical, water	0
Dissolved inorganic	276
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	26
Unidentified codes	0

Station 07226520
Total analyses: 15 From 03/24/76 at 11:52 to 08/07/86 at 10:51

Category	Occurences
Discharge, CFS	0
Temperature	13
pH	12
Specific conductance	12
Calcium mg/l	10
Magnesium mg/l	10
Potassium mg/l	10
Sodium mg/l	10
Bicarbonate mg/l	5
Carbonate mg/l	5
Chloride mg/l	10
Sulfate mg/l	10
Alkalinity mg/l	10
Total dissolved solids	10
Other:	
Administrative	11
Meteorological	14
Site descriptions	27
Qualitative	0
Physical, water	0
Dissolved inorganic	130
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	20
Unidentified codes	0

Station 07226530
Total analyses: 30 From 10/14/68 to 04/05/74 at 11:30

Category	Occurences
Discharge, CFS	0
Temperature	24
pH	20
Specific conductance	30
Calcium mg/l	20
Magnesium mg/l	20
Potassium mg/l	10
Sodium mg/l	10
Bicarbonate mg/l	21
Carbonate mg/l	21
Chloride mg/l	30
Sulfate mg/l	30
Alkalinity mg/l	21
Total dissolved solids	10
Other:	
Administrative	0
Meteorological	9
Site descriptions	51
Qualitative	0
Physical, water	0
Dissolved inorganic	134
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07226540
Total analyses: 42 From 10/14/68 to 04/21/73 at 14:35

Category	Occurences
Discharge, CFS	0
Temperature	36
pH	28
Specific conductance	42
Calcium mg/l	28
Magnesium mg/l	28
Potassium mg/l	14
Sodium mg/l	14
Bicarbonate mg/l	28
Carbonate mg/l	28
Chloride mg/l	42
Sulfate mg/l	42
Alkalinity mg/l	28
Total dissolved solids	14
Other:	
Administrative	0
Meteorological	14
Site descriptions	66
Qualitative	0
Physical, water	0
Dissolved inorganic	184
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07226560
Total analyses: 252 From 10/14/68 to 06/14/90 at 09:32

Category	Occurences
Discharge, CFS	0
Temperature	229
pH	114
Specific conductance	104
Calcium mg/l	70
Magnesium mg/l	70
Potassium mg/l	55
Sodium mg/l	54
Bicarbonate mg/l	59
Carbonate mg/l	59
Chloride mg/l	85
Sulfate mg/l	85
Alkalinity mg/l	71
Total dissolved solids	47
Other:	
Administrative	239
Meteorological	154
Site descriptions	486
Qualitative	8
Physical, water	26
Dissolved inorganic	2073
Total organic, water	417
Physical, sediment	13
Inorganic, sediment	399
Organic, sediment	12
Biological	84
Unidentified codes	0

Station 07226800
Total analyses: 15 From 03/26/63 to 08/17/83 at 11:45

Category	Occurences
Discharge, CFS	1
Temperature	6
pH	12
Specific conductance	14
Calcium mg/l	5
Magnesium mg/l	5
Potassium mg/l	3
Sodium mg/l	5
Bicarbonate mg/l	12
Carbonate mg/l	12
Chloride mg/l	13
Sulfate mg/l	9
Alkalinity mg/l	3
Total dissolved solids	4
Other:	
Administrative	3
Meteorological	1
Site descriptions	0
Qualitative	0
Physical, water	1
Dissolved inorganic	44
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07226810
Total analyses: 2 From 11/14/67 at 14:55 to 11/14/67 at 15:00

Category	Occurences
Discharge, CFS	0
Temperature	2
pH	2
Specific conductance	2
Calcium mg/l	2
Magnesium mg/l	2
Potassium mg/l	2
Sodium mg/l	2
Bicarbonate mg/l	2
Carbonate mg/l	2
Chloride mg/l	2
Sulfate mg/l	2
Alkalinity mg/l	2
Total dissolved solids	2
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	14
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07226820
Total analyses: 2 From 10/20/67 at 12:00 to 10/20/67 at 13:30

Category	Occurences
Discharge, CFS	0
Temperature	2
pH	2
Specific conductance	1
Calcium mg/l	2
Magnesium mg/l	2
Potassium mg/l	2
Sodium mg/l	2
Bicarbonate mg/l	2
Carbonate mg/l	2
Chloride mg/l	2
Sulfate mg/l	2
Alkalinity mg/l	2
Total dissolved solids	2
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	26
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07226830
Total analyses: 1 From 10/02/68 at 12:00 to 10/02/68 at 12:00

Category	Occurences
Discharge, CFS	0
Temperature	0
pH	0
Specific conductance	0
Calcium mg/l	0
Magnesium mg/l	0
Potassium mg/l	0
Sodium mg/l	0
Bicarbonate mg/l	0
Carbonate mg/l	0
Chloride mg/l	0
Sulfate mg/l	0
Alkalinity mg/l	0
Total dissolved solids	0
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	0
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227000
Total analyses: 332 From 10/01/59 to 08/31/71 at 16:45

Category	Occurences
Discharge, CFS	332
Temperature	6
pH	329
Specific conductance	329
Calcium mg/l	332
Magnesium mg/l	331
Potassium mg/l	14
Sodium mg/l	331
Bicarbonate mg/l	329
Carbonate mg/l	212
Chloride mg/l	329
Sulfate mg/l	329
Alkalinity mg/l	23
Total dissolved solids	329
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	4
Dissolved inorganic	2566
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227070
Total analyses: 3 From 07/02/64 to 09/04/64

Category	Occurences
Discharge, CFS	3
Temperature	0
pH	3
Specific conductance	3
Calcium mg/l	1
Magnesium mg/l	1
Potassium mg/l	1
Sodium mg/l	1
Bicarbonate mg/l	3
Carbonate mg/l	3
Chloride mg/l	3
Sulfate mg/l	1
Alkalinity mg/l	0
Total dissolved solids	1
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	13
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227073
Total analyses: 11 From 11/06/64 to 01/04/66

Category	Occurences
Discharge, CFS	11
Temperature	0
pH	11
Specific conductance	11
Calcium mg/l	5
Magnesium mg/l	5
Potassium mg/l	5
Sodium mg/l	5
Bicarbonate mg/l	11
Carbonate mg/l	11
Chloride mg/l	11
Sulfate mg/l	5
Alkalinity mg/l	0
Total dissolved solids	6
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	60
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227080
Total analyses: 1 From 11/06/64 to 11/06/64

Category	Occurences
Discharge, CFS	1
Temperature	0
pH	0
Specific conductance	0
Calcium mg/l	0
Magnesium mg/l	0
Potassium mg/l	0
Sodium mg/l	0
Bicarbonate mg/l	1
Carbonate mg/l	1
Chloride mg/l	1
Sulfate mg/l	0
Alkalinity mg/l	0
Total dissolved solids	0
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	1
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227100
Total analyses: 655 From 10/01/59 to 09/12/90 at 16:00

Category	Occurences
Discharge, CFS	648
Temperature	251
pH	611
Specific conductance	623
Calcium mg/l	587
Magnesium mg/l	586
Potassium mg/l	175
Sodium mg/l	554
Bicarbonate mg/l	527
Carbonate mg/l	518
Chloride mg/l	585
Sulfate mg/l	585
Alkalinity mg/l	212
Total dissolved solids	556
Other:	
Administrative	146
Meteorological	125
Site descriptions	3
Qualitative	0
Physical, water	1
Dissolved inorganic	4636
Total organic, water	32
Physical, sediment	409
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227125
Total analyses: 59 From 07/23/64 to 01/04/66

Category	Occurences
Discharge, CFS	58
Temperature	0
pH	58
Specific conductance	58
Calcium mg/l	9
Magnesium mg/l	6
Potassium mg/l	9
Sodium mg/l	9
Bicarbonate mg/l	58
Carbonate mg/l	58
Chloride mg/l	58
Sulfate mg/l	9
Alkalinity mg/l	0
Total dissolved solids	9
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	174
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227140
Total analyses: 152 From 07/22/69 at 16:00 to 11/12/86 at 16:00

Category	Occurences
Discharge, CFS	144
Temperature	145
pH	138
Specific conductance	141
Calcium mg/l	139
Magnesium mg/l	139
Potassium mg/l	138
Sodium mg/l	139
Bicarbonate mg/l	95
Carbonate mg/l	92
Chloride mg/l	138
Sulfate mg/l	138
Alkalinity mg/l	141
Total dissolved solids	138
Other:	
Administrative	135
Meteorological	111
Site descriptions	21
Qualitative	0
Physical, water	101
Dissolved inorganic	3734
Total organic, water	225
Physical, sediment	360
Inorganic, sediment	395
Organic, sediment	0
Biological	336
Unidentified codes	0

Station 07227448
Total analyses: 32 From 02/14/68 at 09:50 to 05/02/73 at 11:20

Category	Occurences
Discharge, CFS	31
Temperature	32
pH	30
Specific conductance	31
Calcium mg/l	31
Magnesium mg/l	31
Potassium mg/l	0
Sodium mg/l	7
Bicarbonate mg/l	31
Carbonate mg/l	31
Chloride mg/l	32
Sulfate mg/l	32
Alkalinity mg/l	31
Total dissolved solids	31
Other:	
Administrative	0
Meteorological	0
Site descriptions	0
Qualitative	0
Physical, water	0
Dissolved inorganic	264
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

Station 07227470
Total analyses: 286 From 11/21/49 to 09/01/77 at 11:30

Category	Occurences
Discharge, CFS	269
Temperature	77
pH	267
Specific conductance	271
Calcium mg/l	249
Magnesium mg/l	249
Potassium mg/l	64
Sodium mg/l	95
Bicarbonate mg/l	254
Carbonate mg/l	223
Chloride mg/l	261
Sulfate mg/l	261
Alkalinity mg/l	231
Total dissolved solids	249
Other:	
Administrative	4
Meteorological	0
Site descriptions	66
Qualitative	0
Physical, water	12
Dissolved inorganic	2455
Total organic, water	288
Physical, sediment	0
Inorganic, sediment	14
Organic, sediment	156
Biological	34
Unidentified codes	0

Station 07227500
Total analyses: 1180 From 07/19/38 to 08/21/90 at 09:20

Category	Occurences
Discharge, CFS	1165
Temperature	219
pH	821
Specific conductance	875
Calcium mg/l	787
Magnesium mg/l	787
Potassium mg/l	268
Sodium mg/l	657
Bicarbonate mg/l	761
Carbonate mg/l	628
Chloride mg/l	865
Sulfate mg/l	859
Alkalinity mg/l	487
Total dissolved solids	606
Other:	
Administrative	461
Meteorological	47
Site descriptions	566
Qualitative	0
Physical, water	185
Dissolved inorganic	8219
Total organic, water	1019
Physical, sediment	409
Inorganic, sediment	208
Organic, sediment	462
Biological	0
Unidentified codes	0

Station 07227900
Total analyses: 41 From 11/17/65 to 01/03/84 at 11:00

Category	Occurences
Discharge, CFS	0
Temperature	35
pH	32
Specific conductance	39
Calcium mg/l	38
Magnesium mg/l	38
Potassium mg/l	32
Sodium mg/l	34
Bicarbonate mg/l	35
Carbonate mg/l	35
Chloride mg/l	40
Sulfate mg/l	38
Alkalinity mg/l	38
Total dissolved solids	39
Other:	
Administrative	7
Meteorological	0
Site descriptions	18
Qualitative	0
Physical, water	5
Dissolved inorganic	329
Total organic, water	0
Physical, sediment	0
Inorganic, sediment	0
Organic, sediment	0
Biological	0
Unidentified codes	0

<u>Representative outputs from USGS data base</u>

The usefulness of the USGS data base can be illustrated by data extracted from the files described in TAB 5. For this illustration, data are presented for the Amarillo gage; they have been extracted from files 2MSO500 and 2MCL500. The data printout presents the measured numbers along with computed values for use in plotting double mass curves. Three graphs show significant time-variant trends in the data. Regression analyses which are readily performed on the data indicate the following relationships. All values in metric tons unless otherwise noted.

Dependent variable	Independent variable	Time Period	R-SQ	Intercept	Slope	Comment
Chloride	days	Note a	0.99	-3.4 EE 06	145.1	Slope equals 1.68 kg/sec
Chloride	days	Note b	0.96	-1.2 EE 06	61.8	Slope equals 0.72 kg/sec
Chloride	days	Note c	0.98	-2.4 EE 06	103.1	Slope equals 1.19 kg/sec
Sulfate	days	Note a	0.99	-2.9 EE 06	125.8	Slope equals 1.46 kg/sec
Sulfate	days	Note b	0.97	-0.8 EE 06	44.6	Slope equals 0.52 kg/sec
Sulfate	days	Note c	0.95	-1.9 EE 06	81.5	Slope equals 0.84 kg/sec
Chloride	sulfate	Note d	0.99	-1758	0.8671	Slope shows Cl:SO4 = 1.15:1
Chloride	sulfate	Note e	0.99	-115482	0.662	Slope shows Cl:SO4 = 1.51:1

Note a. 1/65 through 7/74.

Note b. 8/74 through 3/85.

Note c. 5/85 through 5/90.

Note d. 1/65 through 8/78.

Note e. 9/78 through 5/90.

Discharge, Chloride and Sulfate – Canadian River Near Amarillo, Texas

Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
01/01/65	6.4	182	194					
01/22/65	6.9	408	368	194456.55273	79.338273513	71.560011404	408	368
01/24/65	8.4	131	134	297382.51636	92.821574749	85.352090531	312	287
02/01/65	7	199	189	606160.40727	154.26837504	143.71111191	255	237
03/01/65	6.7	145	150	918124.10182	199.50311075	190.50566609	217	207
03/11/65	20.3	608	552	1340978.2691	456.59844445	423.92116643	340	316
03/18/65	6.4	180	192	1505659.8109	486.24112198	455.54002246	323	303
04/01/65	5.6	163	168	1807575.9709	535.45345606	506.26193734	296	280
05/01/65	6.1	180	165	2106551.3891	589.26903133	555.59288134	280	264
05/11/65	1158.01	513	347	23390354.095	11507.8598192	7941.0724201	492	340
05/16/65	307	278	211	31289921.804	13703.9396424	9607.8812067	438	307
06/01/65	17.3	245	196	31798670.138	13828.5829843	9707.5958803	435	305
06/09/65	5559.99	47	56	106738439.354	17350.752137	13904.2229564	163	130
06/12/65	386	200	166	109576255.209	17918.315308	14375.3003883	164	131
06/15/65	12499.98	47	56	170841611.73	20797.787065	17806.160353	122	104
06/16/65	874	200	166	177267132.6	22082.891239	18872.796818	125	106
06/21/65	7765	124	116	300955958.78	37420.305686	33220.700655	124	110
06/29/65	850	200	166	310329573.33	39295.028595	34776.72067	127	112
06/30/65	594	632	480	311785240.53	40215.010265	35475.440926	129	114
07/01/65	346	405	328	313481068.31	40901.820517	36031.672438	130	115
07/04/65	72	640	512	315951291.44	42482.763319	37296.42668	134	118
07/29/65	1517.01	176	157	367997863.47	51642.959996	45467.738489	140	124
08/01/65	670	760	624	371281691.83	54138.669553	47516.847387	146	128
08/02/65	389	315	242	372234982.31	54438.956051	47747.543682	146	128
08/03/65	193	760	624	372707951.62	54798.412726	48042.676531	147	129
08/04/65	170	315	242	374374371.98	55323.335141	48445.950259	148	129
08/11/65	133	560	436	376329965.29	56418.467394	49298.588942	150	131
08/16/65	878	205	159	392467286.02	59726.618143	51864.422937	152	132
08/26/65	50.3	500	416	393453414.77	60219.682521	52274.6525	153	133
09/01/65	68.3	656	420	395294564.21	61427.476554	53047.935265	155	134
09/17/65	296	289	244	402911085.52	63628.651212	54906.366464	158	136
09/22/65	528	223	195	410027680.72	65215.651942	56294.102528	159	137
09/28/65	297	86	90	413302931.92	65497.323545	56588.875136	158	137
10/01/65	440	212	222	423007379.92	67554.666521	58743.262592	160	139
10/16/65	2460	48	56	480278326.83	70303.671973	61950.435619	146	129
10/20/65	411	204	211	488335959.41	71947.429019	63650.596094	147	130
11/01/65	578	500	428	501084075.19	78321.48691	69106.789648	156	138
11/07/65	456	225	225	506112743.7	79452.937325	70238.240063	157	139
11/10/65	40	510	430	507289040.43	80052.848656	70744.047656	158	139
12/01/65	39.3	570	432	509793082.09	81480.152401	71825.793652	160	141
01/01/66	10.8	590	446	510613549.06	81964.227912	72191.721919	161	141
02/01/66	51	605	411	514300504.11	84194.83572	73707.060447	164	143
03/01/66	56.3	690	498	517404824.69	86336.816921	75253.012096	167	145
03/18/66	6.8	268	230	517663119.85	86406.040023	75312.419982	167	145
04/01/66	7.1	170	150	517958909.46	86456.324257	75356.788425	167	145
04/21/66	12	401	384	518282391.06	86586.040379	75481.005359	167	146
04/23/66	18	170	150	518370613.32	86601.038162	75494.238697	167	146
04/25/66	14	401	384	518422076.3	86621.674818	75514.000482	167	146
04/26/66	13	170	150	518517650.41	86637.922417	75528.336599	167	146
05/01/66	13.2	150	121	519099917.29	86725.262449	75598.790891	167	146
06/01/66	154	330	274	525326938.09	88780.179313	77304.99459	169	147
06/03/66	859	65	84	528484559.62	88985.424712	77570.234799	168	147
06/04/66	197	308	260	533070891.54	90398.014945	78762.6811	170	148
06/22/66	74	138	127	535519059.11	90735.862069	79073.59838	169	148
07/01/66	11	114	111	535882975.91	90777.348584	79113.993145	169	148
07/19/66	12	266	206	536235864.93	90871.217063	79186.688283	169	148
07/25/66	1210	114	111	549579480.93	92392.389287	80667.829659	168	147
07/28/66	86	266	206	550317117	92588.600483	80819.78269	168	147
08/01/66	299	245	204	558743567.62	94653.080884	82538.778616	169	148
08/20/66	355	360	240	569183201.07	98411.348928	85044.290645	173	149
08/25/66	570	150	118	576865889.07	99563.752128	85950.847829	173	149
08/31/66	2250	475	306	596164507.25	108730.595764	91856.224993	182	154
09/01/66	801	475		599108925	110129.194193	91856.224993	184	153
09/03/66	56.6	350	298	601189499.83	110857.395386	92476.236294	184	154

Discharge, Chloride and Sulfate – Canadian River Near Amarillo, Texas

Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
10/01/66	9.6	152	146	601883514.9	110962.885676	92577.562494	184	154
11/01/66	11.4	152	141	602554004.04	111064.800025	92672.101462	184	154
11/18/66	10.5	215	197	602939976.4	111147.784083	92748.138018	184	154
12/01/66	12.6	183	180	603418582.13	111235.368932	92834.287049	184	154
12/19/66	11.9	308	278	603870598.66	111374.590021	92959.947643	184	154
01/01/67	24.6	470	368	605196873.22	111997.939064	93448.016681	185	154
02/01/67	18.5	440	364	606171606.6	112426.821752	93802.819632	185	155
02/13/67	15.1	270	240	606541649.94	112526.733455	93891.630035	186	155
02/21/67	11.2	180	170	606761225.33	112566.257026	93928.957851	186	155
03/01/67	11.2	148	142	607296440.34	112645.468847	94004.958382	185	155
04/01/67	11	128	117	607754705.94	112704.126844	94058.575458	185	155
04/04/67	595	390	340	617503265.07	116626.130491	97475.27879	189	158
04/15/67	208	128	117	620816500.85	117050.224671	97862.927376	189	158
04/17/67	48	390	340	621169389.87	117187.851388	97982.909642	189	158
04/21/67	11	128	117	621236781.87	117196.477564	97990.794506	189	158
04/22/67	9.2	390	340	621259327.56	117205.270382	97998.46004	189	158
04/23/67	12	128	117	621391660.94	117222.209055	98013.943046	189	158
05/01/67	41.8	338	292	623389159.82	117897.363676	98597.212719	189	158
06/01/67	519	252	204	662181220.33	127672.962925	106510.793062	193	161
07/01/67	1161.01	210	184	720507660.74	139921.51541	117242.858098	194	163
07/12/67	1868.01	124	168	791463239.42	148720.00717	129163.395317	188	163
08/01/67	141	231	208	796300759.71	149837.47436	130169.599538	188	163
08/09/67	491	652	286	801715400.59	153367.8202	131718.18683	191	164
08/10/67	381	231	208	812452784.15	155848.15581	133951.56261	192	165
09/01/67	34.8	512	382	814243695.92	156765.10263	134635.6909	193	165
09/21/67	630	252	225	837402037.74	162601.00477	139846.31781	194	167
10/01/67	62	410	334	838693513.52	163130.50984	140277.67072	195	167
10/08/67	62	222	221	839301266.83	163265.43108	140411.9842	195	167
10/09/67	24	410	334	839389489.08	163301.6022	140441.45044	195	167
10/11/67	54	780	636	839587989.15	163456.43226	140567.69648	195	167
10/12/67	491	410	334	840791242.68	163949.7662	140969.58316	195	168
10/13/67	696	222	221	851877839.34	166410.99066	143419.72102	195	168
10/25/67	54	410	334	853135006.46	166926.42918	143839.61484	196	169
11/01/67	38	362	345	854764667.55	167516.3665	144401.84792	196	169
11/29/67	1020.01	290	234	892259493.33	178389.86597	153175.63715	200	172
12/01/67	220	238	194	894416037.33	178903.12344	153594.00669	200	172
12/07/67	21	418	324	894802009.69	179064.45989	153719.06173	200	172
12/16/67	7	238	194	894887781.33	179084.87354	153735.70143	200	172
12/17/67	44	418	324	895265176.53	179242.62473	153857.97748	200	172
12/23/67	79	238	194	896717167.8	179588.19866	154139.66378	200	172
01/01/68	34	592	380	897925322.57	180303.42628	154598.76259	201	172
01/21/68	287	318	200	906013587.87	182875.49465	156216.41565	202	172
01/24/68	136	515	320	907846650.27	183819.52178	156802.99562	202	173
02/01/68	55	648	416	908992314.27	184561.91205	157279.59185	203	173
02/10/68	43	312	236	909677262.06	184775.61576	157441.23952	203	173
02/14/68	38	598	362	910608496.97	185332.49424	157778.34656	204	173
03/01/68	18	585	424	911314275	185745.37439	158077.59645	204	173
03/17/68	24	698	444	912049460.46	186258.53384	158404.01879	204	174
03/26/68	7	380	314	912178117.91	186307.42367	158444.41723	204	174
04/01/68	8	160	136	912511401.98	186360.74912	158489.74386	204	174
04/29/68	74	575	544	915140915.29	187872.71927	159920.1991	205	175
04/30/68	37	160	136	915231588.17	187887.22693	159932.53061	205	175
05/01/68	15	188	147	915286727.07	187897.59305	159940.63603	205	175
05/03/68	480	290	204	922932655.8	190114.91238	161500.40549	206	175
05/14/68	30	525	372	923998674.71	190674.57231	161896.96453	206	175
06/01/68	2080	485	382	972422889.98	214160.31671	180395.01476	220	186
06/02/68	443	189	158	974594137.69	214570.68253	180738.0719	220	185
06/05/68	15	485	382	974796313.69	214668.73789	180815.30313	220	185
06/13/68	46	130	118	975529048.53	214763.99342	180901.76584	220	185
06/18/68	4	260	221	975617270.78	214786.93121	180921.26296	220	185
07/01/68	33	225	187	976264233.98	214932.49793	181042.24508	220	185
07/04/68	10	375	298	976313246.35	214950.87756	181056.85076	220	185
07/05/68	525	225	187	985319268.17	216977.23247	182740.97684	220	185

Discharge, Chloride and Sulfate – Canadian River Near Amarillo, Texas

Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
07/18/68	27	375	298	986146351.8	217287.38883	182987.44777	220	186
07/30/68	11	225	187	986335049.4	217329.84579	183022.73422	220	186
08/01/68	33	255	218	986901142.2	217474.19946	183146.14245	220	186
08/13/68	251	119	109	990899325.77	217949.9833	183581.94446	220	185
08/14/68	2560	255	218	997172908.31	219549.74685	184949.58545	220	185
08/15/68	1070	119	109	1001106150.49	220017.80267	185378.30885	220	185
08/17/68	226	255	218	1002490749.77	220370.87549	185680.15149	220	185
08/20/68	16	482	420	1002627984.38	220437.02257	185737.79003	220	185
08/24/68	48	255	218	1003157317.91	220572.00262	185853.18474	220	185
08/29/68	596	119	109	1008999591.66	221267.2332	186489.99258	219	185
09/01/68	55	302	257	1009606119.66	221450.40465	186645.87028	219	185
09/07/68	32	540	421	1009919798.78	221619.79138	186777.92919	219	185
09/09/68	11	302	257	1010243280.38	221717.48282	186861.06396	219	185
10/01/68	7.6	280	260	1010587837.3	221813.95876	186950.64876	219	185
10/16/68	532	106	105	1022321397.15	223057.71611	188182.67254	218	184
10/19/68	17	435	390	1022654681.23	223202.69468	188312.65333	218	184
11/01/68	17	512	460	1023550382.17	223661.29356	188724.67577	219	184
12/01/68	6.6	510	448	1024043691.61	223912.88138	188945.67839	219	185
01/01/69	15	710	532	1025183229.07	224721.95297	189551.91232	219	185
02/01/69	49	650	478	1028725597.65	227024.49255	191245.1645	221	186
03/01/69	52	730	472	1032484845.94	229768.7438	193019.5297	223	187
04/01/69	3.1	480	416	1032716551.89	229879.96265	193115.91937	223	187
05/01/69	539	365	251	1071682606.29	244102.57251	202896.39902	228	189
05/30/69	390	142	133	1086496593.2	246206.15865	204866.65928	227	189
06/01/69	134	210	205	1086989167.5	246309.59925	204967.63701	227	189
06/02/69	72	475	336	1087606723.2	246602.93824	205175.13575	227	189
06/08/69	753	114	128	1094987985.2	247444.40211	206119.93728	226	188
06/10/69	3.8	210	205	1095006609.9	247448.31329	206123.75534	226	188
06/12/69	26	475	336	1095134042	247508.84356	206166.57254	226	188
06/14/69	1090	210	205	1101811976.6	248911.20982	207535.54913	226	188
06/17/69	7730	114	128	1158641812.2	255389.81108	214809.76809	220	185
06/20/69	1600	210	205	1174325768.6	258683.44191	218024.97914	220	186
06/25/69	375	475	336	1179380168.6	261084.28191	219723.25754	221	186
07/01/69	68	720	428	1180213378.8	261684.19325	220079.8715	222	186
07/05/69	1020	126	136	1187712270.4	262629.05359	221099.72076	221	186
07/07/69	420	265	218	1190800049.3	263447.315	221772.85656	221	186
07/11/69	1470	126	136	1208812093	265716.8325	224222.4945	220	185
07/17/69	239	265	218	1211740581.7	266492.88201	224860.90504	220	186
07/21/69	904	126	136	1220602017	267609.42287	226066.06025	219	185
07/25/69	325	265	218	1224982497	268770.25007	227021.00489	219	185
08/01/69	84	235	205	1225908830.7	268987.93848	227210.90329	219	185
08/03/69	1070	120	130	1231153153.6	269617.25723	227892.66527	219	185
08/05/69	136	235	205	1232153005.8	269852.2225	228097.63497	219	185
08/09/69	1.6	428	354	1232184373.7	269865.64797	228108.73922	219	185
08/21/69	759	235	205	1244274498.5	272706.8273	230587.2148	219	185
08/22/69	118	120	130	1244563671.5	272741.52805	230624.80728	219	185
08/23/69	12	235	205	1244593078.9	272748.43879	230630.8358	219	185
08/24/69	758	428	354	1246450647.5	273543.47815	231288.41508	219	186
08/25/69	1510	120	130	1261252381.3	275319.6862	233212.64048	218	185
09/01/69	6550	80	114	1341510126.8	281740.30584	242362.02346	210	181
09/04/69	1040	141	148	1354253341.3	283537.09909	244248.01921	209	180
09/11/69	2780	80	114	1395129652.6	286807.20399	248907.9187	206	178
09/16/69	822	141	148	1415273734	289647.51948	251889.24275	205	178
10/01/69	440	203	182	1433065222	293259.19154	255127.29357	205	178
10/19/69	296	385	256	1442132509.3	296750.09714	257448.51911	206	179
10/26/69	448	203	182	1447621894	297864.44224	258447.58713	206	179
10/29/69	237	385	256	1449364283.6	298535.26221	258893.63885	206	179
11/01/69	214	412	266	1451199796.6	299291.49357	259381.88531	206	179
11/05/69	65	595	390	1453111278.8	300428.82547	260127.36336	207	179
11/25/69	33	170	122	1454000853.2	300580.05312	260235.89144	207	179
11/27/69	31	595	390	1454228760.6	300715.65808	260324.77536	207	179
12/01/69	48	600	400	1456287279.9	301950.76964	261148.18307	207	179
01/01/70	26	244	212	1457370453.2	302215.06391	261377.8158	207	179

Discharge, Chloride and Sulfate – Canadian River Near Amarillo, Texas

Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
01/04/70	60	600	412	1459576009.5	303538.39773	262286.50502	208	180
01/31/70	31	244	212	1460639577.8	303797.90839	262511.9815	208	180
02/01/70	26	505	354	1461308596.6	304135.76287	262748.81414	208	180
02/21/70	14	219	168	1461668837.4	304214.65562	262809.3346	208	180
02/22/70	19	505	354	1461761960.9	304261.68298	262842.30032	208	180
02/25/70	21	219	168	1461864886.9	304284.22377	262859.59188	208	180
02/26/70	19	505	354	1461958010.4	304331.25113	262892.5576	208	180
03/01/70	29	365	272	1463166165.2	304772.22762	263221.17569	208	180
04/01/70	156	252	187	1469282908.1	306313.64685	264365.00663	208	180
04/02/70	137	645	384	1470122244.9	306855.01904	264687.31194	209	180
04/06/70	192	252	187	1471298541.6	307151.44581	264907.27942	209	180
04/07/70	69	645	384	1471890365.9	307533.17248	265134.53995	209	180
04/13/70	27	252	187	1472088866	307583.1945	265171.65946	209	180
04/13/70	156	860	550	1472280014.2	307747.58197	265276.79098	209	180
04/14/70	21	134	87	1472331477.2	307754.47801	265281.26826	209	180
04/15/70	22	204	154	1472439304.4	307776.47476	265297.87365	209	180
04/18/70	1840	252	187	1494984991.6	313457.98795	269513.91717	210	180
04/25/70	112	645	384	1496769041.7	314608.70022	270198.99239	210	181
05/01/70	37	860	532	1498083798.3	315739.39094	270898.44293	211	181
05/24/70	111	392	245	1501484031	317072.28217	271731.49994	211	181
05/26/70	28	860	532	1501758500.3	317308.32572	271877.51758	211	181
06/01/70	23	605	444	1501927592.9	317410.62677	271952.59472	211	181
06/01/70	29	800	552	1502176330.7	317609.61697	272089.89795	211	181
06/08/70	106	280	242	1503475158.3	317973.28871	272404.21424	211	181
06/11/70	7.2	605	444	1503554558.3	318021.32572	272439.46785	212	181
06/17/70	11	280	242	1503824126.3	318096.80476	272504.70331	212	181
07/01/70	50	205	182	1504804373.6	318297.75546	272683.10831	212	181
07/03/70	35	452	333	1505276117.6	318510.98374	272840.19907	212	181
07/12/70	78	940	732	1506231858.7	319409.38037	273539.80154	212	182
07/13/70	119	205	182	1506523482.3	319469.1632	273592.87703	212	182
07/14/70	132	183	131	1507008704.7	319557.9589	273656.44117	212	182
07/16/70	16	452	333	1507067519.5	319584.54321	273676.02651	212	182
07/17/70	56	940	732	1507204754.1	319713.54375	273776.48225	212	182
07/18/70	16	452	333	1507400803.6	319802.1581	273841.76672	212	182
07/27/70	2.6	205	182	1507439033.2	319809.99518	273848.72451	212	182
07/30/70	1060	452	333	1513933171.4	322745.34563	276011.27253	213	182
08/01/70	518	218	194	1521549692.7	324405.74728	277488.87766	213	182
08/11/70	272	121	123	1525215817.5	324849.34838	277939.81101	213	182
08/12/70	395	135	164	1526183811.7	324980.0276	278098.56206	213	182
08/13/70	110	218	198	1526722947.7	325097.55924	278205.31098	213	182
08/16/70	270	121	123	1528046281.5	325257.68264	278368.08104	213	182
08/17/70	40	218	198	1528193318.6	325289.73672	278397.19439	213	182
08/19/70	431	560	354	1530833859.7	326768.43973	279331.94593	213	182
08/22/70	311	121	123	1532358144.2	326952.87816	279519.43293	213	182
08/23/70	229	218	198	1535164102	327564.57696	280075.01258	213	182
09/01/70	18	355	282	1535450824.4	327666.36339	280155.86827	213	182
09/05/70	7.3	590	396	1535549216.7	327724.41486	280194.83163	213	182
09/12/70	11	355	282	1535710957.5	327781.83284	280240.44254	213	182
09/17/70	571	202	158	1544106775.4	329477.78806	281566.98176	213	182
09/24/70	71	355	282	1544976744.8	329786.62721	281812.31315	213	182
09/27/70	36	590	396	1545285522.7	329968.80617	281934.58919	214	182
10/01/70	71	600	380	1546764470.8	330856.17501	282496.58946	214	183
10/14/70	7.4	670	480	1547045556.7	331044.50257	282631.5107	214	183
11/01/70	31	700	460	1548868816.6	332320.78452	283470.21026	215	183
12/01/70	15	640	460	1549548863.2	332756.01431	283783.03167	215	183
12/08/70	12	600	450	1550004678.1	333029.50329	283988.14842	215	183
01/01/71	9.8	820	490	1550388935.1	333344.59398	284176.43431	215	183
01/09/71	17	590	430	1550743049.4	333553.52143	284328.70347	215	183
01/18/71	32	820	490	1551488037.3	334164.41153	284693.74756	215	183
01/28/71	38	720	440	1552139901.8	334633.75393	284980.56791	216	184
02/01/71	15	340	240	1552378837	334714.99192	285037.91238	216	184
02/10/71	34	690	460	1553545331.3	335519.87295	285574.49973	216	184
03/01/71	29	370	340	1554291544.5	335795.97185	285828.21223	216	184

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Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
03/03/71	15	760	550	1554622378	336047.40528	286010.17063	216	184
03/19/71	5.6	370	340	1554821368.2	336121.03165	286077.8273	216	184
04/01/71	29	350	290	1555922921.1	336506.57516	286397.27763	216	184
04/19/71	42	510	380	1556900717.7	337005.25145	286768.84036	216	184
04/20/71	25	720	500	1557268310.4	337269.91821	286952.63672	217	184
05/01/71	4.8	620	440	1557350651.2	337320.96949	286988.86666	217	184
05/04/71	100	310	260	1560904047.6	338422.52236	287912.74972	217	184
05/30/71	1120	220	180	1599329740.7	346876.17484	294829.37447	217	184
06/01/71	412	240	180	1602358704.7	347603.12622	295374.58801	217	184
06/05/71	56	480	380	1602839025.9	347833.68038	295557.11005	217	184
06/08/71	31	590	420	1603142902.6	348012.96761	295684.73825	217	184
06/13/71	928	240	180	1613376684.1	350469.07517	297526.81892	217	184
06/17/71	898	100	91	1618878321.9	351019.23895	298027.46796	217	184
06/18/71	426	240	180	1620444266.9	351395.06576	298309.33806	217	184
06/20/71	1480	100	91	1625884639.3	351939.10299	298804.41195	216	184
06/21/71	212	240	180	1626663935.9	352126.13417	298944.68533	216	184
06/23/71	137	480	380	1628342609.3	352931.89743	299582.58125	217	184
07/01/71	569	220	250	1652744639.9	358300.34415	305683.08888	217	185
07/28/71	1570	100	75	1708532962.8	363879.17644	309867.2131	213	181
07/30/71	64	220	250	1708846641.9	363948.18585	309945.63288	213	181
08/01/71	456	440	310	1710522864.7	364685.7239	310465.26196	213	182
08/02/71	745	130	170	1719651417.5	365872.43575	312017.11593	213	181
08/11/71	1850	140	150	1787656072	375393.08739	322217.81411	210	180
09/01/71	142	250	240	1795137809.3	377263.52172	324013.43106	210	180
09/23/71	1080	110	91	1826897821	380757.123	326903.59212	208	179
09/25/71	561	250	240	1832397008.2	382131.9198	328223.39705	209	179
10/01/71	26	420	320	1833161601	382453.0488	328468.06677	209	179
10/19/71	136	220	160	1836661083.8	383222.93501	329027.98401	209	179
10/22/71	91	420	320	1837553108.8	383597.58552	329313.43202	209	179
10/27/71	104	250	200	1838699998.1	383884.30785	329542.80988	209	179
10/31/71	491	220	160	1841708131.9	384546.09729	330024.11129	209	179
11/01/71	314	190	140	1843247120.2	384838.50505	330239.56964	209	179
11/04/71	42	460	290	1844019064.9	385193.59962	330463.43361	209	179
11/16/71	4379.99	68	50	1919154846.8	390302.83279	334220.22271	203	174
11/18/71	137	190	140	1920162050.9	390494.20157	334361.23128	203	174
11/22/71	47	460	290	1920910714.7	390838.58694	334578.34379	203	174
12/01/71	66	610	380	1922123770.7	391578.5511	335039.30507	204	174
12/07/71	45	520	320	1923833076.9	392467.39031	335586.28305	204	174
01/01/72	62	280	210	1926795874.3	393296.97358	336208.4705	204	174
01/15/72	65	580	380	1929264872.1	394728.99232	337146.68967	205	175
02/01/72	33	600	560	1930033140.9	395189.9536	337576.9202	205	175
02/03/72	30	490	420	1930216937.3	395280.01381	337654.11467	205	175
02/06/72	33	280	260	1931308687.7	395585.70393	337937.96978	205	175
03/01/72	14	490	420	1932252175.7	396048.01305	338334.23474	205	175
04/01/72	11	320	290	1932899138.9	396255.04127	338521.85407	205	175
04/18/72	26	270	240	1933854880	396513.09136	338751.23193	205	175
05/01/72	37	260	230	1934852281.6	396772.41578	338980.6343	205	175
05/10/72	585	50	60	1943453951.4	397202.49927	339496.73449	204	175
05/13/72	84	260	230	1944174433.1	397389.82453	339662.44529	204	175
05/17/72	21	320	290	1944663331.4	397546.27199	339804.2258	204	175
06/01/72	6.2	310	250	1944845657.4	397602.79305	339849.8073	204	175
06/10/72	261	120	110	1950921965.2	398331.94998	340518.20116	204	175
06/20/72	82	320	210	1952328620.1	398782.07953	340813.59867	204	175
06/24/72	37	310	250	1952736648	398908.56819	340915.60565	204	175
06/29/72	272	120	110	1955069636.5	399188.52681	341172.23439	204	175
07/01/72	75	300	260	1956815701.9	399712.34644	341626.21141	204	175
07/18/72	2840	140	170	2064691914.3	414815.01617	359965.16751	201	174
08/01/72	315	190	220	2073183306.3	416428.38065	361833.27375	201	175
08/09/72	540	130	170	2085093310.7	417976.68122	363857.97449	200	175
08/19/72	254	520	320	2088828052.8	419918.74712	365053.09197	201	175
08/21/72	470	89	99	2092283424.4	420226.27519	365395.17376	201	175
08/25/72	234	520	320	2094290480.7	421269.94447	366037.43177	201	175
08/28/72	4899.99	89	99	2136318496.8	425010.43789	370198.20536	199	173

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Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
09/01/72	1540	35	51	2145753376.8	425340.65869	370679.38424	198	173
09/02/72	1020	120	150	2184497650.2	429989.97151	376491.02526	197	172
10/02/72	525	180	200	2218591875.7	436126.93209	383309.87035	197	173
10/25/72	360	360	250	2239324105.5	443590.53482	388492.9278	198	173
11/18/72	35	350	240	2241082424	444205.94632	388914.92425	198	174
12/05/72	10	560	370	2241597053.8	444494.13901	389105.33729	198	174
12/30/72	31	670	450	2243268375.4	445613.92449	389857.43201	199	174
01/18/73	121	400	280	2250978020.2	448697.78241	392016.13255	199	174
02/20/73	38	670	450	2252607681.3	449789.65534	392749.48004	200	174
02/22/73	39	630	410	2253563422.4	450391.77222	393141.33389	200	174
03/12/73	347	240	210	2276948446.4	456004.17798	398052.18893	200	175
04/18/73	259	340	300	2319156668.7	470354.97355	410714.65561	203	177
07/23/73	62	85	9.6	2328272968.3	471129.85902	410802.17208	202	176
08/16/73	20	280	270	2329179697	471383.74306	411046.98884	202	176
08/29/73	0.43	190	180	2329191815.4	471386.04554	411049.17013	202	176
09/08/73	40	140	110	2331250334.6	471674.23824	411275.60725	202	176
10/10/73	8.2	290	260	2331712521.2	471808.27235	411395.77577	202	176
10/24/73	6.6	290	320	2332100699.1	471920.84395	411519.9927	202	176
11/27/73	8.8	290	270	2332564356.1	472055.30447	411645.18008	202	176
12/06/73	12	320	270	2333064282.2	472215.28082	411780.16013	202	176
12/31/73	10	480	400	2333419621.8	472385.84385	411922.29598	202	177
01/04/74	16	290	270	2333890140.5	472522.29427	412049.33603	202	177
01/24/74	19	670	460	2334844656.3	473161.81984	412488.41329	203	177
02/14/74	15.7	570	440	2336691442.2	474214.48778	413300.99907	203	177
04/30/74	12	300	260	2337808924.1	474549.73235	413591.54436	203	177
05/01/74	9.6	290	260	2338291205.7	474689.59403	413716.93759	203	177
06/10/74	28	210	180	2340967280.8	475251.56979	414198.6311	203	177
07/18/74	5.2	230	200	2341368692	475343.89438	414278.91335	203	177
08/12/74	4230	76	70	2724914943.7	504493.40951	441127.15097	185	162
09/30/74	88	480	290	2730521958.1	507184.77642	442753.18514	186	162
10/03/74	49	520	320	2733584005.5	508777.04107	443733.04032	186	162
11/20/74	37	580	360	2737618948.3	511117.30792	445185.61974	187	163
12/31/74	94	680	410	2744068975.4	515503.32632	447830.13083	188	163
01/15/75	29	630	440	2746165479.2	516824.12375	448752.59253	188	163
02/28/75	79	550	320	2751586246.7	519805.54583	450487.2381	189	164
03/12/75	40	730	450	2754281926.7	521773.39223	451700.2941	189	164
04/24/75	12	630	470	2755208260.3	522356.98244	452135.67093	190	164
05/14/75	5.9	320	290	2755475745.3	522442.57763	452213.24157	190	164
05/31/75	91	180	140	2757817311	522864.05945	452541.06076	190	164
06/04/75	22	210	170	2758895583	523090.49657	452724.367	190	164
07/10/75	44	410	280	2763478239	524969.38553	454007.51068	190	164
08/28/75	17	220	170	2764915526.5	525285.5888	454251.84957	190	164
09/17/75	25	220	190	2766385897.4	525609.0704	454531.22004	190	164
10/15/75	16	280	210	2767640614	525960.39102	454794.71051	190	164
11/20/75	27	140	110	2769261697.9	526187.34277	454973.02974	190	164
12/03/75	2.6	260	230	2769548420.2	526261.89057	455038.97588	190	164
02/18/76	21	320	270	2772430347.2	527184.10721	455817.09616	190	164
03/24/76	6.4	300	290	2772924391.8	527332.3206	455960.3691	190	164
04/21/76	143	150	130	2783963201.4	528988.14204	457395.41435	190	164
05/26/76	281	200	130	2806687783.8	533533.05852	460349.61006	190	164
06/26/76	2.6	400	320	2806882117.8	533610.79212	460411.79695	190	164
07/26/76	22	280	170	2807906476.2	533897.61248	460585.93788	190	164
08/03/76	2380	100	80	2994545557	552561.52055	475517.06434	185	159
09/28/76	1370	90	61	3101980658.1	562230.67965	482070.6055	181	155
10/06/76	180	460	280	3110141216.6	565984.53658	484355.5619	182	156
11/04/76	21	790	580	3111762300.5	567265.19288	485295.79057	182	156
12/08/76	26	770	510	3114852530.1	569644.66962	486871.80763	183	156
02/09/77	39	860	500	3120252467.2	574288.61558	489571.77621	184	157
03/31/77	2.2	380	270	3120403425.3	574345.97965	489612.5349	184	157
04/06/77	1.8	360	300	3120555608.7	574400.76567	489658.18991	184	157
06/08/77	5	540	380	3121266288	574784.53247	489928.24804	184	157
07/31/77	6	180	220	3121729454.8	574867.90251	490030.14474	184	157

Discharge, Chloride and Sulfate – Canadian River Near Amarillo, Texas

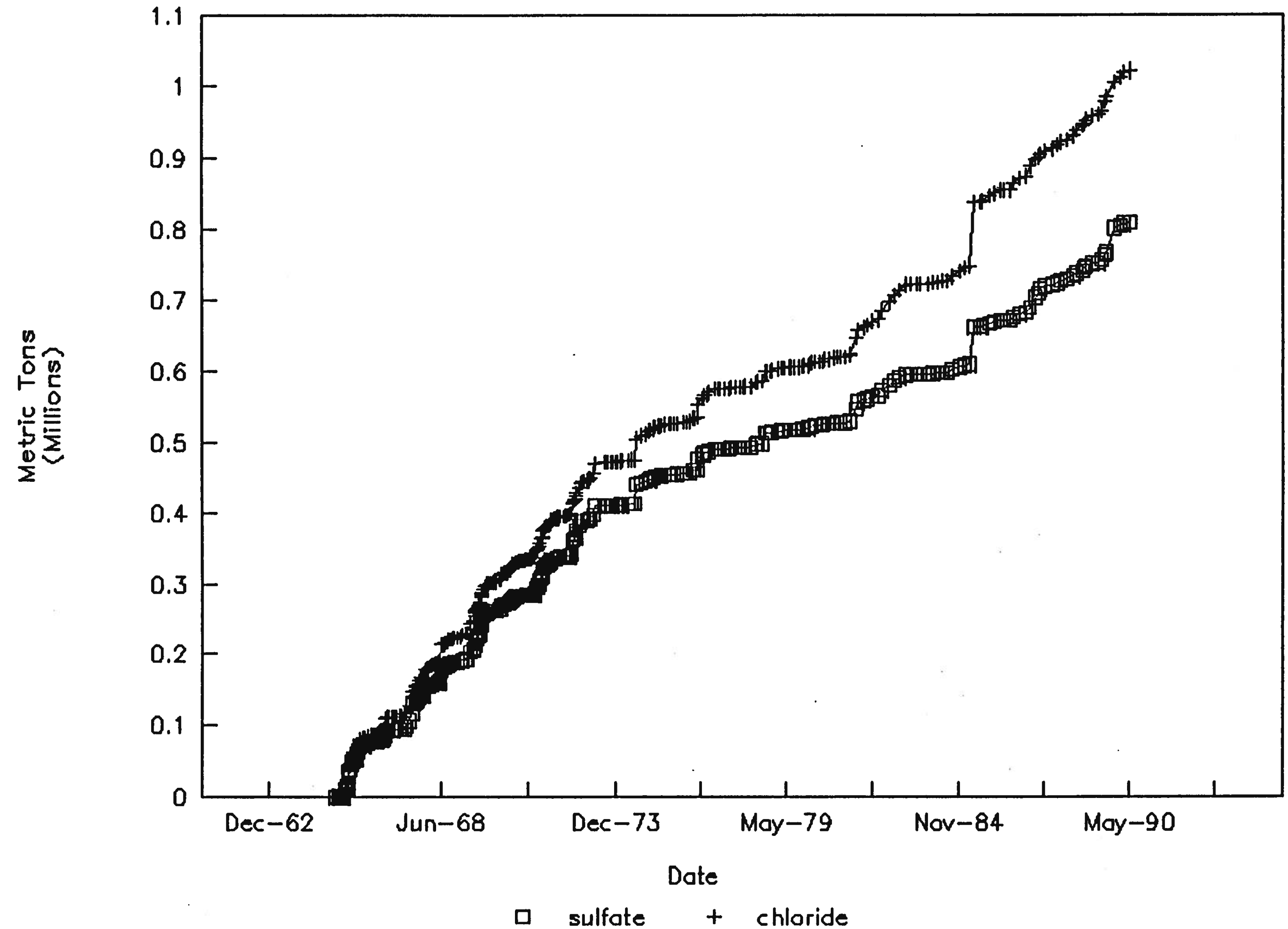
Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
08/10/77	200	130	110	3137903534.8	576970.53291	491809.29354	184	157
10/05/77	1.1	1000	770	3138063927.8	577130.92587	491932.79612	184	157
12/07/77	1.4	700	530	3138221747.6	577241.39973	492016.44062	184	157
01/05/78	4.7	1500	1100	3138590320.5	577794.25919	492421.87089	184	157
02/09/78	3	920	420	3138972617	578145.97192	492582.4354	184	157
04/19/78	0.38	610	390	3139024300.5	578177.49887	492602.59197	184	157
05/31/78	295	250	170	3162881068.5	584141.69087	496658.24253	185	157
06/24/78	20	600	400	3164964094	585391.50615	497491.45272	185	157
08/24/78	2.3	170	220	3165212096.5	585433.66658	497546.01328	185	157
09/20/78	6000	32	36	3584267805.6	598843.44927	512632.01881	167	143
10/20/78	2	730	670	3584441799.5	598970.46481	512748.59471	167	143
11/30/78	8.2	1200	750	3585054699.1	599705.94434	513208.26942	167	143
12/20/78	10	1000	680	3586096211.9	600747.45707	513916.49807	168	143
02/23/79	14	1300	760	3587794490.3	602955.21899	515207.18966	168	144
03/29/79	7.2	1300	1100	3588341468.2	603666.29036	515808.86543	168	144
04/26/79	3.4	1500	820	3588491446.1	603891.25711	515931.84726	168	144
05/04/79	12	1100	760	3589329557.5	604813.17967	516568.81193	169	144
06/22/79	11	540	510	3590502178.3	605446.3949	517166.84854	169	144
07/30/79	1.1	220	140	3590596527.1	605467.15164	517180.05737	169	144
08/31/79	15	150	170	3592269074	605718.03367	517464.39035	169	144
10/29/79	0.84	360	260	3592355531.8	605749.15849	517486.86938	169	144
11/23/79	17.3	830	580	3593457819.9	606664.05757	518126.19645	169	144
12/20/79	14	850	570	3594641468.4	607670.15887	518800.87614	169	144
01/31/80	15	1100	620	3595928043	609085.39087	519598.55236	169	144
02/28/80	78	430	330	3601280193.1	611386.81542	521364.7619	170	145
03/27/80	6.7	950	670	3601748138.6	611831.36368	521678.28541	170	145
04/25/80	26	450	360	3604647219.9	613135.95027	522721.95468	170	145
06/26/80	14	330	200	3606311189.7	613685.06029	523054.74863	170	145
07/31/80	0.03	1300	490	3606313137.9	613687.593	523055.70327	170	145
08/18/80	180	210	140	3621531476.8	616883.44417	525186.27072	170	145
10/08/80	2.55	280	170	3621868927	616977.9302	525243.63724	170	145
12/04/80	18	960	430	3623765705.4	618798.83754	526059.25198	171	145
01/02/81	10.3	1100	700	3624661774	619784.51293	526686.49996	171	145
02/13/81	2.88	860	530	3625025249.7	620097.10202	526879.14207	171	145
04/15/81	0.54	500	340	3625096048	620132.5012	526903.21352	171	145
05/31/81	180	170	120	3637226608	622194.6964	528358.88072	171	145
06/09/81	44	270	190	3641539696	623359.23016	529178.36744	171	145
08/19/81	1730	120	89	3834440106.2	646507.27938	546346.50394	169	142
09/08/81	947	98	92	3941193935.4	656969.15465	556167.85623	167	141
11/19/81	36	1000	490	3946134381.7	661909.6009	558588.6749	168	142
12/29/81	29	1100	520	3949154768.6	665232.0265	560159.27609	168	142
02/12/82	36	900	600	3954536326.1	670075.42828	563388.21061	169	142
04/30/82	27	620	470	3958572494.3	672577.85253	565285.20963	170	143
06/14/82	192	460	250	3987744653.1	685997.04559	572578.24934	172	144
09/01/82	285	240	150	4035237633.5	697395.36088	579702.1964	173	144
10/28/82	280	200	150	4078809624.8	706109.75914	586237.99509	173	144
01/06/83	76	590	300	4092219407.4	714021.53092	590260.9299	174	144
03/21/83	109	480	270	4108112891.7	721650.40335	594552.17064	176	145
05/05/83	15	850	530	4110465485.1	723650.10778	595799.04517	176	145
07/27/83	0.03	480	220	4110469896.2	723652.22512	595800.01561	176	145
09/02/83	0.09	71	34	4110482798.7	723653.1412	595800.4543	176	145
11/21/83	2.7	430	320	4110965815.6	723860.83844	595955.01969	176	145
01/26/84	12	440	340	4112759668.1	724650.13354	596564.92954	176	145
03/22/84	17	270	210	4114946844.8	725240.67126	597024.23665	176	145
05/10/84	12	1100	670	4116652475.1	727116.86454	598167.00892	177	145
07/16/84	1.1	1000	500	4116789954.7	727254.34422	598235.74876	177	145
08/20/84	136	330	200	4138120135.4	734293.30384	602501.78489	177	146
11/21/84	40	760	380	4145815076.5	740141.45906	605425.86251	179	146
01/24/85	30	1100	540	4149968874.3	744710.63666	607668.91333	179	146
03/14/85	29	950	510	4154197416	748727.75125	609825.46958	180	147
05/23/85	1680	320	190	4427980479.3	836338.3315	661844.2516	189	149
07/25/85	55	83	110	4434180543.3	836852.93681	662526.25864	189	149
08/23/85	12	860	470	4435842062.4	838281.84326	663307.17263	189	150

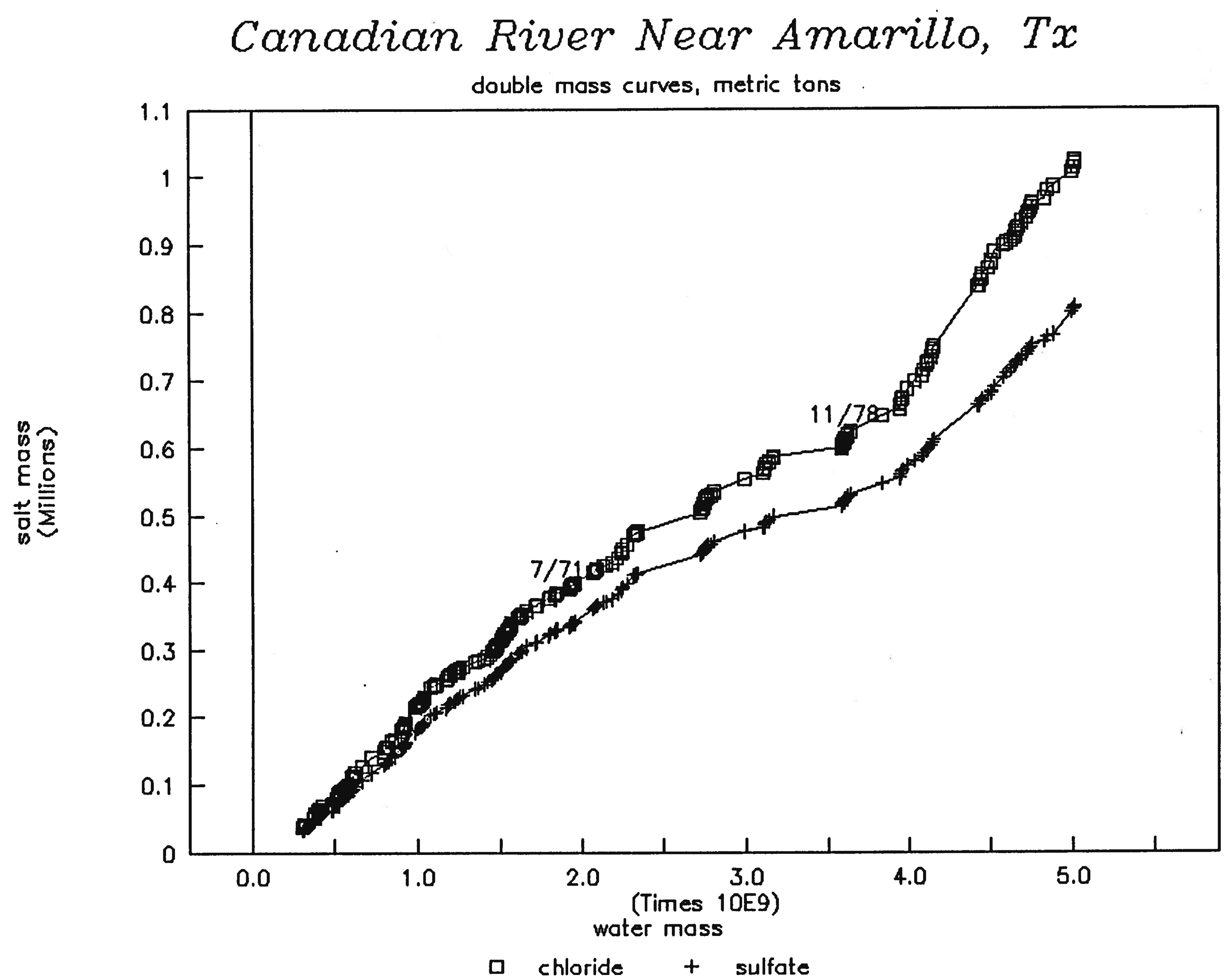
Discharge, Chloride and Sulfate – Canadian River Near Amarillo, Texas

Date	Q CFS	Cl mg/l	SO4 mg/l	Accum. Volume Mt	Accum. Cl Mass Mt	Accum. SO4 Mass Mt	Accum. Cl conc. ppm	Accum. SO4 conc. ppm
11/15/85	47	840	400	4444307722.9	845392.99809	666693.43684	190	150
01/17/86	29	970	550	4448785002.3	849735.95913	669155.94052	191	150
03/21/86	28	1100	600	4452627571.6	853962.78537	671461.4821	192	151
05/09/86	0.38	440	240	4452684376.9	853987.77971	671475.11538	192	151
07/21/86	0.1	800	520	4452697732.8	853998.46441	671482.06043	192	151
08/26/86	235	330	150	4485235815.7	864736.03177	676362.77287	193	151
11/11/86	141	300	180	4508214037.1	871629.49818	680498.85272	193	151
01/06/87	17	890	510	4510547025.6	873705.85795	681688.67686	194	151
03/03/87	118	770	410	4528764921.2	887733.63754	689158.01404	196	152
05/12/87	425	190	280	4580840557.5	897628.00845	703739.19222	196	154
06/11/87	333	140	240	4603690121.5	900826.9474	709223.08756	196	154
07/07/87	260	160	260	4627583648.7	904649.91176	715435.40466	195	155
08/25/87	123	220	200	4649738462.4	909523.97077	719866.36739	196	155
12/01/87	22	940	470	4653916766.4	913451.57653	721830.17027	196	155
01/27/88	37.8	930	480	4658455801.4	917672.87907	724008.90707	197	155
03/08/88	74.8	360	300	4667437807.2	920906.40115	726703.5088	197	156
05/04/88	25	930	540	4671511959.9	924695.36318	728903.55127	198	156
07/19/88	142	400	230	4690825281.8	932420.69194	733345.6153	199	156
08/23/88	206	200	130	4720862508.8	938428.13735	737250.45482	199	156
11/15/88	49	940	560	4726746443.1	943959.03555	740545.458	200	157
11/29/88	324	180	300	4740641448.2	946460.13647	744713.95953	200	157
12/20/88	45	1100	510	4746100200.2	952464.76367	747497.92305	201	157
03/08/89	40	870	480	4753010943.5	958477.11031	750815.07982	202	158
05/10/89	8.1	1000	700	4753983593.8	959449.76067	751495.93507	202	158
06/14/89	880	83	73	4828384361.8	965625.02441	756927.19114	200	157
07/18/89	260	610	280	4848136344.4	977673.73377	762457.74625	202	157
08/15/89	273	160	99	4887942960.8	984042.7924	766398.60128	201	157
11/14/89	546	190	310	4995654981.7	1004508.07638	799789.32777	201	160
01/23/90	65	720	410	5005132747.6	1011332.06777	803675.21175	202	161
03/13/90	68	780	370	5014464701.6	1018610.99191	807128.03475	203	161
05/15/90	14	1100	630	5017226548.3	1021649.02327	808867.99816	204	161
08/21/90	192	240	170					
averages	363.2	403.9	294.3				199.1	169.1

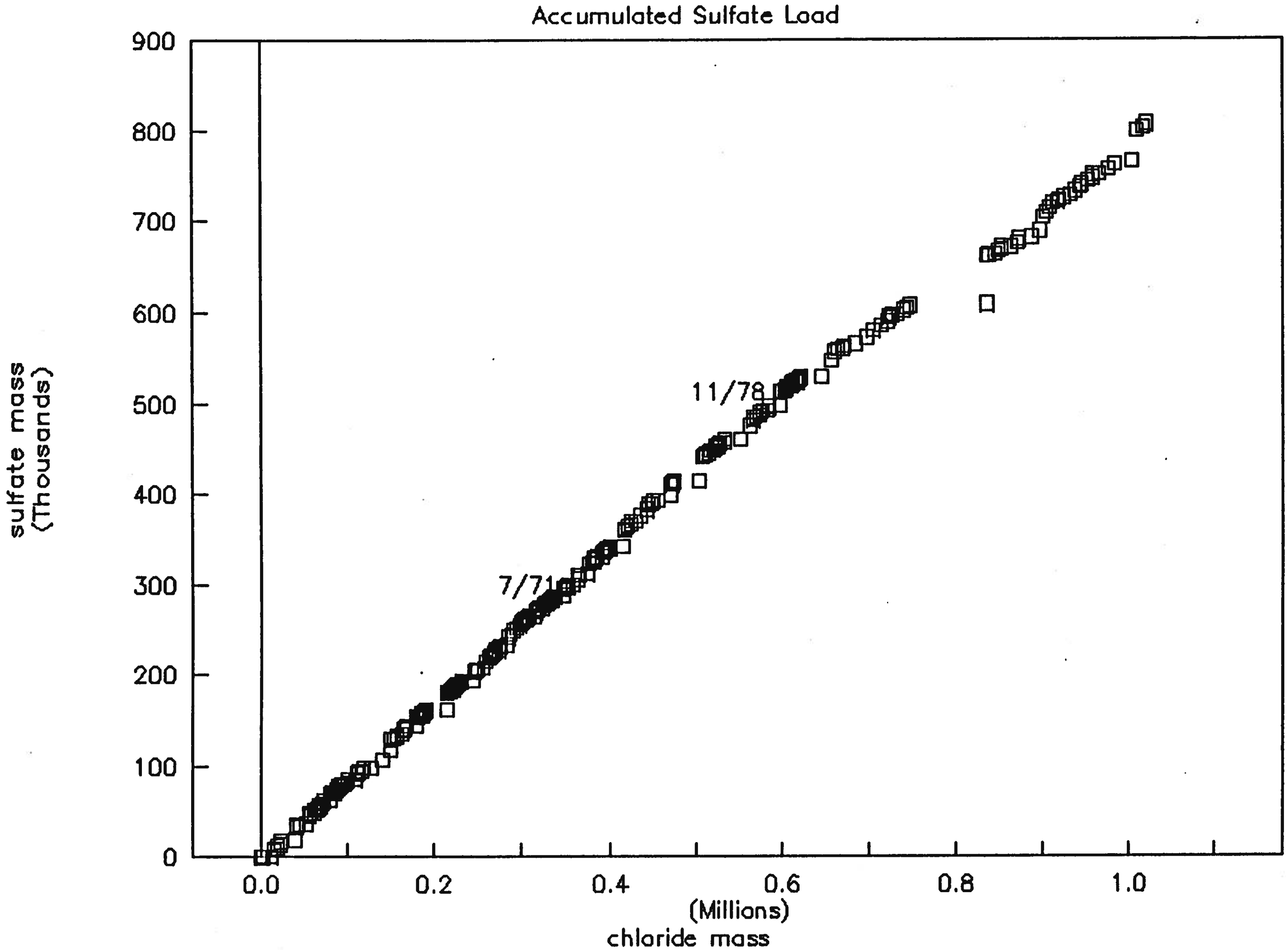
Canadian River Near Amarillo, Tx

Accumulated salt load




Canadian River Near Amarillo, Tx
double mass curves, metric tons
salt mass (Millions)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
1.0
2.0
3.0
4.0
5.0
(Times 10E9)
water mass
7/71
11/78
chloride
+ sulfate

Canadian River Near Amarillo, Tx



Texas Water Quality Board Survey of Canadian River, November, 1969 through January, 1970

Part 1: Ute Dam to Mile 0.5

STATION	Ute Lake	Ute Lake	Ute Lake	Spring wtr fm spl chnl	Seepage fm seepage gal behind dam	Seepage below dam	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R 1/2 mile
LOCATION	N side, 50 yds ab spl		S side, nr dam & park	(taken blw dam)			directly below dam	300 yards below dam	1/4 mile below dam	500 yards below dam	500 yards below dam	500 yards below dam	below Ute Lake
RIVER MILE	–	–	–	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.5
SAMPLE DATE	11-25-69	12-22-69	01-28-70	11-25-69	12-22-69	12-22-69	11-25-69	11-25-69	11-25-69	11-25-69	12-22-69	01-28-70	11-25-69
FLOW, cfs							3.3	3	3	3	7	9.05	
FIELD ANALYSES (mg/l, unless noted)													
Ammonia													
Chloride			25	40			3600	2520	3500	3000			
Chlorine													
Hardness, Total (CaCO3)				290			298	550	593	630		2550	
Oxygen, dissolved											6.0	5.0	
pH, pH units		8.65		8.2		8.5	7.7	7.8	8.1	7.9	8.5		
Phosphate, –Ortho				0			0	0.1	0	0			
Sodium				86			1125	1900	1950	2075			
Sulfate				186			140	220	240	240			
Temperature, F.												49	
Turbidity, JTU		49	30			??					15	5.0	
LAB ANALYSES, (mg/l, unless noted)													
Alkalinity, Methyl Orange (CaCO3)	112												
Alkalinity, Phenolpthalein (CaCO3)	0	0			0	0					0		0
Alkalinity, Total (CaCO3)		126			232	230					382		373
Aluminum	0	insuf samp											
Ammonia	0												
Bicarbonate					283								455
BOD, 5-Day		<0.5	2.0			2.5	2.5		2.0	1.5	1.0	1.0	
Calcium		32			36	40					164		150
Calcium (as CaCO3)	60.2		85									250	
Carbonate					0								0
Chloride	20	18	18		55	61					3430	2550	2980
Conductivity, umhos/cm		525	564			1008	5824		11760	12320	13608	10251	
Fluoride	0.58	0.7			0.8	0.9					1.2		1.3
Hardness, Total (CaCO3)	114.7	103			212	218					680		620
Iron	0	0.55			<0.02	0.06					0.40		<0.02
Magnesium		3			29	14							61

Texas Water Quality Board Survey of Canadian River, November, 1969 through January, 1970

Part 1: Ute Dam to Mile 0.5

STATION	Ute Lake	Ute Lake	Ute Lake	Spring wtr fm spl chnl	Seepage fm seepage gal	Seepage below dam	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R
LOCATION	N side, 50 yds ab spl		S side, nr dam & park	(taken blw dam)	behind dam		directly below dam	300 yards below dam	1/4 mile below dam	500 yards below dam	500 yards below dam	500 yards below dam	1/2 mile below Ute Lake
RIVER MILE	–	–	–	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.3	0.3	0.5
SAMPLE DATE	11–25–69	12–22–69	01–28–70	11–25–69	12–22–69	12–22–69	11–25–69	11–25–69	11–25–69	11–25–69	12–22–69	01–28–70	11–25–69
LAB ANALYSES,CONT.(mg/l,unless noted)													
Magnesium (as CaCO3)	54.5										65		
Manganese	0.018	<0.05			<0.05	<0.05					<0.05		<0.05
Ammonia (as NH4)	0					4							
NH3–Nitrogen		<1.0	<1.0			<1.0					<1.0	<1.0	
Nitrate (as NO3)	0.02				<0.4								<0.4
NO2–Nitrogen		<0.05	<0.03			<0.05					<0.05	<0.05	
NO3–Nitrogen		<0.3	<0.3			<0.3					<0.3	<0.3	
pH, pH units	8.3	8.2	8.2		8.0	8.0	8.3		8.2	8.2	8.2	8.1	8.0
Phosphate, Ortho–	0.15	<0.2	<0.2			<0.2					<0.2	<0.2	
Phosphate, Total	--												
Potassium	--	3.5				3.0					11.5		
Silica	--	5				10					10		
Sodium	54	65	68		117	115					2350	1740	2020
Solids, Total Suspended		15	<10			<10	43		38	48	15	<10	
Solids, Fixed Suspended		10					38		36	46	9		
Solids, Volatile Suspended		5					5		2	2	6		
Sulfate	90	96	104		140	151					560	495	520
Total dissolved solids					660								6200
Comments							Low Conductance					High Hardness	

Texas Water Quality Board Survey of Canadian River, November, 1969 through January, 1970

Part 2: Mile 2.2 to mile 70, and tributaries

STATION	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Revuelto Creek	Punta de Agua Creek	Punta de Agua Creek	Pitcher Crk	E Amarillo Creek	E Amarillo Creek	E Amarillo Creek
LOCATION	under bridge '1 mile below dam'	at Hwy 54	Pyle Ranch NM	Shelton Rch TX	Fulton Rch TX	Fulton Rch TX	Bridge at Tascosa Boys Ranch	at Hwy 39	under Hwy 54 bridge	at FM 767 bridge	Fain Ranch Lat 35 28' Lon 101 53'	at AT&SF RR	at Hwy 87–287	directly blw North STP
RIVER MILE	2.2	2.2	18.5	34	55.5	55.5	70							
SAMPLE DATE	11–25–69	11–25–69	12–22–69	01–28–70	11–25–69	01–28–70	01–28–70	12–22–69	11–25–69	11–25–69	12–15–69	12–15–69	12–15–69	12–15–69
FLOW, cfs	3		29	14.29	30	17.76	36.92			8	0.47	14	14	14
FIELD ANALYSES (mg/l, unless noted)														
Ammonia									0.15					
Chloride				1900	930	1250	1000		27	34				
Chlorine														0.06
Hardness, Total (CaCO3)					486				218	233				
Oxygen, dissolved			3.0	8.0							60	11	5	7
pH, pH units			8.5		8.3				7.5	8.6	8.5	8.5	8.5	8.4
Phosphate, –Ortho					0				0.25	0				
Sodium					620				--	56				
Sulfate					180				12	58				
Temperature, F.			50		51					51	40	36	35	58
Turbidity, JTU			80	35		20	30				5	41	40	35
LAB ANALYSES, (mg/l, unless noted)														
Alkalinity, Methyl Orange (CaCO3)	370													
Alkalinity, Phenolpthalein (CaCO3)	0	0	0					0						
Alkalinity, Total (CaCO3)		341	274					235						
Aluminum	0													
Ammonia	0													
Bicarbonate		416						287						
BOD, 5–Day			<0.5	1.0	2.0	1.0	2.0			3.0	2.0	28	30	8.5
Calcium	530	145	152					80						
Calcium (as CaCO3)				280		300	230							
Carbonate		0						0						
Chloride	3400	3290	2880	1840		1240	910	151			6	326	400	301
Conductivity, umhos/cm			11760	8188	4394	5688	4472			712	444	2560	2720	2368
Fluoride	1.0	1.3	1.2					1.1						
Hardness, Total (CaCO3)	635	640	730					405						
Iron	0	0.06	1.20					<0.02						
Magnesium		68	85					50						

Texas Water Quality Board Survey of Canadian River, November, 1969 through January, 1970

Part 2: Mile 2.2 to mile 70, and tributaries

STATION	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Canadian R	Revuelto Creek	Punta de Agua Creek	Punta de Agua Creek	Pitcher Crk	E Amarillo Creek	E Amarillo Creek	E Amarillo Creek
LOCATION	under bridge "1 mile below dam"	at Hwy 54	Pyle Ranch NM	Shelton Rch TX	Fulton Rch TX	Fulton Rch TX	Bridge at Tascosa Boys Ranch	at Hwy 39	under Hwy 54 bridge	at FM 767 bridge	Fain Ranch Lat 35 28' Lon 101 53'	at AT&SF RR	at Hwy 87–287	directly blw North STP
RIVER MILE	2.2	2.2	18.5	34	55.5	55.5	70							
SAMPLE DATE	11–25–69	11–25–69	12–22–69	01–28–70	11–25–69	01–28–70	01–28–70	12–22–69	11–25–69	11–25–69	12–15–69	12–15–69	12–15–69	12–15–69
LAB ANALYSES,CONT.(mg/l,unless noted)														
Magnesium (as CaCO3)	105													
Manganese	0	<0.05	<0.05					<0.05						
Ammonia (as NH4)														
NH3–Nitrogen			<1.0	<1.0		<1.0	<1.0				<1.0	18.4	20.2	21.4
Nitrate (as NO3)	0	<0.4						<0.4						
NO2–Nitrogen			<0.05	<0.05		<0.05	<0.05				<0.05	1.23	2.50	0.14
NO3–Nitrogen			<0.3	<0.3		<0.3	<0.3				<0.3	1.6		<0.3
pH, pH units	8.1	7.8	8.1	8.0		8.1	8.1	8.2		8.6	8.0	7.9	7.8	7.6
Phosphate, Ortho–	0		0.2	<0.2		<0.2	<0.2				<0.2	25	27	34
Phosphate, Total	--													
Potassium	--		11.0											
Silica	--		8											
Sodium	2175	2280	1900	1280		840	670	356			21	309	364	288
Solids, Total Suspended			110	58	106	25	36	1620		69	<10	20	18	20
Solids, Fixed Suspended			95	19	94	19	29			59		13	10	8
Solids, Volatile Suspended			15	39	12	6	7			10		7	8	12
Sulfate	265	520	540	125		540	442	690			16	312	254	266
Total dissolved solids		6700												
Comments	Decline in Flow													

NOTES

Some of the analyses listed here do not appear in the report text or tables; it is not clear if they were originally part of the report Appendix. Because the samples were taken on the same dates and by the same entities as those reported in the text and tables, they have been included.

The following analyses may have been missing from the copy of the report in CRMWA files: 12/22/69 samples from Canadian River at Fulton Ranch, Shelton Ranch and Tascosa Boys Ranch, and from Revuelto Creek; also 1/28/70 sample of seepage from Ute Reservoir. A map showing the locations of sampling, mentioned in the report text, also was missing from the CRMWA file copy. Some of the analyses values are illegible.

Some river mile designations are approximate because detailed location descriptions are not available for all sampling locations. First bridge over Canadian is about 2.2 river miles below dam.

The individual analysis reports do not always provide units for parameters measured. Units reported in other analyses have been assumed to apply; if no units are reported on any of the analyses, we have used units typically reported in 1970's vintage studies.

Discharge reported in units other than cfs was converted to cfs. Discharge at some sampling stations was estimated rather than gauged.

Surface water samples collected in Ashby Lewis Canadian River Survey, 01/29/73 and 03/01/73

SAMPLE IDENTIFICATION	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	S10	S16?	S9	N5	N2	S1	N1
PHOTO	11	13	15	17	19	21	23	24	27	29	32	34	2	9	10	24	32	34	35
RIVER MILE	28	31	34	38	41	45	48.5	51.5	55.5	58	63	66							
NAME			Shelton Ranch						Fulton Ranch				Revuelto Creek		Rano Canyon	Antelope Creek	Punta de Agua Creek	Alamosa Creek	East Cheyenne Creek
PARAMETERS (mg/l, unless noted)																			
Alkalinity, M. (as CaCO3)	258	252	248	236	190	198	184	192	183	174	256	230	244	196	248	210	298	346	184
Alkalinity, P. (as CaCO3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Bicarbonate	315	307	300	288	231	241	224	234	223	212	312	280	298	239	302	256	354	422	224
Calcium (as CaCO3)	308	320	312	312	304	312	292	316	312	288	248	216	80	44	56	110	66	64	100
Chloride	2150	1850	1900	2350	2350	1650	1750	1350	1250	1300	650	700	210	130	65	25	40	235	25
Fluoride	1.10	1.10	1.70	1.90	2.10	1.90	1.15	1.70	1.10	0.70	2.04	2.25	1.01	0.90	1.03	0.70	4.08	0.70	1.54
Hardness, Total (as CaCO3)	620	572	596	616	576	588	572	588	564	528	448	428	364	174	118	204	282	178	172
Iron	0	0.01	0.04	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.14	0.04	0.04	0.07	0.01	0.23	0.04	0	0
Magnesium (as CaCO3)	312	252	284	304	272	276	280	272	252	240	200	212	284	130	62	94	216	114	72
Manganese	0.01	0.01	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0
pH (pH units)	7.92	7.94	8.16	8.17	7.97	8.01	8.0	8.03	8.09	7.96	7.96	7.89	8.27	8.17	8.18	8.18	8.40	8.15	7.94
Sodium	1465	1300	1330	1530	1100	980	879	840	726	700	462	532	376	110	168	37	68	342	26
Specific Conductance (umhos/cm)	7000	7000	7100	7500	6100	6000	5100	5000	5000	4100	2700	3200	2600	780	950	510	790	2000	500
Sulfate	555	535	455	545	545	530	485	485	470	485	355	365	90	230	130	130	320	90	580
Total Dissolved Solids, Calculated	5106	4565	4583	5339	4804	3991	3236	3499	3234	3226	2229	2307	1340	884	784	653	1076	1268	1029

NOTES

Sampling points listed in downstream order from Ute Lake. Samples with an R prefix collected in river and listed first. Those with an N prefix collected in a tributary entering river from north; those with an S prefix collected in a tributary entering river from south. Tributary samples listed second.

Some river mile designations are approximate, based on large–scale maps; they may be changed as small–scale maps become available.

Sampling point identified on this table of analyses as "S–16?" was not located on accompanying aerial photographs; however, there are two S–17 stations marked on photographs and only one S–17 analysis. Ashby Lewis indicated October 15, 1991 that "S–17" marked on photo number 9 probably is the location where the sample reported as S–16 was taken.

Seventeen soil sample extracts from tributaries were analyzed for Na, Cl, SO4, and NaCl; they are not reported here.

Surface water samples collected by Ashby Lewis Canadian River Survey, 01/29/73 and 03/01/73

SAMPLE IDENTIFICATION	L1	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R18	R17	R16	R15	R14	R13	R13A
PHOTO	1	1	1	1	1	1	1	1	1	1	1	1	2	3	5	6	8	10	10
RIVER MILE		0.0	0.3	0.4	0.6	1.0	1.3	1.4	1.6	1.7	2.0	2.2	4.9	9.1	15.0	18.5	21	25	25.5
NAME	Ute Lake															Pyle Ranch			
PARAMETERS (mg/l, unless noted)																			
Alkalinity, M. (as CaCO3)	152	284	344	346	356	350	362	368	350	354	344	342	366	332	284	272	262	262	252
Alkalinity, P. (as CaCO3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonate	185	346	419	422	434	427	441	449	427	432	420	417	446	405	346	332	320	320	307
Calcium (as CaCO3)	60	144	244	364	324	284	264	228	224	280	252	350	248	256	320	300	244	296	126
Chloride	35	1250	2150	2700	2800	2750	3300	3450	3600	3800	3550	3400	4750	3100	2700	2550	2300	2000	2200
Fluoride	1.01	2.08	1.80	2.40	1.96	3.0	3.0	2.12	2.08	2.12	3.0	2.24	1.50	1.10	1.44	0.70	1.10	2.10	1.2
Hardness, Total (as CaCO3)	124	292	472	600	612	580	652	588	640	628	620	648	800	652	660	652	624	588	470
Iron	0.02	0.28	0.25	0.29	0.32	0.47	0.31	0.29	0.26	0.28	0.25	0.26	0.43	0.38	0.03	0.10	0.03	0	0.10
Magnesium (as CaCO3)	64	148	228	236	288	296	388	360	416	348	368	298	552	396	340	352	380	292	344
Manganese	0	0	0	0	0	0	0.01	0.02	0.04	0.01	0.01	0	0	0	0	0	0	0.04	0
pH (pH units)	8.03	7.93	7.76	7.96	8.04	7.92	8.06	8.16	8.14	8.10	8.21	8.08	7.96	7.92	7.96	7.93	8.0	7.96	7.85
Sodium	79	610	1104	1620	1630	1610	3250	2300	2220	2500	2300	2500	2100	3400	1620	1450	2395	1375	2395
Specific Conductance (umhos/cm)	600	3100	7000	9860	9600	9800	10500	10000	11000	11600	10800	10500	14200	10400	8500	7800	7800	7500	7500
Sulfate	128	290	480	550	520	520	550	580	620	640	640	580	740	900	1380	740	660	565	290
Total Dissolved Solids, Calculated	552	2790	4627	5895	5998	4441	8196	7579	7509	8002	7533	7548	8838	8458	6707	5725	6300	4850	5663
							Note 1						Note 2	Note 3					Note 4

Note 1. High sodium
Note 2. High magnesium, chloride
Note 3. High sulfate
Note 4. Low calcium, hardness, sulfate

Documents obtained from USBR files

The search of USBR files (Oklahoma City) has not yet been conducted. The following page is copied from a USBR file report provided by CRMWA.

August 5, 1975

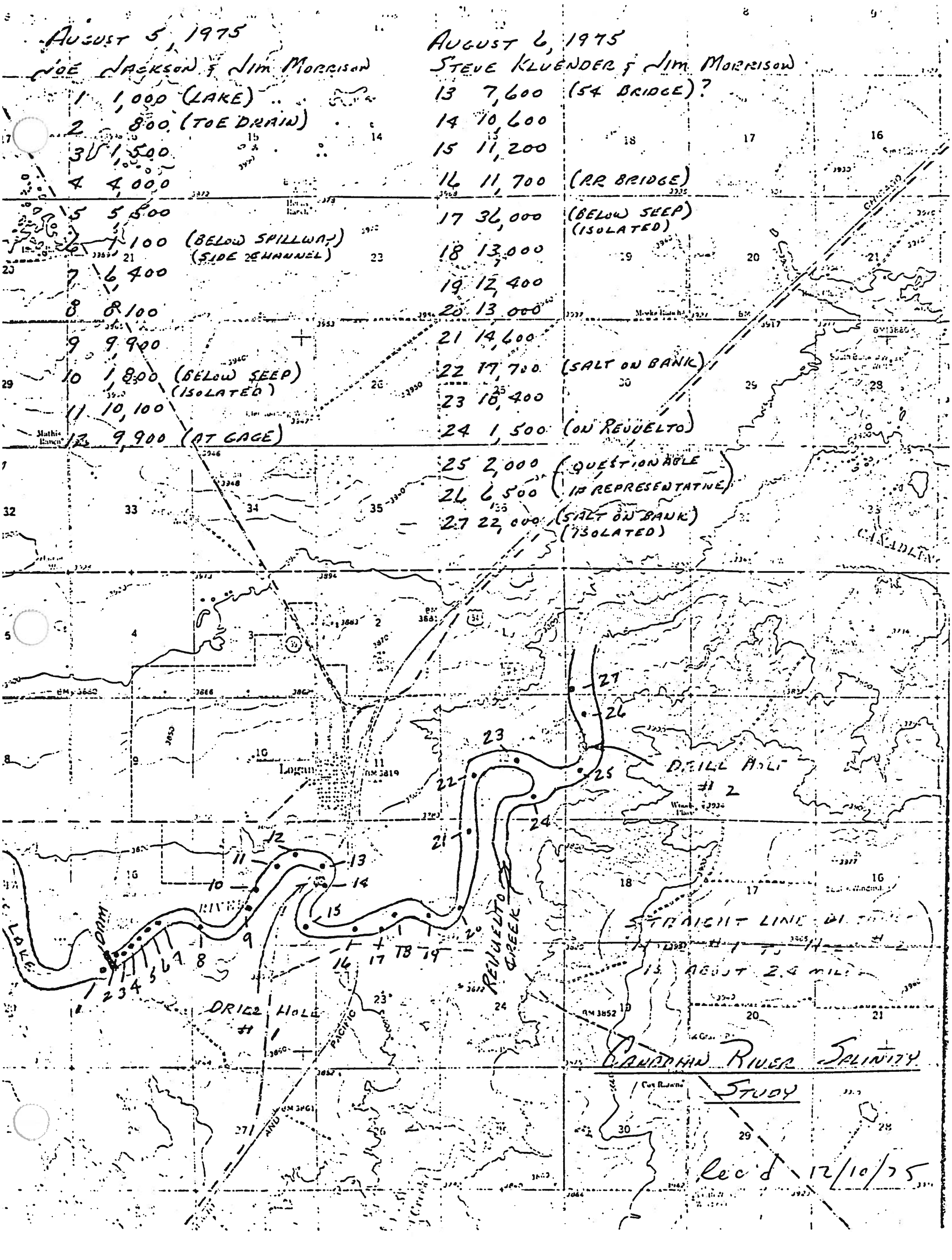
Joe Jackson & Jim Morrison

1 1,000 (LAKE)
2 800 (TOE DRAIN)
3 1,500
4 4,000
5 5,500
6 1,100 (BELOW SPILLWAY) (SIDE CHANNEL)
7 6,400
8 8,100
9 9,900
10 1,800 (BELOW SEEP) (ISOLATED)
11 10,100
12 9,900 (AT GAGE)

August 6, 1975

Steve Kluender & Jim Morrison

13 7,600 (54 BRIDGE)?
14 10,600
15 11,200
16 11,700 (RR BRIDGE)
17 36,000 (BELOW SEEP) (ISOLATED)
18 13,000
19 12,400
20 13,000
21 14,600
22 17,700 (SALT ON BANK)
23 10,400
24 1,500 (ON REVUELTO)
25 2,000 (QUESTIONABLE IF REPRESENTATIVE)
26 6,500
27 22,000 (SALT ON BANK) (ISOLATED)



Canadian River Salinity Study

Rec'd 12/10/75

Results of water quality determinations, Canadian River water between Ute Dam and Revuelto Creek, Oct. 19 and 20 1983. HGC (1984), Table B.2.

Sample	Distance from Ute Dam (miles)	Date	TDS mgl	Cl mg/l	Br mg/l	LWA COMMENTS
1	0.2	10-20-83	1350	570	0.56	
2	0.5	10-20-83	2580	1080		
3	0.8	10-20-83	3850	1720	0.59	
4	1.1	10-20-83	4130	2150		
5	1.5	10-20-83	5050	2550	0.69	
6	1.9	10-19-83	6450	3250		STEADY INCREASE TO THIS POINT
7	2.2	10-19-83	6150	3300	0.6	
8	2.4	10-20-83	5380	2760		
9	2.6	10-19-83	6730	3370	0.71	
10	2.9	10-20-83	5550	2880		
11	3	10-19-83	7250	3654		INCREASE BEGINS AGAIN
12	3.2	10-20-83	6000	3110	0.37	
13	3.5	10-19-83	7650	3860		
14	3.7	10-20-83	8230	4280		
15	3.9	10-19-83	9030	4660	0.5	STEADY INCREASE TO THIS POINT
16	4	10-20-83	9150	4760		
17	4.3	10-19-83	9350	4860		
18	4.6	10-20-93	9350	4900	0.6	
19	4.9	10-20-83	9750	5105		INCREASE BEGINS AGAIN
20	5.3	10-20-83	10400	5500	0.67	
21	5.6	10-20-83	10600	5560		
[illegible]	5.9	10-19-83	11400	5910		
[illegible]	5.95	10-20-83	10700	5620	0.52	

Results of water quality determinations, Canadian River water between Ute Dam and Dunes damsites, Jan. 4 and 5, 1984
HGC (1984), Table B.3

Sample	Distance from Ute Dam (miles)	Temp (C)	Sp. Cond. umphos (25)	TDS mg/l	Cl mg/l	Br mg/l	HGC COMMENTS (LWA COMMENTS)
1	0	14	1950	1230	330	0.39	(Low chloride)
2	0.13	10	3557				
3	0.26	8.3	3979				
4	0.37	5	967				Seep on N. canyon wall
5	0.48	4	4466				
6	0.6	13.6	10492	2420	900	0.49	(TDS and K don't match)
7	0.66	16.5	13735				Brine pool.
8	0.72	13	18160				River bends to SE
9	0.86	12.8	21160				
10	0.92	6.9	9560				
11	0.95	6.9	9560				
12	1.08	4.9	8696				River bends to NE.
13	1.17	3	10180				
14	1.2	3	11070				
15	1.26	2.2	11213				
16	1.37	2.7	10650				
17	1.44	2.2	11210	5740	3060	0.73	
18	1.51	3	10710				Site 1.
19	1.61	3	10710				
20	1.69	3.2	10280				
21	1.9	3	10710				USGS gage.
22	1.97	3	10180				Hiway 54.
23	2.01	3.2	10280				
24	2.13	3.1	8720				River bends to SSW
25	2.42	3	9460	6110	6020	0.75	(Chloride, TDS don't match)
26	2.57	3.2	10990				
27	2.65	3.3	11310				River bends to E.
28	2.71	3.5	11230				
29	2.76	3	10890				
30	2.99	1.2	12980				
31	3.1	1.6	13160				
32	3.12	1.2	14120				RR bridge.
33	3.24	3	12860				
34	3.36	2.7	14080				
35	3.51	2.5	16000	8740	4600	1.01	
36	3.63	1.8	15860				
37	3.81	2.9	15050				
38	3.92	2.9	16130				
39	4.01	3.9	15220				
40	4.07	1.1	15520				
41	4.1	1	15960				River bends to N.
42	4.39	1	13460				
43	4.62	1	16150				
44	4.74	1.4	17050				
45	4.89	2	16480				
46	5.03	2.2	18380				
47	5.11	2.2	18570				
48	5.21	3.5	12110				
49	5.36	4	19140	11400		0.85	
50	5.44	5.7	18400				
51	5.64	2.4	19340				Site 3.
52	5.74	3.9	16960				
53	5.93	3.8	18750				
54	6.14	3	19460				
55	6.24	3.8	19620				
56	6.33	4	19660	11000	5940	0.88	

Results of water quality determinations, Canadian River water between Ute Dam and Revuelto Creek, Jan. 31 and Feb. 1, 1984
HGC (1984), Table B.4

Sample	Distance from Ute Dam (mile	Temp (C)	Sp. Cond. umhos (25)	TDS mg/l	Cl mg/l	Br mg/l	LWA COMMENTS
1	0	15	1860	1175	340	0.25	
2	0.13	10.3	3540				
3	0.37	9	3460				(Dift pattern than early Jan.)
4	0.48	11.3	4270				
5	0.66	10.2	4400				(Why dift than next line?)
6	0.66	10.2	18500	4525	2200	0.63	(TDS, SC don't match)
7	0.72	8	5880				
8	0.92	6	5650				(Why dift than next line?)
9	0.92	6	19400				
10	0.95	4	6200	3275	1450	0.49	
11	1.1	5	6900				(Why dift than next line?)
12	1.1	5	50000				
13	1.2	3.5	7360				(Why dift than next line?)
14	1.2	3.5	61400				
15	1.25	3.5	7540	5750	2840	0.49	
16	1.26	2.5	8730				
17	1.4	3.5	11600	5000	2410	0.51	
18	1.5	5	10800				
19	1.8	3.8	10400				
20	2	4.5	10200	6150	2950	0.62	
21	2.1	3.7	10300				
22	2.7	5.9	11000				
23	3	4.7	11400	6800			
24	3.1	7.2	61300	30400	16900	2.27	
25	3.4	5.1	13300	7880	4010	0.69	
26	3.6	5.2	15200				
27	3.9	10	61400				
28	4	5.6	15200				
29	4.1	3.3	14700				
30	4.2	3.8	15600				
31	4.4	4.2	14700				
32	4.6	5	15800				
33	4.8	7.5	16200				
34	5.3	7.9	18800	11400	6000	1.05	
35	5.6	8.1	19500				
36	6	8	19100	11600	5910	0.7	
37	115	12.8	5400	3420	1450	0.41	
38	148	10.9	3480	2275	810	0.48	

Figure 37

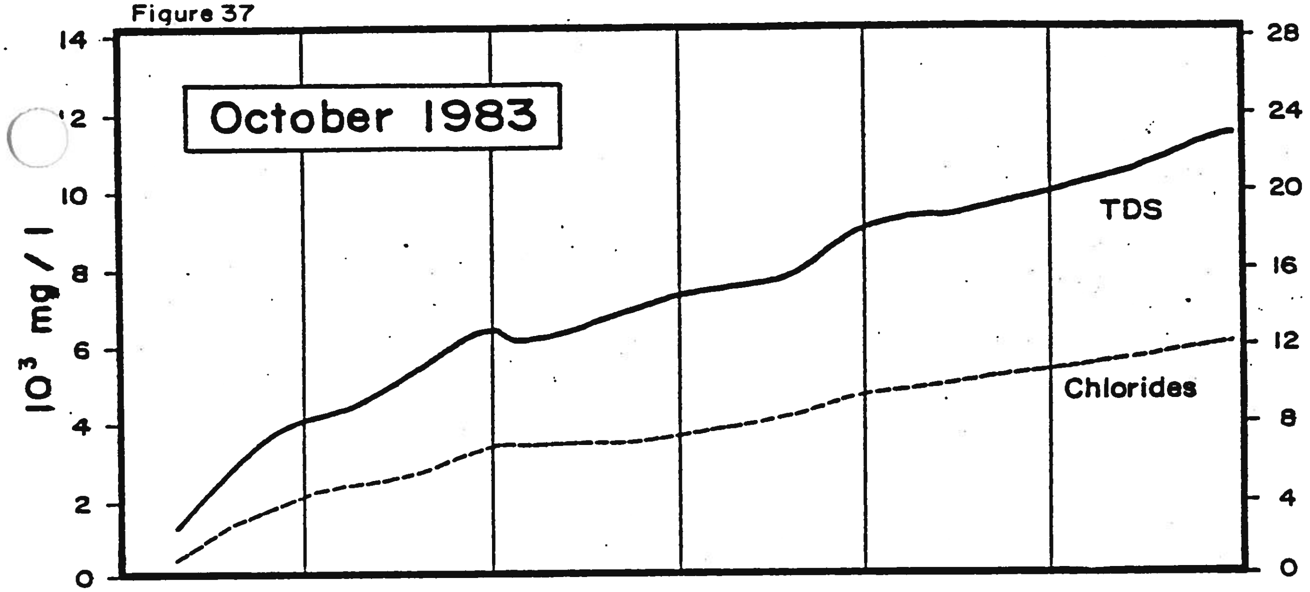


Figure 38

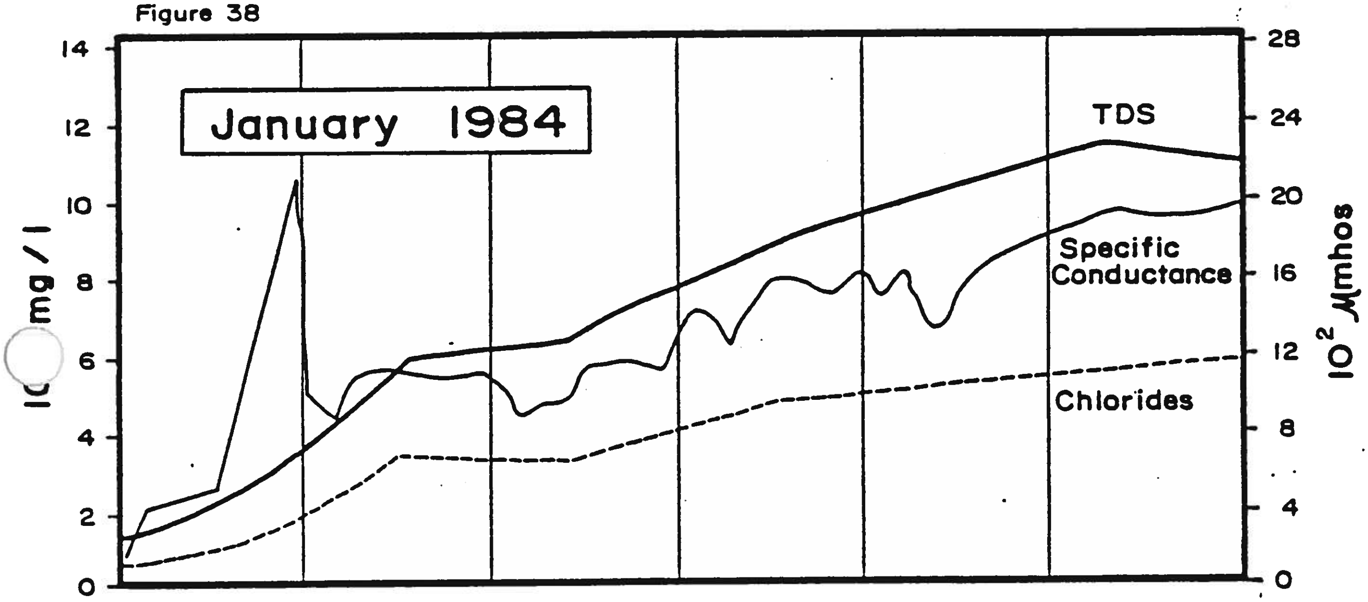
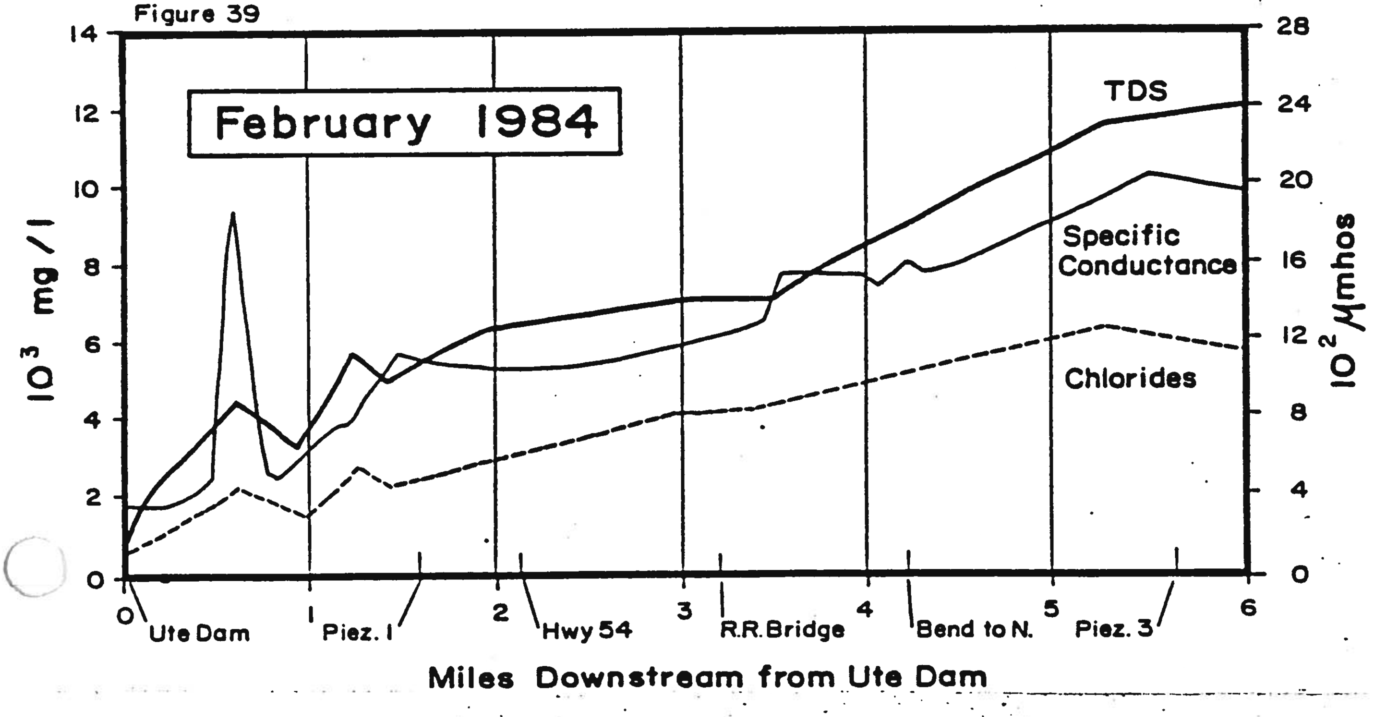


Figure 39



Water Quality Analyses, USBR (1984)

SITE 1 River (Mile 1.6): Table 4.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.	Flow (cfs)
05-13-83	2024				2320				5828			9500		
05-23-83	1984	53.4	131.3	10.2	2880				5438	8.06		10700		0.0
06-07-83					2750	830	396.5		5634	7.84	9500	9500	21	1.6
06-22-83					1000				2354	8.16	4500	4400	30	6.2
07-07-83	1604	31.2	80	6.80	1128	1120	304.8	0.6	2500	8.33	4250	4250	29	5.1
07-26-83					3000				5623	7.85	9000	9500	29	1.6
08-24-83					3350 *				5775	7.92	9000	10490	32	1.4
09-28-83					2950				5857	7.78	9000	9500	26	1.4
10-26-83	2172	84.8	136	12.0	2684	745	406.26	0	5643	7.97	8840	9400	19.0	1.6
11-21-83					3100				6201	7.7	9400	10100	13	1.5
12-13-83					3100				6222	7.99	11000	10000	8.9	1.4
01-19-84	2304	95.2	128	9.24	2740	387.6	431.9	0	5396	7.97	9050	11800	0	1.9
02-15-84					4100				8000	7.76	11950	13800	10	1.5
03-14-84					3000				5722	7.93	8500	9200	17	2.0
04-18-84	2186	72.0	148	14.6	3560	475	427.0	0	6711	8.13	11080	10780	22	1.6
05-15-84					3500				5947	7.79	10240	10000	20	1.7
06-08-84					3000				5286	7.86	10088	9328	27	1.0
07-19-84	2281	5.76	122.4	12.0	3696	587.5	378.2	0	6411	8.03	10700	12160	29.0	1.2
08-14-84					3680 *				6098	7.72	11540	11348	30.0	1.2
MEAN	2079	57.1	124	10.8	2923	691	390.8	0.1	5613	8.4	9273	9777	21	2.0

* Value adjusted by USBR.

NOTE: Mean values are calculated from data not reproduced from USBR report.

Water Quality Analyses, USBR (1984)

SITE 1 – 16' Piezometer: Table 5.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	5600				7720				16252			19000	
05–23–83	5920	128.2	357.2	21.1	6920	350	467.2	0	16072	7.92		22500	
06–07–83					8350				15849	7.71	24000	24500	18
06–22–83					9000				15665	7.70	24900	25000	15
07–07–83	6840	134.4	308	21.4	8880	352	487.96	0	16942	8.01	25500	25500	16
07–26–83					9000				15949	7.74	23800	26000	17
08–24–83					9500				15867	7.51	22800	26000	17
09–28–83					8400				15408	7.54	22100	25000	17
10–26–83	5320	228.8	336	23.7	8360	950	529.48	0	16123	7.70	24700	24000	16
11–21–83					8250				15440	7.54	22500	24000	15
12–13–83					8250				15216	7.50	22250		15.6
01–19–84	6220	200	324	21.9	8160	825	536.8	0	15034	8.01	23700	21500	15
02–15–84					8100				14980	7.60	21000	23400	14
03–14–84					9500				15439	7.42	21500	22000	15
04–18–84	5249	254.4	380	23.6	8360	885	523.38	0	14801	7.99	24700	24880	14
05–16–84					8500				15123	7.64	23700	22080	16
06–08–84					8500				15030	7.63		22400	17
07–19–84	5417	226	325.6	18.4	8880	950	453.84	0	16477	7.66	21400	21640	17
08–14–84					8200				14457	7.51	22200	21084	17
MEAN	5795.1	195.3	338.5	21.7	8465	719	499.8	0.0	15585	7.7	23172	23360	16

Water Quality Analyses, USBR (1984)

SITE 1 – 22' Piezometer: Table 6.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	Lab pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	5440				6600				14502			22500	
05–23–83	6160	126.3	341.2	19.6	6720	830	634.4	0	15737	7.82		24500	
06–07–83					7950				14738	7.60	23000	22000	15
06–22–83					9000				15029	7.73	23250	23000	15
07–07–83	5800	122.4	280	18.4	7800	760	363.56	0	14948	8.0	21500	21500	16
07–26–83					9000				15248	7.63	22900	25000	16
08–24–83					8500				13411	7.58	19800	21000	17
09–28–83					6400				12025	7.62	16500	19500	17
10–26–83	4920	188.8	297.6	19.6	6160	855	497.76	0	12534	7.65	17300	20000	16
11–21–83					6200				11920	7.52	17000	17200	15
12–13–83					6700				12412	7.70	19000	18000	15.6
01–19–84	5400	182.4	283.2	18.6	6600	787.6	523.3	0	12150	7.92	19500	17900	15
02–15–84					7200				14131	7.64	19510	20000	15
03–14–84					8500				14923	7.62	20000	20900	15
04–18–84	4639	100.8	352	21.9	8760	795	509.96	0	12897	7.95	22200	20680	15
05–16–84					8000				13439	7.63	20950	20800	16
06–08–84					7500				12723	7.62	20000	18348	15
07–19–84	4862	152.6	304	16.6	9120	812.5	469.7	0	14135	7.84	22000	20400	17
08–14–84					8500				12824	7.60	21160	18420	17
MEAN	5317	145.6	310	19.1	7643	807	499.8	0.0	13670	7.7	20328	20613	16

Water Quality Analyses, USBR (1984)

SITE 2 River (Mile 2.2): Table 7.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbona mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.	Flow (cfs)
05-13-83	1968				2516				5683			15000		
05-23-83	2120	53.4	134.5	10.6	2990	375	381.86	1.8	5699	8.37		9900		0.45
06-07-83					2850				5840	7.85	9250	10000	24	2.0
06-22-83					1000				2422	8.24	4400	4500	30	5.9
07-07-83	1440	33.6	68	6.62	1004	278	291.6	1.2	2275	8.33	4500	4500	30.5	6.1
07-26-83					2500				5798	7.94	9500	10000	30	1.1
08-24-83					3500				6110	8.0	9000	10880	32	1.6
09-28-83					3250				6354	7.88	9100	10500	24	1.8
10-26-83	2290	105.6	136	12.5	2616	450	413.58	0	5848	8.0	9180	9500	18.0	1.9
11-21-83					3200				6400	7.75	10000	10200	14	2.1
12-13-83					3250				6365	8.06	10000	12500	3.3	2.0
01-19-84	2276	100.8	128	10.5	2700	450	435.54	0	5175	8.01	8850	9600	2.0	1.9
02-15-84					4800				9176	7.72	13700	14500	10	1.3
03-14-84					3000				5987	7.90	9400	9600	17.5	1.4
04-18-84	2242	79.2	148	14.8	3420	450	422.12	0	7275	8.03	11510	10896	22	1.5
05-16-84					4000				6395	7.83	10368	10672	16	1.7
06-08-84					2500				6200 *	7.91	8656	9798	28	1.0
07-19-84	2308	187.7	123.2	12.3	3400 *	500	373.32	0	6648	7.96	11300	12484	33.0	0.9
08-14-84									6332	7.81	11980	11820	30	1.3
MEAN	2092	93.4	123	11.2	2916	417	386	0.5	5894	7.98	9453	10361	21.4	2.0

Water Quality Analyses, USBR (1984)

Site 2 – 22' Piezometer: Table 8.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l		Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05-13-83		5080				5720				13902			21000	
05-23-83		5600	147.7	365.2	10.6	6600	925	559.6	0	15779	7.83		24000	
06-07-83						8300				15677	7.65	23000	24900	15
06-22-83						9500				15629	7.66	24000	24500	15
07-07-83		6080	165.6	336	20.4	8480	790	352.6	0	16573	7.91	24000	24000	15
07-26-83						9000				15640	7.64	23000	26000	15
08-24-83						9000				15706	7.53	22800	25000	15
09-28-83						8550				15855	7.64	21800	24500	15
10-26-83		7800	260.8	352	18.2	6680	1025	428.22	0	17124	7.94	24200	24000	15
11-21-83						8250				15357	7.63	21500	23500	15
12-13-83						8000				14969	7.63	22100	22100	14.4
01-19-84		6220	238.4	337.6	19.9	7720	995	391.6	0	14892	8.12	33000	21250	14
02-15-84						7600				14786	7.64	20100	21500	15
03-14-84						8000				14778	7.50	20200	21000	17
04-18-84		5029	132	368	22.6	7800	855	470.92	0	15300	7.90	24000	23400	14.75
05-16-84						8000				14532	7.56	21720	21000	17
06-08-84						8000				14619	7.49	22440	19948	17
07-19-84		4869	162.2	276.8	13.9	9240	787.5	425.78	0	14669	7.79	22500	20760	12
08-14-84						9000				14156	7.48	21480	21080	16
MEAN		521.5	184	339	18	8076	896	438	0	15260	7.7	23049	22813	15.1

Water Quality Analyses, USBR (1984)

SITE 2 – 40' Piezometer: Table 9.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	5480				6960				15409			23000	
05–23–83	5920	144.8	418.1	23.2	7360	980	461.1		16838	7.89		26000	
06–07–83					8600			0	16369	7.54	24500	25500	15
06–22–83					10000				16159	7.84	24000	25000	15
07–07–83	5920	183.6	342	20.7	8160	910	336.7		17133	7.88	24500	24500	15
07–26–83					9000			0	16096	7.74	23800		15
08–24–83					9500				16279	7.51	23600	26000	15
09–28–83					8150				16181	7.60	21700	24500	15
10–26–83	6400	267.2	377.6	19.5	7200	1005	448.96	0	16391	8.00	24700	24000	15
11–21–83					8400				15903	7.59	22100	23500	15
12–13–83					8500				15728	7.32	23100	23000	15.6
01–19–84	6680	256	377.6	21.2	8680	1025	307.44	0	15920	8.06	22000	22200	16
02–15–84					8350				15719	7.58	21600	22500	16
03–14–84					9000				15701	7.46	21400	22000	17
04–18–84	5277	141.6	400	22.6	7960	1045	463.6	0	15596	8.0	25200	24400	15
05–16–84					9500				15219	7.49	22600	21760	16
06–08–84					7500				15036	7.39	22120	21040	15
07–19–84	5223	150.7	337.6	19.1	9120	1112.5	416.02	0	15011	8.04	21400	21440	16
08–14–84					8500				14881	7.6	26040	22160	16
MEAN	5843	191	375	21	8444	1013	406	0	15872.1	7.7	23198	23472	15.4

Water Quality Analyses, USBR (1984)

SITE 2 – 55' Piezometer: Table 10.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	Field Conduct. umhos	Field Conductivity umhos
05-13-83	5040				5920				14296			21000
05-23-83	5200	164.24	352.4	19.3	6600	1045	457.5	0	15416	7.96		24000
06-07-83					8000				14838	7.53	22100	23000
06-22-83					9500				15273	7.84	23000	23500
07-07-83	5480	176.4	302	19.7	8160	940	339.2	0	15832	7.85	22500	22500
07-26-83					9000				15074	7.69	21900	25000
08-24-83					9000				14946	7.54	22200	24000
09-28-83					8300				15458	7.48	21000	24000
10-26-83	6160	259.2	361.6	17.4	7180	962.5	411.14	0	15947	8.05	23900	23500
11-21-83					8200				15053	7.48	22000	23000
12-13-83					8150				14992	7.28	22000	21200
01-19-84	7600	264	344	22.5	7960	865	412.36	0	15123	7.95	21700	20900
02-15-84					7900				14857	7.47	20200	23000
03-14-84					8000				14843	7.38	20000	21100
04-18-84	4872	144	372	23.8	7440	990	445.3	0	14857	7.78	24100	23000
05-16-84					8500				14419	7.39	21680	21200
06-08-84					8500				14398	7.62	22200	20044
07-19-84	4949	158.4	315.2	18.9	8880	1450	419.68	0	14172	7.98	22600	20560
08-14-84					7700 *				14249	7.59	21420	20296
MEAN	5614	194	341	20	7642	1042	414	0	14200	7.2	20769	21290

Water Quality Analyses, USBP (1984)

SITE 3 River (Mile 5.4): Table 11.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbona mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.	Flow (cfs)
05-13-83	4240				4600				5674			7500		
05-23-83	3898	82.6	171.4	16.2	4400	610	397.7	0	10799	8.09		20800		2.8
06-07-83					5550				10420	7.77	16150	17000	23	3.1
06-22-83					2500				1630	8.19	8250	7100	29	6.6
07-07-83	1752	48	88	8.90	1976	388	305.0	0	4109	8.20	6500	6500	25	5.8
07-26-83					6000				10400 *	7.90	15800	16250	26	2.4
08-24-83					6000				10740	7.98	16500	17000	28	1.8
09-28-83					6000				11570	7.81	17000	19000	18	1.5
10-26-83	5040	203.2	203.2	18.6	5320	2150	462.38	0	10600 *	8.14	18300	18800	15	2.3
11-21-83					6750				12665	7.65	18500	20000	11	2.7
12-13-83					6550				12324	7.82	18000	19500	5.5	2.2
01-19-84	4052	147.2	206.4	14.6	4860	590	373.3		9299	8.25	15000	18000	0	4.2
02-15-84					7800			0	14652	7.65	20900	22900	5	2.2
03-14-84					6500				11336	7.82	16100	17500	14	2.3
04-18-84	4229	98.4	236	22.4	6560	895	483.92	0	12111	7.98	20400	19526	16	2.2
05-16-84					6500				11895	7.82	18784	18520	17	2.8
06-08-84					5500				10385	7.91	15836	16168	21	2.4
07-19-84	5213	123.8	225.6	20.8	8280	1150	434.32	0	14294	7.94	20500	22760	25	2.0
08-14-84					7200				13275	7.74	21340	21640	26	4.5
MEAN	4061	117	188	17	5729	964	409	0	10430	7.9	16698	17182	17.9	3.0

Water Quality Analyses, USBR (1984)

Site 3 – 20' Piezometer: Table 12.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05-13-83	4080				4600				13415			20000	
05-23-83	5920	172	237	23.6	6840	1375	422.61	7.98	16348	8.46		26000	
06-07-83					8200				16191	7.76	25000	24200	14
06-22-83					9500				16250 *	8.08	25500	24000	14
07-07-83	6000	165.6	208	23.1	8480	1325	429.4		16414	8.06	20000	20000	14
07-26-83					9000				16300 *	7.95	22900	25000	15
08-24-83					7500			0	14377	7.73	21500	23100	15
09-28-83					5900				11183	7.86	15200	18500	16
10-26-83	4600	121.6	112	16.7	4920	800	412.36		10714	8.18	16100	17000	18
11-21-83					6250			0	11889	7.76	17000	18800	17
12-13-83					6500				12198	7.73	18000	16400	18.9
01-19-84	5660	166.4	188.8	20.4	5940	715	307.44		11937	8.29	18700	17250	16
02-13-84					6100			0	11610	7.83	16600	17500	15
03-14-84					6200				11773	7.73	17100	17900	15
04-18-84	4112	200.6	204	24.7	8360	860	444.1		11926	8.02	20100	19568	13
05-16-84					7500			0	12050	7.81	18368	19124	13
06-08-84					6500				11992	7.71	18388	19280	14
07-19-84	4213	109	200	17.1	7040	987.3	464.82	0	12764	7.89	18800	16124	15
08-14-84					6640 *				12029	7.81	18798	17152	15
MEAN	4941	156	192	21	6946	1010	413	1.3	13229	7.93	19297	19837	15.2

Water Quality Analyses, USBR (1984)

Site 3 – 34' Piezometer: Table 13.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	5720												
05–23–83	8360	205	438.9	31.0	10720	1720	580.7	0	26106	8.23		39500	
06–07–83					13550				26319	7.53	38000	39000	14
06–22–83					14500				23000 *	7.74	39000	38000	14
07–07–83	9880	252	392	30.8	14240	1540	451.4	0	26617	7.89	37000	37000	14
07–26–83					15000				24000 *	7.71	32800	40000	15
08–24–83					15500				25460	7.39	36000	34000	15
09–28–83					13250				25218	7.58	33000	36000	15
10–26–83	6560	388	436.8	35.8	11880	1125	585.6	0	25077	7.68	35900	32500	15
11–21–83					13250				25009	7.62	31600	33000	15
12–13–83					13150				24652	7.17	34000	34100	15.6
01–19–84	10280	382.4	448	36.6	13120	1525	594.14	0	25231	7.83	35900	33800	16
02–13–84					13250				24919	7.60	32550	32000	16
03–14–84					12800				24426	7.45	33000	32000	16
04–18–84	8333	232.4	428	32.0	11880	1435	553.88	0	25004	7.58	38200	37096	14
05–16–84					12100 *				23709	7.55	33060	33280	15
06–08–84					13500				23613	7.52	34080	29560	14
07–19–84	8550	220	400	26	12320	1875	485.56	0	24305	7.73	36000	30520	14
08–14–84					11800				24569	7.61	29400	31880	15
MEAN	8240	280	424	32	13101	1537	542	0	24846	7.63	34676	34624	14.9

Water Quality Analyses, USBR (1984)

SITE 4 River (Revuelto Creek): Table 14.

Date	Sodiumdium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbona mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.	Flow (cfs)
05-13-83	290				165				1276			2000		
05-23-83	210	24.3	78.4	9.2	123	680	224.0	3.0	1260	8.56	1750	1460		26.0
06-07-83					95				1300 *	8.14	1800	1900	24	6.7
06-22-83					100				1250 *	8.25			35.5	0.01
07-07-83														
07-26-83														
08-24-83					20				1089	8.34	1000	1500	28	3.3
09-28-83					65				829	8.24	1300	1400	21	7.8
10-26-83	163.2	46.4	60.8	6.85	68.5	345	240.3	0	767	8.26	1180	1350	16	14.3
11-21-83					100				937	8.19	1550	1500	12	5.6
12-13-83					240				1492	8.28		2300	10	1.7
01-19-84	894	97.6	89.6	5.33	656	662	386.74	0	2294	8.17	3350	4300	0	
02-15-84					370				1911	8.25	2800	3200	4	0.4
03-14-84					825				2618	8.19	4000	4000	17	0.1
04-18-84	315	50.4	72	8.7	229	520	219.6	1.2	1397	8.39	2430	2068	19	4.3
05-16-84					100				1051	8.17	1493		16	11.7
06-08-84					2150				5339 a/	7.79	7954	8464	21	
07-19-84	127	5.28	20	2.4	54.8	175.0	209.84	1.2	536	8.42	628			55
08-14-84					200				291	7.57	617	568	24	
MEAN	333	45	64	6.5	327	476	256	1.1	1508	8.2	2275	2572	17.7	9.13

a. Note on table says "concentration in pool?"

Water Quality Analyses, USBR (1984)

Site 4 – 15' Piezometer: Table 15.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	3640				4320				10955	7.87		16500	
05–23–83	3536	147.7	302.7	15.5	5200	960	516.1	0	10452	7.65		16500	
06–07–83					3850 *				7973	8.04	11700 *		12
06–22–83					3000				7150 *	8.46	10000	9500	14
07–07–83	1676	3.6	8.4	4.8	1204	515	505	1.8	3454	8.16	5250	5250	14
07–26–83					500				4000 *	8.09	4300	5000	15
08–24–83					320				1532	8.03	2600	2750	16
09–28–83					360				1580	8.23	2600	2750	17
10–26–83	369.6	17.6	27.2	3.9	306.8	475	319.64	0	1482	7.91	2310	2550	17
11–21–83					215				1256	7.87	2200	2500	15
12–13–83					240				1276	8.2	2200	2800	14.4
01–19–84	692	36.8	51.2	4.08	398.8	485	306.22	0	1504	7.85	2560	2750	12
02–13–84					435				1717	7.75	2700	3000	11
03–14–84					425				1735	8.08	2700	2750	11
04–18–84	516	31.2	72	5.6	511	350	284.26	0	1795	7.78	3250	2964	11
05–16–84					500				3766	7.78	2874	3132	11
06–08–84					650				1999	8.37	3220	2800	13
07–19–84	555	40.3	89.6	5.2	580	512.5	303.78	0.6	2754		3080	2892	14
08–14–84													
MEAN	1569	46	92	6.5	1279	550	373	0.4	3688	8.0	3972	5082	13.6

Water Quality Analyses, USBR (1984)

Site 4 – 20.5' Piezometer: Table 16.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	4760				5480				13378			21000	
05–23–83	4980	129.2	203.4	19.9	6300 *	1200	564.86	0	13787	8.03		21000	
06–07–83					6550				14921	7.68	20250	20600	12
06–22–83					4000				9000 *	8.14	13200	13000	14
07–07–83	2364	4.32	12	6.89	2156	615	653.9	1.2	5291	8.41	8000	8000	14
07–26–83					1000				4400 *	8.18	7000	7000	14
08–24–83					700				2483	7.96	4000	4400	15
09–28–83					510				1964	8.06	3100	3500	15
10–26–83	1044	7.2	12	3.1	592 *	462.5	374.54	0	1736	8.30	2720	3000	15
11–21–83					517 *				1601	8.04	2650	2800	15
12–13–83					570				2029	7.99	3300	3300	16.7
01–19–84	726	10.6	25.6	3.52	645	492	305.0	0.9	1736	8.35	2610	2800	14
02–13–84					700				2208	7.95	3550	3800	13
03–14–84					600				2040	7.89	2800	3700	12
04–18–84	1075	36	88	7.8	1150	375	283.04	0	3349	8.01	5940	5532	12
05–16–84					1550				3753	7.79	5982	6452	11
06–08–84					2550				6250 *	7.69	8694	7464	13
07–19–84	972	42	112	6.1	1274	612.5	322.08	0	3101	8.30	4510	4280	14
08–14–84													
MEAN	2274	38	75.5	7.9	2046.9	626	417	0.4	5168	8.0	6144	7868	13.7

Water Quality Analyses, USBR (1984)

SITE 6 River (Mile 9.9): Table 17.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbona mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.	Flow (cfs)
05-13-83	1370				1536				4459			7500		
05-23-83	756	37	93	8.6	900	395	280.6	0	2383	8.30		4235		32.0
06-07-83					2050				2038	7.95	7600	7250	18.5	11
06-22-83					2500				5970	8.06	10000	10000	27	5.5
07-07-83	2196	62.4	116	11.6	3244	514	305	0	5696	8.15	9100	9100	22	4.5
07-26-83					6500				11025	7.87	17000	17000	24	1.0
08-24-83					1800				3882	8.12	6200	7200	25	6
09-28-83					1150				2685	8.05	4250	4750	17	10
10-26-83	1100	88	76.8	8.35	996	387.5	273.3	2.4	2549	8.37	3650	4600	11	17.5
11-21-83					2050				4475	7.98	9000	7800	10	10
12-13-83					4150				8243	8.0	12175	13800	3.3	5.0
01-19-84	5480	220.8	310.4	19.9	6400	875	662.46	0	13209	7.80	18880	22000	0	0
02-15-84					5550				10711	7.70	15200	16800	4.0	3
03-14-84					6000				11889	7.72	15000	18000	14	2.5
04-18-84	2034	81.6	148	16.3	2900	550	364.78	0	6321	8.11	10820	11555	12	6
05-16-84					1500				3431	8.05	5536	5228	16	13.0
06-08-84					6500				11630	7.64	17020		20	1.5
07-19-84	296	9.6	32	3.8	297.6	150	231.8	0	1121	8.32	1586	1758	23	60
08-14-84					250				460	7.57	951	908	24	201
MEAN	1890	83	129	11.4	2962	479	353	0.4	5904	8.0	9645	9416	15.9	21.6

Water Quality Analyses, USBR (1984)

Site 6 – 21' Piezometer: Table 18.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	2792				4000 *				7752			13000	
05–23–83	2792	49.5	91.3	13.8	3720	560	666.1	0	7694	8.16		12800	
06–07–83					3850				8900 *	7.65	13000	13000	14
06–22–83					3500				7197	8.06	11250	12000	14
07–07–83	2828	48	100	13.3	3640	564	528.3	0	7246	8.07	11800	11800	14
07–26–83					3500				7116	7.86	11200	13000	15
08–24–83					4000				6366	7.7	9250	11000	15
09–28–83					3250				6483	7.78	9700	4000	15
10–26–83	3244	101.6	97.6	13.8	3400 *	687.5	484.34	0	6669	8.10	9370	10800	16
11–21–83					3700				7470	7.74	11200	12000	12
12–13–83					4200				8296	7.49	12000	11900	17.7
01–19–84	4120	376	244.8	19.5	4840	810	513.62	0	9637	8.0	16500	13500	16
02–13–84					4950				9807	7.74	14000	15000	14
03–14–84					5500				10454	7.56	13900	15100	16
04–18–84	3505	230	312	25.1	5200	635	472.14	0	10876	7.78	18500	15200 *	14
05–16–84					5500				10706	7.58	16782	17660	14
06–08–84					5500				11842	7.42	17048	17852	15
07–19–84	3784	142.1	337.6	19.4	5300 *	887.5	447.74	0	11397	7.9	18000	15260	15
08–14–84									11598	7.53	18916	16200	17
MEAN	3295	158	197	17.5	4308	691	519	0	8816	7.8	13672	13214	14.9

Site 6 – 31' Piezometer: Table 19.

Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	LAB Conduct. umhos	Field Conductivity umhos	Field Water Temp.
05–13–83	4920				6040				14160			22000	
05–23–83	5260	148.6	254.7	28.2	5920	970	588.0	0	15048	7.93		23000	
06–07–83					7750				15200 *	7.58	22500	24000	14
06–22–83					8500				14719	7.73	22250	22000	15
07–07–83	4360	151.2	260	24	7280	935	530.7	0	14356	7.92	21500	21500	15
07–26–83					8000				14020	7.62	20100	22700	15
08–24–83					8000				14056	7.74	20050	21800	15
09–28–83					7050				13770	7.64	19200	21500	15
10–26–83	6160	67.2	266.4	25.6	6600 *	1280	679.54	0	13545	7.87	20400	19500	15
11–21–83					6900				13511	7.51	19500	22900	10
12–13–83					6950				13618	7.70	19950	21500	10
01–19–84	5800	216	292.8	24.7	6840	1170	707.6	0	13740	8.01	22200	19000	15
02–13–84					6600				13226	7.65	18300	18500	14
03–14–84					6600 *				13035	7.74	18000	20000	16
04–18–84	4519	212.2	276	27.1	6400	765	684.42	0	13201	7.69	22400	20584	15
05–16–84					6500 *				12659	7.58	19204	20100	16
06–08–84					6500				13300 *	7.63	19376	21004	15
07–19–84	4365	128.6	187.2	19.3	6864	1100	583.16	0	12173	7.76	19350	19420 *	15
08–14–84					6500 *				12035	7.63	20800		15
MEAN	5055	154	256	24.8	6937	1037	629	0	13651	7.72	20299	21167	14.4

SITE 6 – 50' Piezometer: Table 20

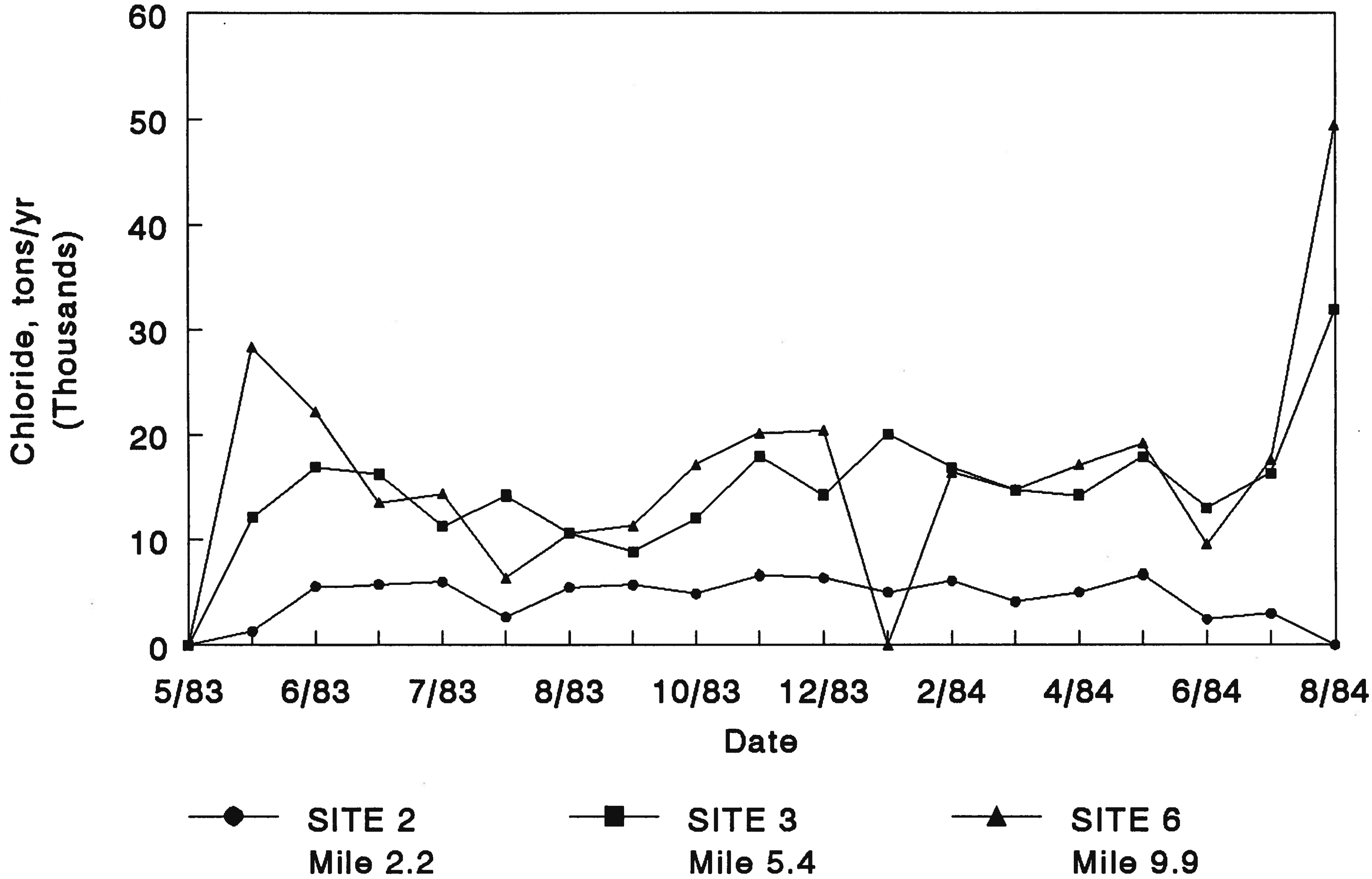
Date	Sodium mg/l	Magnesium mg/l	Calcium mg/l	Potassium mg/l	Chloride mg/l	Sulfate mg/l	Bicarbonate mg/l	Carbonate mg/l	Total Dissolved Solids mg/l	LAB pH pH Units	Field Conduct. umhos	Field Conductivity umhos
05-13-83	5920											
05-23-83	7720	163.2	456.5	43.2	10750 *	1285	555.1	0	20432	7.73		30100
06-07-83					10150				20800 *	7.24	30000	32000
06-22-83					11300 *				20224	7.49	29500	31500
07-07-83	8160	43.2	75.2	39.2	10400	1365	570.0	0	20846	7.89	30000	30000
07-26-83					11100 *				20426	7.47	29200	31000
08-24-83					11500				20275	7.18	27500	30000
09-28-83					10550				20418	7.42	27200	30000
10-26-83	8360	383.2	426.4	44.2	10700 *	1625	786	0	20825	7.76	30300	30000
11-21-83					10700				20590	7.21	28500	31800
12-13-83					10450				20077	7.28	28100	28000
01-19-84	8280	353.6	496	43.5	10280	1612	812.52	0	18600 *	7.89	32000	28000
02-15-84												
03-14-84												
04-18-84												
05-16-84												
06-08-84												
07-19-84												
MEAN	7688	235.8	363.5	42.5	10716	1472	681	0	20319	7.5	29230	30218

Water Quality Analyses, USBR (1984)

Chloride loading, surface water

Date	SITE 1 River (Mile 1.6) Flow cfs	Chloride mg/l	Chloride tons/yr	SITE 2 River (Mile 2.2) Flow cfs	Chloride mg/l	Chloride tons/yr	SITE 3 River (Mile 5.4) Flow cfs	Chloride mg/l	Chloride tons/yr	SITE 4 Revuelto Creek Flow cfs	Chloride mg/l	Chloride tons/yr	SITE 6 River (Mile 9.9) Flow cfs	Chloride mg/l	Chloride tons/yr
05-13-83		2320	0		2516	0		4600	0		165	0		1536	0
05-23-83	0.0	2880	0	0.45	2990	1324	2.8	4400	12123	26.0	123	3147	32.0	900	28339
06-07-83	1.6	2750	4330	2.0	2850	5609	3.1	5550	16930	6.7	95	626	11	2050	22189
06-22-83	6.2	1000	6101	5.9	1000	5806	6.6	2500	16236	0.01	100	1	5.5	2500	13530
07-07-83	5.1	1128	5661	6.1	1004	6026	5.8	1976	11277			0	4.5	3244	14364
07-26-83	1.6	3000	4723	1.1	2500	2706	2.4	6000	14170			0	1.0	6500	6396
08-24-83	1.4	3350	4615	1.6	3500	5510	1.8	6000	10627	3.3	20	65	6	1800	10627
09-28-83	1.4	2950	4064	1.8	3250	5756	1.5	6000	8856	7.8	65	499	10	1150	11316
10-26-83	1.6	2684	4226	1.9	2616	4891	2.3	5320	12040	14.3	68.5	964	17.5	996	17151
11-21-83	1.5	3100	4576	2.1	3200	6612	2.7	6750	17933	5.6	100	551	10	2050	20172
12-13-83	1.4	3100	4271	2.0	3250	6396	2.2	6550	14179	1.7	240	401	5.0	4150	20418
01-19-84	1.9	2740	5123	1.9	2700	5048	4.2	4860	20085		656	0	0	6400	0
02-15-84	1.5	4100	6052	1.3	4800	6140	2.2	7800	16885	0.4	370	146	3	5550	16384
03-14-84	2.0	3000	5904	1.4	3000	4133	2.3	6500	14711	0.1	825	81	2.5	6000	14760
04-18-84	1.6	3560	5605	1.5	3420	5048	2.2	6560	14201	4.3	229	969	6	2900	17122
05-16-84	1.7	3500	5855	1.7	4000	6691	2.8	6500	17909	11.7	100	1151	13.0	1500	19188
06-08-84	1.0	3000	2952	1.0	2500	2460	2.4	5500	12989		2150	0	1.5	6500	9594
07-19-84	1.2	3696	4364	0.9	3400	3011	2.0	8280	16295	55	54.8	2966	60	297.6	17570
08-14-84	1.2	3680	4345	1.3		0	4.5	7200	31882		200	0	201	250	49446
MEAN	2	2923	4598	2	2916	4892	3	5729	15518	11	327	890	22	2962	17143

Water Quality Analyses, USBR (1984)
River Chloride Loading



Canadian River Stream Survey
May, 1983 [USBR (1984), Appendix B]

MILE	LOCATION	TEMP, °C	SPECIFIC CONDUCTIVITY, MICROMHOS	COMMENTS
0.1	Discharge pipe from under dam drains	15.0	2400	Air temp = 19.5°C
0.15	Ponded area below pipes	15.0	2500	Deep water; sedges, cat tails on bank
0.3	Seep at toe of outlet works at base of spillway	18.5	1050	Milky color in pond
0.35	Beaver dam in center channel	19.0	3700	Cat tails
	Puddle, N. bank	18.5	3750	1 foot under surface
0.4	S. bank	17.5	5500	Below riffle, water greenish & fairly clear
	Center	18.0	5000	
	N. bank	18.3	4800	
0.5	S. side channel	21.5	15400	Greenish, slightly cloudy water; 5' feet deep near N. bank
	Middle	18.0	5400	
	N. side	19.0	12500	
	Upstream by big rock (in middle) bottom	17.9	5000	
0.8	River–wide cliffs on North, measurement taken S. side	27.0	7000	Many cat tails; springs on N. side; air temp = 16.0°C
0.9	N. side	24.0	7200	At wide section below dam
	Middle	24.0	7200	
	S. side	27.0	5000	
1.1	Southside	30.0	9800	River below fallen rock, below tallest cliff
	Middle	23.5	9700	
1.2	Pool connected to stream	33.0	15100	
	River right above pool	32.0	10900	
1.3	Northside	32.0	10800	River with cliff on east side
	Southside	32.0	11200	
1.4	Pool connected to river upstream from USBR Sampling Site 1	29.5	11000	
1.6	Northside	29.5	10700	USBR Sampling Site 1
	Southside	30.0	9400	

Canadian River Stream Survey
May, 1983 [USBR (1984), Appendix B]

MILE	LOCATION	TEMP, °C	SPECIFIC CONDUCTIVITY, MICROMHOS	COMMENTS
1.9	Northside	29.5	11000	River at U.S.G.S. gauge site
	Southside	29.5	11000	
2	Pool between Hwy 54 bridge & U.S.G.S. gauge site	27.0	12500	Pool not connected to river
	River north side	30.0	11500	
	River south side	30.0	9500	
2.2	USBR Sampling Site 2	27.0	10400	River stage 1.02
2.8	N. side	24.8	11900	White deposts on rocks on south bank
	Center	24.8	12100	
	S. side	24.8	12100	
	Railroad bridge — sampled upstream:			
3.2	North pilings	19.0	33800	2.5 feet deep
	Middle pilings	19.5	12200	2 feet deep
	South pilings	20.0	28000	1.5 feet deep
	South pilings	18.2	27900	2 feet deep
	N. bank	24.5	12200	40 feet downstream of railroad bridge
	Center	24.5	13000	
	S. bank	25.0	13500	
	Pool 900 ft upstream, S. side		>50000	
3.5	Center	25.0	14300	225 feet upstream of mile 3.5
	S. side	25.0	14000	
	N. side	26.0	14500	
	Center channel	25.0	13500	Gravel in channel (placed for telephone line)
	N. side, 50 feet upstream	25.0	18000	
	South side	25.0	8100	
4.1	Pool, N. side of channel	20.0	29500	
	N. side stream, 50 ft S. of pool	22.0	15200	
	Center	20.0	15100	1 foot deep
	Southside	20.0	15000	2 feet deep

Canadian River Stream Survey
May, 1983 [USBR (1984), Appendix B]

MILE	LOCATION	TEMP, °C	SPECIFIC CONDUCTIVITY, MICROMHOS	COMMENTS
4.4	North bank	19.0	17000	
	Center channel	19.0	17000	
	South bank	19.0	17000	
	Pool 900 ft on N. bank	21.0	34800	
	Pool 1050 ft upstream of last pool	19.5	24500	
5.2	Several pools on S. bank	19.0	>50000	White deposits on soil and rocks along S. bank for about 300 feet
5.4	South bank	19.0	17500	
	Pool 600 ft upstream on N. bank	19.5	17500	
	South side of pool	20.0	18100	
	S. side of pool 750 feet upstream	22.5	47300	At 2 foot depth; pool 69 ft by 6 ft by 3 ft deep; blue–green water
	Stream on N. side of channel	20.2	18200	
	Pool 900 ft upstream on N. bank	28.5	46700	Red algal growth on bottom
	Stream at this site	22.0	18500	
5.5	Beaver Lodge on N. bank	19.5	10500	Flow from N. side of channel
	Main channel	19.0	17500	
	Pool S. side	19.0	24800	Red algal growth
5.7	5 ft from South bank	18.5	17500	
	5 ft from North bank	18.5	17500	
	Pool 200 ft upstream on N. bank	19.5	21800	
5.9	North bank	19.0	17500	Air temp = 22.5°C; red algal growth along stream edge; black material on bottom in center
	Center	19.0	17500	
	Pool 100 ft upstream	18.0	19500	
6.1	North bank	28.2	18300	
	Middle	29.5	21800	
	South bank	29.0	22200	
	Mouth of Revuelto Creek (Mile 0.1): 10 ft from West bank	29.0	1620	
	10 ft from East bank	29.0	1630	

Canadian River Stream Survey
May, 1983 [USBR (1984), Appendix B]

MILE	LOCATION	TEMP, °C	SPECIFIC CONDUCTIVITY, MICROMHOS	COMMENTS
	Revuelto Creek above Hwy 39 bridge (Mile 2.1): West bank	29.5	1630	
	Center	29.5	1610	
	East bank	29.5	1580	Muddy water
6.2	Pool South side channel	29.0	5500	Air temp = 29.0°C
	South bank	29.0	2800	
	Center	29.0	4500	
	North bank	29.0	4800	
6.6	Pool North side of alluvial channel	30.0	42000	Sketch provided
	Stream on S. side of alluvial channel North bank	28.5	5800	
	Center	28.2	4250	
	South bank	28.2	4210	
7.3	North stream of split channel	25.8	4350	Very muddy water; sketch provided
	Mouth of pool	25.0	7900	
	South stream of split channel	25.8	4250	
	End of pool	28.0	14500	
7.9	North bank	20.2	4200	Near large rock; air temp = 26°C
	20 ft from N. bank	25.0	4090	
	40 ft from N. bank	16.0	4000	
	South bank	25.0	4190	
8.4	Pool on North bank	27.5	2150	Yellow growth or deposit on bottom of pool; cottonwoods on North bank
	Pool 200 ft upstream	26.8	39000	
8.8	S. side 200 ft downstream	23.5	4280	
	S. side 300 ft downstream in hole	25.5	16000	
	50 ft wide stream on N. side of channel	23.2	4250	N. bank 6 feet deep; cloudy water
	Mid channel	23.2	4200	
	South bank	23.2	4300	
	300 ft upstream on South bank	26.8	25000	

Canadian River Stream Survey
May, 1983 [USBR (1984), Appendix B]

MILE	LOCATION	TEMP, °C	SPECIFIC CONDUCTIVITY, MICROMHOS	COMMENTS
9.5	S. bank	20.2	4300	Cloudy water; air temp = 22.5°C
	10 ft from S. bank	20.5	4350	
	30 ft from S. bank	20.0	4350	
	N. side main channel	22.0	4350	
	N. channel near N. bank	22.0	4400	
	Center N. channel	22.5	4420	
	Water originating fr. sand just upstream on N. bank	22.0	4480	
	Clear pool 50 ft upstream	23.2	8000	
	3–4 ft pool 70 ft upstream on N. bank	22.0	7800	
9.7	Pool on N. Side	11.2	11500	Clear water
	Center channel	21.0	4320	Flow near S. bank – muddy water
	S. bank	20.2	4450	
	Pool just upstream	17.0	22100	
9.9	USBR Sampling Site 6: N. branch	22.0	4300	River stage 0.68 inches; reddish water; air temp 23.0°C
	S. branch	22.0	4250–4280	

CHLORIDE INFLOW TO LAKE MEREDITH

DATE		RESERVOIR WATER FLOW AND STORAGE (AF)								CHLORIDE CONCENTRATION (mg/l)				CHLORIDE TONNAGE							
		INFLOW		OUTFLOW		EVAPORATION		STORAGE						STORAGE (TONS)		OUTFLOW (TONS/YR)		INFLOW (TONS/YR)			AVG mg/l
YR	MO	MONTH	YEAR	MONTH	YEAR	MONTH	YEAR	END OF MONTH	END OF YEAR	AT TOWER	MID-LAKE	U/S END	AVG	TOTAL	ANNUAL CHANGE	MONTH	YEAR	MONTH	YEAR	AVERAGE	
65	1							4,320					650	3,819		0		3,819			ERR
65	2							4,920					650	4,349		0		530			ERR
65	3							5,550					650	4,906		0		557			ERR
65	4							4,970					650	4,393		0		(513)			ERR
65	5							17,738					420	10,132		0		5,738			ERR
65	6	143,360		0		3,008		158,090		200	160		180	38,700		0		28,568			146
65	7	9,141		0		4,479		162,752		130	130		135	29,881		0		(8,819)			-708
65	8	18,963		0		5,365		176,350		140			145	34,776		0		4,895			189
65	9	10,073		0		4,525		181,898		150			152	37,602		0		2,826			206
65	10	31,913		0		3,723		210,088		154			156	44,572		0		6,970			160
65	11	5,982		0		2,524		213,546		157	156		158	45,887		0		1,314			161
65	12	2,410	221,842	0	0	1,195	24,819	214,761	210,441	159	160		160	46,732	46,732	0	0	845	46,732	46,732	257
66	1	1,799		0		509		216,051		161	169		165	48,482		0		1,750			714
66	2	4,060		0		1,100		219,011		170			170	50,635		0		2,153			389
66	3	2,976		50		3,533		218,404		175			180	53,465		12		2,842			701
66	4	2,511		79		4,709		216,127		184	187		186	54,671		20		1,226			358
66	5	2,377		569		6,190		211,725		189			190	54,710		151		190			59
66	6	9,140		110		6,146		214,609		a 192			195	56,914		29		2,233			179
66	7	9,858		60		7,597		216,810		a 197			200	58,972		16		2,074			154
66	8	19,973		60		4,888		231,835		a 202			205	64,636		16		5,680			209
66	9	3,677		300		3,536		231,676		a 208			210	66,167		85		1,616			322
66	10	(528)		0		3,673		227,475					215	66,514		0		347			-482
66	11	977		0		3,471		224,981					218	66,702		0		189			142
66	12	(649)	56,171	0	1,248	1,291	46,643	223,041	8,280	222	222		223	67,644	20,912	0	329	942	21,241	33,987	-1064
67	1	2,048		0		2,280		222,809		226	228		227	68,786		0		1,142			409
67	2	1,560		20		2,238		222,111		227	228		230	69,476		6		697			328
67	3	3,232		320		4,309		220,714		230	229		232	69,640		100		263			60
67	4	13,705		575		4,942		228,902		234			227	70,667		183		1,210			65
67	5	4,941		561		6,283		226,999		230			230	71,005		175		514			76
67	6	38,317		556		5,611		259,149		221			220	77,537		167		6,699			128
67	7	60,460		132		6,716		312,761		218	213		217	92,302		39		14,804			180
67	8	15,381		950		6,442		320,750		210			213	92,915		271		884			42
67	9	6,914		0		4,914		322,750		212			213	93,494		0		579			61
67	10	3,747		0		5,843		320,654		213			220	95,940		0		2,445			479
67	11	1,283		0		2,140		319,797		228			228	99,163		0		3,223			1843
67	12	1,937	153,525	0	3,114	1,461	53,179	320,273	97,232	229			230	100,181	32,538	0	942	1,019	33,480	33,818	386
68	1	6,008		0		1,506		324,775		232	232		234	103,356		0		3,175			388
68	2	3,345		0		1,507		326,613		234	237		235	104,386		0		1,029			226
68	3	2,651		803		2,912		325,549		232	237		235	104,045		253		(87)			-24
68	4	4,451		930		6,700		322,370		236	235		240	105,222		298		1,475			243
68	5	14,091		2,740		5,580		328,161		245	245		240	107,112		913		2,803			146
68	6	8,340		3,554		7,205		325,742		240	240		241	106,765		1,160		813			72
68	7	9,847		4,240		6,090		325,259		242	242		248	109,703		1,395		4,334			323
68	8	12,852		3,734		6,506		327,871		250	250		253	112,814		1,270		4,380			250
68	9	(333)		4,326		5,988		317,224		256	253		256	110,445		1,506		(863)			1901
68	10	3,892		3,562		4,699		312,855		256	257		255	108,498		1,240		(706)			-133
68	11	8		3,862		2,152		306,849		252	254		253	105,581		1,324		(1,594)			-146165
68	12	(882)	64,270	4,192	31,943	1,061	51,886	300,714	(19,559)	255	253		257	105,106	4,924	1,454	10,814	979	15,738	29,298	-814
69	1	2,747		3,694		2,841		296,926		261	258		259	104,589		1,311		795			212
69	2	3,548		3,576		2,364		294,534		256	NA		260	104,147		1,245		803			166
69	3	4,403		2,354		1,686		294,897		258	260		260	104,276		826		954			159
69	4	3,537		5,243		4,929		288,262		a 260			262	102,714		1,854		292			61
69	5	27,226		4,458		5,588		305,442		264	264		266	110,497		1,601		9,384			253
69	6	61,549		6,088		6,720		354,203		267			260	125,246		2,203		16,953			202
69	7	30,505		7,128		7,904		369,676		256	248		252	126,695		2,482		3,931			95
69	8	22,627		6,997		8,700		376,606		248			245	125,485		2,360		1,150			37
69	9	95,384		4,332		4,667		462,991		255	252		230	144,824		1,502		20,841			160
69	10	13,871		4,594		3,741		468,527		231	223		225	143,369		1,443		(11)			-1
69	11	3,288		4,699		2,594		464,522		218	220		225	142,144		1,393		168			37
69	12	1,693	270,378	4,486	57,629	1,782	53,516	459,947	159,233	219	221		225	140,744	35,638	1,336	19,557	(64)	55,195	34,477	-28

CHLORIDE INFLOW TO LAKE MEREDITH

DATE		RESERVOIR WATER FLOW AND STORAGE (AF)								CHLORIDE CONCENTRATION (mg/l)				CHLORIDE TONNAGE							
		INFLOW		OUTFLOW		EVAPORATION		STORAGE						STORAGE (TONS)		OUTFLOW (TONS/YR)		INFLOW (TONS/YR)			AVG mg/l
YR	MO	MONTH	YEAR	MONTH	YEAR	MONTH	YEAR	END OF MONTH	END OF YEAR	AT TOWER	MID-LAKE	U/S END	AVG	TOTAL	ANNUAL CHANGE	MONTH	YEAR	MONTH	YEAR	AVERAGE	
70	1	2,873		3,320		1,526		457,974		a 227	231		230	143,254		1,025		3,535			903
70	2	3,354		3,688		3,262		454,378		229	230		229	141,511		1,149		(594)			-130
70	3	1,920		2,862		3,003		450,433		226	230		231	141,508		880		876			335
70	4	30,287		4,868		6,148		469,704		223	224		235	150,117		1,478		10,086			244
70	5	8,125		5,793		10,811		461,225		242			240	150,544		1,907		2,333			211
70	6	6,650		6,180		10,798		450,897		241	242		245	150,239		2,026		1,721			190
70	7	5,817		7,098		11,540		438,076		248	248		254	151,329		2,394		3,484			439
70	8	25,079		7,445		10,091		445,619		256	256		258	156,359		2,592		7,622			223
70	9	5,606		5,490		7,430		438,305		260	259		261	155,581		1,941		1,163			152
70	10	1,571		4,609		4,395		430,872		261	261		264	154,700		1,636		756			353
70	11	1,652		3,947		3,864		424,713		265	265		265	153,067		1,422		(211)			-94
70	12	158	93,092	4,844	60,144	2,520	75,388	417,507	(42,440)	266	265		266	151,037	10,294	1,752	20,200	(277)	30,493	33,813	-1286
71	1	2,148		5,047		1,932		412,676		266	266		268	150,412		1,826		1,201			410
71	2	4,364		3,991		2,993		410,056		a 269			270	150,573		1,460		1,620			272
71	3	3,630		4,923		5,559		403,204		269	290		273	149,702		1,801		930			188
71	4	5,340		5,256		7,179		396,109		273	273		275	148,145		1,951		395			54
71	5	10,765		6,601		8,746		391,527		277	275		281	149,626		2,487		3,968			270
71	6	16,191		6,046		10,357		391,315		282	284		282	150,077		2,319		2,770			126
71	7	25,680		6,709		9,555		400,731		282	278		285	155,323		2,573		7,819			223
71	8	28,447		5,282		7,054		416,842		282			282	159,867		2,026		6,570			169
71	9	12,950		6,502		6,448		416,842		277	279		279	158,167		2,449		749			42
71	10	5,949		4,923		4,864		413,004		a 279			280	157,272		1,868		973			120
71	11	39,849		4,003		3,459		445,391		280	280		275	166,576		1,524		10,829			199
71	12	5,220	160,533	3,753	63,036	1,467	69,613	445,391	27,884	274			275	166,576	15,539	1,399	23,683	1,399	39,222	34,586	197
72	1	2,743		3,326		2,846		441,962		274	273	510	275	165,294		1,239		(43)			-12
72	2	3,129		4,001		3,127		437,963		274		294	277	164,989		1,491		1,187			278
72	3	4,517		4,837		6,771		430,872		272		312	280	164,076		1,789		876			142
72	4	4,494		6,253		8,391		420,722		283		298	285	163,072		2,407		1,402			229
72	5	11,638		5,196		7,107		420,057		285		290	284	162,243		2,014		1,185			75
72	6	24,956		6,512		7,967		430,534		283		261	281	164,533		2,506		4,796			141
72	7	55,909		6,376		7,536		472,531		278		281	271	174,156		2,411		12,034			158
72	8	45,629		6,714		8,455		502,991		266		241	257	175,805		2,429		4,078			66
72	9	52,447		5,623		7,085		542,730		259		169	240	177,147		1,981		3,322			46
72	10	8,266		6,440		5,159		539,397		235	235	225	240	176,059		2,058		970			86
72	11	5,463		4,688		1,545		538,627		241		244	242	177,273		1,537		2,750			369
72	12	2,798	221,987	4,659	64,625	702	66,691	536,062	90,671	244		270	244	177,887	11,311	1,546	23,408	2,160	34,718	34,602	567
73	1	3,552		3,978		1,327		513,046		b 248	<--EST		255	177,924		1,342		1,379			285
73	2	3,001		3,837		2,161		510,049		251		361	260	180,353		1,310		3,739			914
73	3	13,650		4,171		3,977		515,551		a 248			260	182,299		1,407		3,352			180
73	4	18,312		4,338		5,657		523,867		245		312	270	192,364		1,445		11,511			461
73	5	5,953		4,995		8,270		516,555		266		274	272	191,084		1,807		527			65
73	6	5,199		6,546		10,877		504,331		267		268	275	188,620		2,377		(87)			-12
73	7	11,268		6,647		9,564		499,388		274		277	275	186,771		2,477		628			41
73	8	7,238		6,404		10,150		490,072		274		268	275	183,287		2,386		(1,098)			-111
73	9	(581)		5,437		6,090		477,964		274		280	277	180,059		2,026		(1,202)			1519
73	10	68		5,074		5,746		467,212		280		280	280	177,914		1,932		(212)			-2278
73	11	(794)		4,542		3,398		458,478		280		282	281	175,212		1,730		(973)			899
73	12	(557)	66,309	4,714	60,663	2,193	69,411	451,014	(85,048)	285		285	285	174,813	(3,074)	1,827	22,066	1,428	18,992	32,868	-1880
74	1	938		3,967		1,133		446,852		286		295	291	176,846		1,543		3,576			2798
74	2	2,238		4,406		3,798		440,886		289		299	294	176,284		1,732		1,170			383
74	3	10,064		5,432		5,774		439,745		286		298	292	174,632		2,113		460			34
74	4	3,590		6,844		8,045		428,446		289		299	294	171,310		2,690		(632)			-129
74	5	11,812		7,397		9,767		423,094		291		291	291	167,444		2,928		(939)			-58
74	6	6,202		8,169		9,903		411,223		293		293	293	163,864		3,255		(324)			-38
74	7	3,291		8,957		10,430		395,127		a 295			296	159,062		3,593		(1,208)			-269
74	8	33,615		6,428		7,160		415,154		298		301	300	169,383		2,605		12,926			282
74	9	6,158		5,088		4,348		411,876		302		298	300	168,045		2,090		752			90
74	10	27,955		4,441		4,251		431,139		297		277	287	168,282		1,794		2,030			53
74	11	3,556		4,308		2,837		427,550		296		274	285	165,718		1,734		(830)			-171
74	12	(2)	109,415	4,538	69,975	1,246	68,692	421,763	(29,251)	298		305	302	173,226	(1,587)	1,839	27,916	9,347	26,329	32,214	-2857211

CHLORIDE INFLOW TO LAKE MEREDITH

DATE		RESERVOIR WATER FLOW AND STORAGE (AF)								CHLORIDE CONCENTRATION (mg/l)				CHLORIDE TONNAGE							
		INFLOW		OUTFLOW		EVAPORATION		STORAGE						STORAGE (TONS)		OUTFLOW (TONS/YR)		INFLOW (TONS/YR)			AVG mg/l
YR	MO	MONTH	YEAR	MONTH	YEAR	MONTH	YEAR	END OF MONTH	END OF YEAR	AT TOWER	MID-LAKE	U/S END	AVG	TOTAL	ANNUAL CHANGE	MONTH	YEAR	MONTH	YEAR	AVERAGE	
75	1	3,232		4,393		1,602		419,000		296		404	310	176,650		1,768		5,192			1178
75	2	4,371		3,742		1,069		418,560		299		317	308	175,326		1,522		198			33
75	3	4,855		4,866		3,942		414,606		300		422	310	174,798		1,985		1,457			220
75	4	5,340		5,274		5,838		408,834		304		322	312	173,476		2,180		859			118
75	5	6,646		6,754		7,964		400,762		312		371	312	170,051		2,866		(559)			-62
75	6	30,466		7,137		7,841		416,250		310			315	178,322		3,009		11,279			272
75	7	31,994		6,449		7,386		434,409		308			315	186,101		2,701		10,481			240
75	8	7,691		7,298		8,257		426,545		306			320	185,632		3,037		2,569			245
75	9	(1,957)		6,559		6,044		411,985		305		325	325	182,097		2,721		(815)			305
75	10	(1,042)		5,867		5,702		399,375		307			325	176,524		2,449		(3,124)			2200
75	11	215		4,758		2,764		392,068		309			325	173,294		2,000		(1,230)			-4198
75	12	145	91,955	4,184	67,279	1,716	60,126	386,313	(35,450)	311			325	170,750	(2,476)	1,769	28,008	(774)	25,532	31,607	-3922
76	1	967		3,858		2,496		380,927		312			327	169,406		1,637		292			222
76	2	2,393		4,451		3,985		374,884		314		342	328	167,228		1,901		(277)			-85
76	3	2,959		4,790		5,048		368,005		317			330	165,161		2,065		(2)			-1
76	4	5,167		4,947		5,317		362,908		320			326	160,899		2,153		(2,109)			-299
76	5	7,105		6,245		6,004		357,764		321		328	325	158,132		2,726		(41)			-4
76	6	5,898		7,377		8,371		347,914		326			327	154,724		3,271		(137)			-17
76	7	4,144		6,964		7,157		337,937		332		329	328	150,747		3,144		(833)			-147
76	8	10,418		8,115		7,501		332,739		327			325	147,071		3,609		(67)			-5
76	9	41,553		5,887		4,402		364,003		322		201	320	158,414		2,578		13,921			246
76	10	2,592		4,763		3,478		358,355		322			320	155,956		2,086		(372)			-105
76	11	(15)		4,255		1,607		352,478		322			320	153,398		1,863		(694)			33298
76	12	969	84,150	3,698	65,350	1,641	57,006	348,107	(38,206)	321			324	153,390	(17,360)	1,615	28,648	1,606	11,287	29,913	1216
77	1	2,752		3,717		2,027		345,115		320		326	324	152,071		1,617		299			80
77	2	3,160		4,225		2,774		341,276		320			324	150,380		1,839		147			34
77	3	3,076		5,063		5,523		333,767		321			326	147,979		2,210		(191)			-45
77	4	9,623		4,910		4,618		333,861		321			324	147,113		2,144		1,277			97
77	5	14,137		5,317		5,504		337,177		322			322	147,657		2,328		2,873			149
77	6	6,002		7,161		7,983		328,035		323		328	324	144,545		3,146		35			4
77	7	7,159		8,391		9,050		317,754		321			324	140,015		3,663		(867)			-89
77	8	44,209		6,909		6,366		348,688		319			315	149,378		2,998		12,360			205
77	9	18,374		6,663		5,675		354,724		316		246	315	151,964		2,863		5,449			218
77	10	(1,367)		6,171		4,379		342,808		319			320	149,190		2,677		(97)			52
77	11	(998)		4,439		2,943		334,428		321			323	146,908		1,938		(345)			253
77	12	257	106,383	5,132	68,097	2,452	59,292	327,101	(21,006)	324			325	144,579	(8,811)	2,261	29,684	(68)	20,873	29,218	-193
78	1	549		4,913		1,393		321,344		324		332	328	143,345		2,165		931			1245
78	2	4,867		4,683		1,937		319,592		319			323	140,390		2,032		(923)			-139
78	3	3,486		5,648		3,700		313,731		314			318	135,682		2,412		(2,296)			-483
78	4	3,351		7,077		6,198		303,807		308		316	312	128,911		2,964		(3,807)			-833
78	5	20,174		6,232		5,110		312,639		308			313	133,084		2,611		6,783			247
78	6	42,262		6,446		7,275		341,180		308			314	145,698		2,700		15,313			266
78	7	3,748		8,284		9,450		327,194		308		322	315	140,170		3,470		(2,058)			-403
78	8	4,162		7,010		7,601		316,745		309			315	135,694		2,946		(1,530)			-270
78	9	14,705		5,579		5,450		320,421		310			314	136,833		2,352		3,491			174
78	10	6,327		5,426		4,027		317,295		312		316	314	135,498		2,302		967			112
78	11	724		4,365		1,378		312,276		319			320	135,903		1,894		2,299			2328
78	12	(304)	104,052	5,110	70,773	1,534	55,052	305,328	(21,773)	326			326	135,370	(9,208)	2,266	30,113	1,733	20,905	28,624	-4183
79	1	2,540		5,128		1,874		300,866		333			332	135,847		2,323		2,799			808
79	2	2,228		4,846		1,981		296,267		340			338	136,188		2,241		2,582			850
79	3	3,547		5,220		3,320		291,274		348		342	345	136,666		2,471		2,948			610
79	4	3,459		6,385		3,998		284,351		348			345	133,417		3,022		(227)			-48
79	5	6,466		6,756		5,091		278,970		348			345	130,893		3,197		673			76
79	6	17,587		6,473		5,562		284,523		348			345	133,498		3,063		5,669			236
79	7	4,625		8,365		6,629		274,154		348			345	128,633		3,959		(906)			-144
79	8	21,447		7,499		5,808		282,294		348		342	345	132,452		3,549		7,368			252
79	9	8,236		6,847		4,883		278,800		346			346	131,192		3,222		1,982			175
79	10	554		7,234		4,971		267,149		344			347	126,073		3,384		(1,735)			-2298
79	11	4,172		5,211		2,094		264,016		342			349	125,313		2,424		1,663			292
79	12	1,969	76,832	5,642	75,606	2,286	48,497	258,056	(47,272)	340			350	122,835	(12,536)	2,609	35,464	131	22,928	28,244	49

CHLORIDE INFLOW TO LAKE MEREDITH

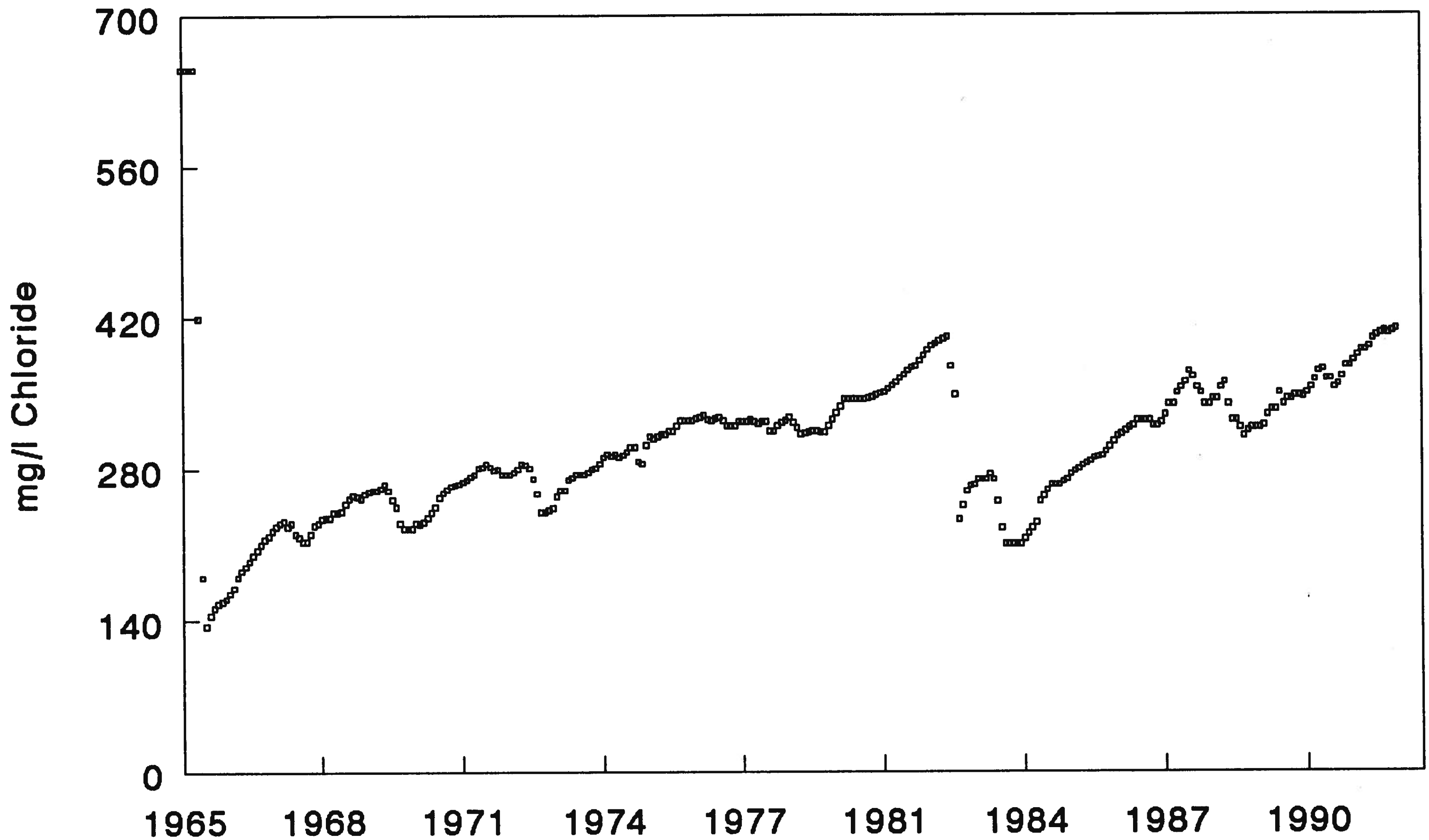
DATE		RESERVOIR WATER FLOW AND STORAGE (AF)								CHLORIDE CONCENTRATION (mg/l)				CHLORIDE TONNAGE							
		INFLOW		OUTFLOW		EVAPORATION		STORAGE						STORAGE (TONS)		OUTFLOW (TONS/YR)		INFLOW (TONS/YR)			AVG mg/l
YR	MO	MONTH	YEAR	MONTH	YEAR	MONTH	YEAR	END OF MONTH	END OF YEAR	AT TOWER	MID-LAKE	U/S END	AVG	TOTAL	ANNUAL CHANGE	MONTH	YEAR	MONTH	YEAR	AVERAGE	
80	1	4,356		4,979		1,077		256,356		339		363	351	122,374		2,296		1,835			309
80	2	10,660		5,059		1,542		260,415		a 344			354	125,374		2,367		5,367			369
80	3	6,637		6,035		3,447		257,570		a 349			357	125,055		2,864		2,546			281
80	4	3,551		6,374		4,253		250,494		354		NA	360	122,642		3,069		655			135
80	5	16,339		6,655		4,549		255,629		a 358			364	126,547		3,240		7,145			321
80	6	12,063		8,235		6,965		252,493		a 362			367	126,024		4,054		3,532			215
80	7	1,264		9,804		8,045		235,908		a 366			371	119,030		4,860		(2,115)			−1227
80	8	8,096		9,004		7,181		227,818		a 370			374	115,877		4,531		1,379			125
80	9	(166)		7,210		4,235		216,208		371		378	375	110,266		3,638		(1,974)			8748
80	10	(957)		6,120		3,755		205,375		a 376			380	106,138		3,130		(999)			765
80	11	191		5,523		1,500		198,542		a 381			385	103,957		2,862		681			2620
80	12	1,057	63,089	5,655	80,653	1,141	47,690	192,803	(65,253)	a 386			390	102,263	(20,572)	2,969	39,899	1,275	19,327	27,687	885
81	1	814		4,778		973		187,866		390		397	394	100,666		2,534		938			845
81	2	1,422		4,463		2,108		182,697		a 394			396	98,393		2,402		129			67
81	3	4,321		4,985		2,591		179,442		a 398			398	97,128		2,698		1,433			243
81	4	2,921		5,943		3,992		172,428		a 402			400	93,801		3,249		(78)			−20
81	5	4,964		6,845		3,854		166,693		405		399	402	91,134		3,770		1,104			163
81	6	17,479		7,816		5,224		171,132		a 398			375	87,277		4,231		374			16
81	7	15,305		8,803		5,206		172,428		392		306	349	81,841		4,693		(743)			−36
81	8	138,915		6,727		4,619		299,997		289		177	233	95,063		2,644		15,866			84
81	9	44,388		5,935		4,043		334,407		a 270			246	111,879		2,179		18,995			314
81	10	7,102		5,371		3,046		333,092		251		266	259	117,328		1,833		7,283			752
81	11	3,628		5,219		1,964		329,537		a 256			264	118,317		1,817		2,806			567
81	12	1,497	242,756	5,700	72,605	1,551	39,171	323,783	130,980	a 265			265	116,691	14,429	2,054	34,106	429	48,535	28,913	210
82	1	2,517		5,542		2,765		317,993		265		297	270	116,767		1,997		2,073			604
82	2	3,991		4,751		2,523		314,710		a 265			270	115,562		1,712		507			93
82	3	4,368		5,820		4,246		309,012		a 265			270	113,469		2,098		5			1
82	4	2,919		5,803		5,422		300,706		265		285	275	112,464		2,091		1,086			273
82	5	7,867		4,329		4,600		299,644		a 265			270	110,029		1,560		(875)			−82
82	6	39,357		5,234		5,441		328,326		a 255			250	111,631		1,815		3,417			64
82	7	70,940		7,535		6,975		384,756		251		109	225	117,735		2,572		8,677			90
82	8	53,011		8,052		7,244		422,471		a 235			210	120,658		2,573		5,496			76
82	9	18,270		7,057		6,038		427,646		225		160	210	122,136		2,159		3,637			146
82	10	20,175		5,029		5,119		437,673		215		195	210	124,999		1,470		4,334			158
82	11	16,008		5,345		3,779		444,557		215		210	210	126,965		1,563		3,529			162
82	12	11,136	250,559	5,111	69,608	1,700	55,852	448,882	125,099	210		190	210	128,201	11,509	1,460	23,072	2,695	34,581	29,228	178
83	1	8,910		4,184		948		452,660		225		246	215	132,358		1,280		5,437			448
83	2	14,368		4,522		833		461,673		215		255	220	138,133		1,322		7,097			362
83	3	9,716		5,440		2,763		463,186		215		255	225	141,735		1,591		5,193			392
83	4	7,191		5,481		4,965		459,931		241		272	230	143,866		1,796		3,928			401
83	5	8,620		6,690		6,786		455,075		248		273	250	154,726		2,256		13,115			1116
83	6	13,103		6,793		7,231		454,154		252		275	255	157,501		2,328		5,103			286
83	7	2,652		9,139		9,994		437,673		256		258	260	154,761		3,182		442			122
83	8	1,771		9,632		8,655		421,157		a 235		220	265	151,785		3,078		102			42
83	9	(1,189)		7,555		7,452		404,961		a 245			265	145,948		2,517		(3,320)			2048
83	10	47		4,816		4,008		396,184		a 249			265	142,785		1,631		(1,532)			−23918
83	11	(2,044)		3,880		2,410		387,850		a 253			268	141,364		1,335		(86)			31
83	12	(1,826)	61,319	5,002	73,134	976	57,021	380,046	(68,836)	a 257			270	139,553	11,352	1,748	24,066	(82)	35,418	29,554	25
84	1	1,291		5,863		1,108		374,366		a 263			275	140,013		2,097		2,557			1453
84	2	1,612		4,900		2,630		368,448		a 268			278	139,303		1,786		1,076			490
84	3	3,734		5,585		3,508		363,089		a 270			280	138,264		2,051		1,012			199
84	4	6,696		6,197		5,606		357,982		a 273			283	137,780		2,301		1,817			199
84	5	5,389		8,009		7,262		348,100		277		310	285	134,924		3,017		161			22
84	6	13,409		6,675		7,503		347,331		a 280			287	135,570		2,542		3,189			174
84	7	3,017		8,975		8,468		332,905		286		294	290	131,298		3,491		(782)			−190
84	8	20,945		7,433		6,151		340,266		a 289			291	134,664		2,921		6,287			220
84	9	(1,515)		7,716		5,680		325,355		291		293	292	129,205		3,054		(2,405)			1165
84	10	7,383		5,330		3,071		324,337		a 294			296	130,565		2,131		3,491			347
84	11	3,165		4,684		2,443		320,375		a 297			300	130,713		1,892		2,040			473
84	12	4,269	69,395	4,361	75,728	1,100	54,530	319,183	(60,863)	a 299			305	132,397	(7,156)	1,773	29,056	3,457	21,900	29,171	594

CHLORIDE INFLOW TO LAKE MEREDITH

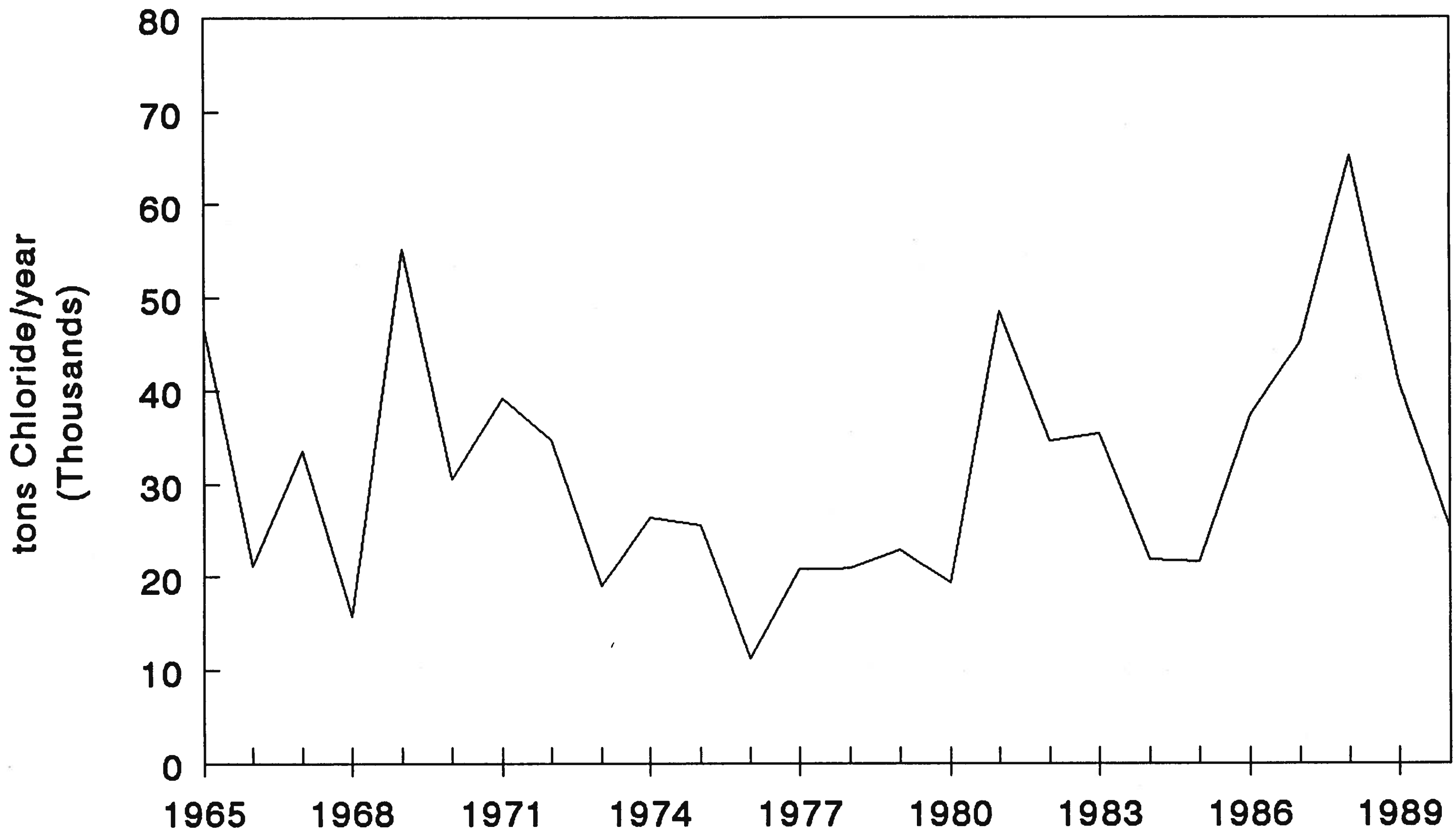
DATE		RESERVOIR WATER FLOW AND STORAGE (AF)								CHLORIDE CONCENTRATION (mg/l)					CHLORIDE TONNAGE							
		INFLOW		OUTFLOW		EVAPORATION		STORAGE							STORAGE (TONS)		OUTFLOW (TONS/YR)		INFLOW (TONS/YR)			AVG mg/l
YR	MO	MONTH	YEAR	MONTH	YEAR	MONTH	YEAR	END OF MONTH	END OF YEAR		AT TOWER	MID-LAKE	U/S END	AVG	TOTAL	ANNUAL CHANGE	MONTH	YEAR	MONTH	YEAR	AVERAGE	
85	1	1,914		4,936		905		315,256			301		354	310	132,912		2,021		2,536			972
85	2	3,563		5,252		1,396		312,170		a	303			312	132,460		2,164		1,712			353
85	3	9,855		4,071		3,153		314,801		a	305			315	134,861		1,689		4,089			304
85	4	5,365		6,570		4,764		308,832		a	316		361	318	133,564		2,824		1,526			209
85	5	7,699		7,319		5,395		303,817		a	325			320	132,221		3,235		1,892			180
85	6	5,866		6,405		6,193		297,085		a	335			325	131,312		2,918		2,009			251
85	7	3,061		8,878		7,480		283,788			344		350	325	125,434		4,153		(1,724)			-413
85	8	2,825		8,218		5,635		272,760		c	325		325	325	120,560		3,632		(1,242)			-323
85	9	14,588		7,258		5,060		275,030		c	325		330	325	121,563		3,208		4,211			212
85	10	19,300		5,227		2,476		286,627		c	320		305	320	124,740		2,275		5,452			207
85	11	1,776		4,626		1,873		281,904		c	315		325	320	122,685		1,982		(74)			-30
85	12	1,060	76,871	5,612	74,371	804	45,133	276,549	(42,634)	c	320		345	323	121,482	(10,915)	2,442	32,543	1,240	21,626	28,812	858
86	1	2,532		4,041		1,945		273,095			353		375	330	122,565		1,940		3,023			876
86	2	5,485		4,429		1,644		272,508		c	335		365	340	126,008		2,018		5,460			730
86	3	4,041		5,899		3,727		266,924		c	320		330	340	123,426		2,567		(15)			-3
86	4	2,836		7,520		5,153		257,087			361		375	350	122,373		3,692		2,640			683
86	5	3,702		7,436		5,257		248,096		c	355		350	355	119,781		3,590		997			198
86	6	16,641		5,069		4,362		255,306		c	335		230	360	124,998		2,309		7,526			332
86	7	3,062		8,004		7245		243,119			377		377	370	122,337		4,104		1,444			346
86	8	8,662		7,622		4948		239,211		c	360			365	118,744		3,732		139			12
86	9	31573		5341		4365		261,078		a	350			355	126,048		2,542		9,846			229
86	10	7930		4392		2146		262,471		a	345			350	124,936		2,060		948			88
86	11	18157		3604		2079		274,945		c	340		340	340	127,135		1,666		3,865			156
86	12	4111	108734	4170	67525	783	43655	274,103	(2,446)	c	335	340	380	340	126,745	5,263	1,900	32,121	1,510	37,383	29,202	270
87	1	4397		3455		1278		273,767		a	340			345	128,451		1,598		3,304			551
87	2	6666		4063		1792		274,777		c	345	345	375	345	128,925		1,907		2,380			254
87	3	8571		4419		2804		276,126		c	355	360	390	355	133,314		2,133		6,522			558
87	4	13614		6758		4005		279,177		a	360			360	136,685		3,309		6,680			355
87	5	55527		6643		4925		323,136		c	360	355	240	340	149,418		3,252		15,985			211
87	6	30296		6179		5657		341,596		c	330	315	235	325	150,985		2,773		4,340			105
87	7	14328		7900		7379		340,645		a	320			325	150,565		3,438		3,018			155
87	8	15330		7443		6460		342,072		c	315	290	305	318	147,939		3,189		563			27
87	9	13765		4642		4248		346,947		c	310	305	285	310	146,273		1,957		291			15
87	10	1540		5232		3749		339,506		a	310			315	145,444		2,206		1,377			656
87	11	263		4120		2181		333,468		a	305			318	144,218		1,709		483			1345
87	12	1913	166609	3487	64341	1143	45620	330,751	56,648	c	305	310	325	318	143,043	16,298	1,446	28,917	271	45,215	29,898	104
88	1	3950		4622		1381		328,698			344		352	318	142,155		2,162		1,274			237
88	2	2702		4633		2152		324,614		c	330	325	345	320	141,272		2,079		1,196			325
88	3	6028		5065		3455		322,122		c	320	340	355	330	144,569		2,204		5,501			669
88	4	10837		6405		4617		321,938		c	330	335	355	335	146,675		2,874		4,981			337
88	5	10591		6101		5961		320,467		c	335	330	345	335	146,005		2,780		2,110			146
88	6	39585		6386		6431		347,235		c	355	350	435	350	165,284		3,083		22,362			414
88	7	34690		6743		6535		368,647		c	350	345	125	340	170,463		3,210		8,388			177
88	8	5614		8033		6583		359,646		c	340	340	345	345	168,746		3,714		1,998			261
88	9	36853		4993		4897		386,610		c	350	350	355	345	181,398		0		15,028			299
88	10	2281		4631		4316		379,944		c	345	335	320	348	179,820		2,173		596			192
88	11	5912		4282		3259		378,315		c	340	335	350	348	179,049		1,980		1,209			150
88	12	4436	163481	5072	66967	2100	51686	375,578	44,827	c	345	345	345	347	177,243	34,200	2,380	31,017	574	65,217	31,370	95
89	1	2909		3715		2217		372,554		c	345	345	350	350	177,336		1,743		1,836			463
89	2	4253		4273		3088		369,446		a	350			355	178,369		2,034		3,067			529
89	3	5140		6014		5187		363,385		c	360	360	370	362	178,902		2,944		3,477			496
89	4	3756		6731		5738		354,672		c	365	370	385	370	176,471		3,341		2,911			568
89	5	22905		7160		6044		364,374		c	370	370	380	372	184,344		3,603		9,476			303
89	6	25743		5900		5800		378,417		c	360	360	360	363	186,817		2,889		5,362			153
89	7	8599		7978		7889		371,148		c	360	360	350	363	183,229		3,906		318			27
89	8	18457		7348		5970		376,287		c	365	365	325	355	181,672		3,647		2,090			83
89	9	11589		5485		5699		376,692		c	365	360	345	358	183,404		2,723		4,455			282
89	10	-2415		6042		4553		363,682		c	365	360	360	365	180,532		2,999		127			-39
89	11	8585		4534		3359		364,374		c	375	370	380	375	185,831		2,312		7,611			650
89	12	775	110295	3683	68662	544	56069	360,922	(14,656)	c	365	375	390	375	184,070	6,827	1,828	33,970	68	40,797	31,747	64

LAKE MEREDITH

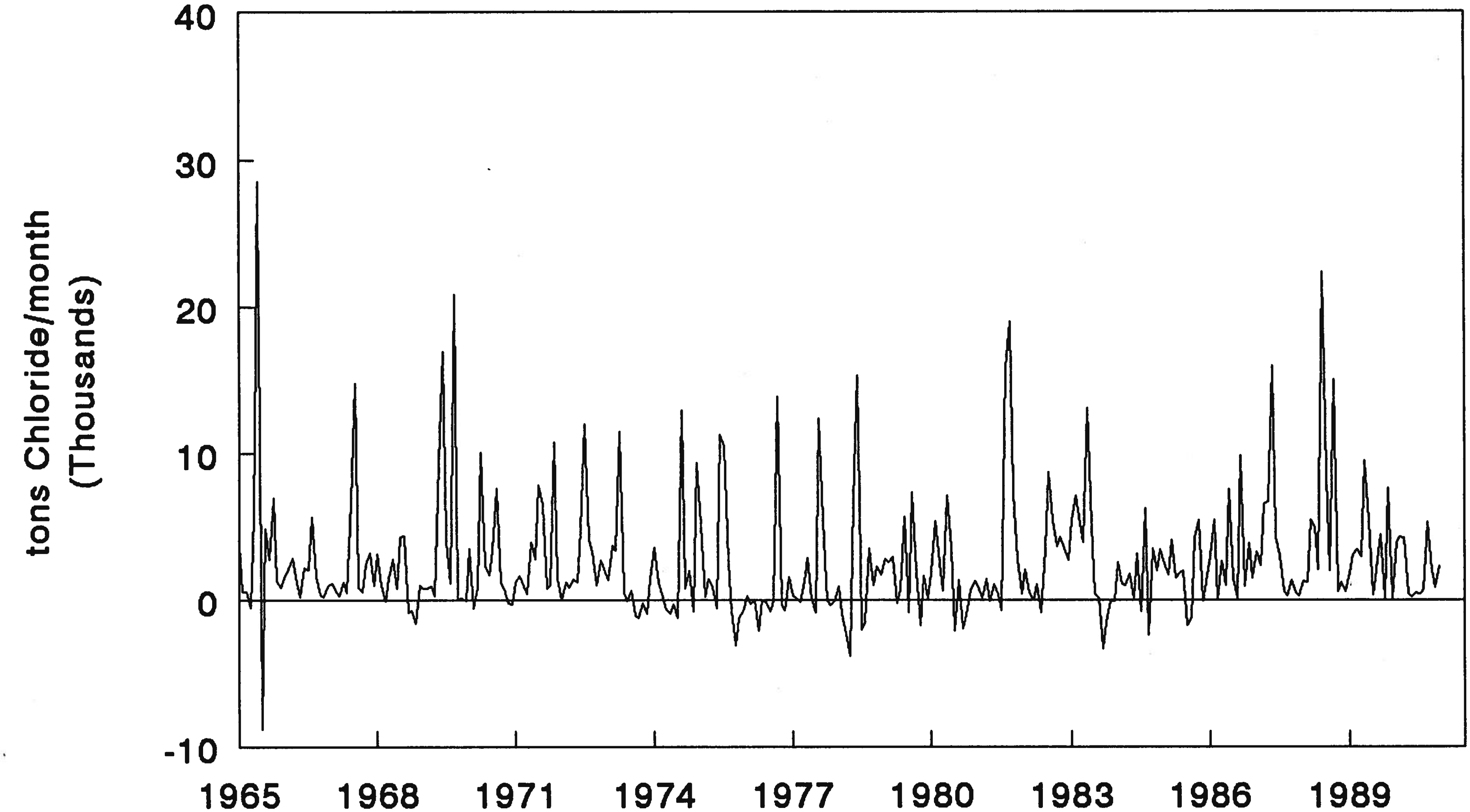
Salt Concentration Variation over Time



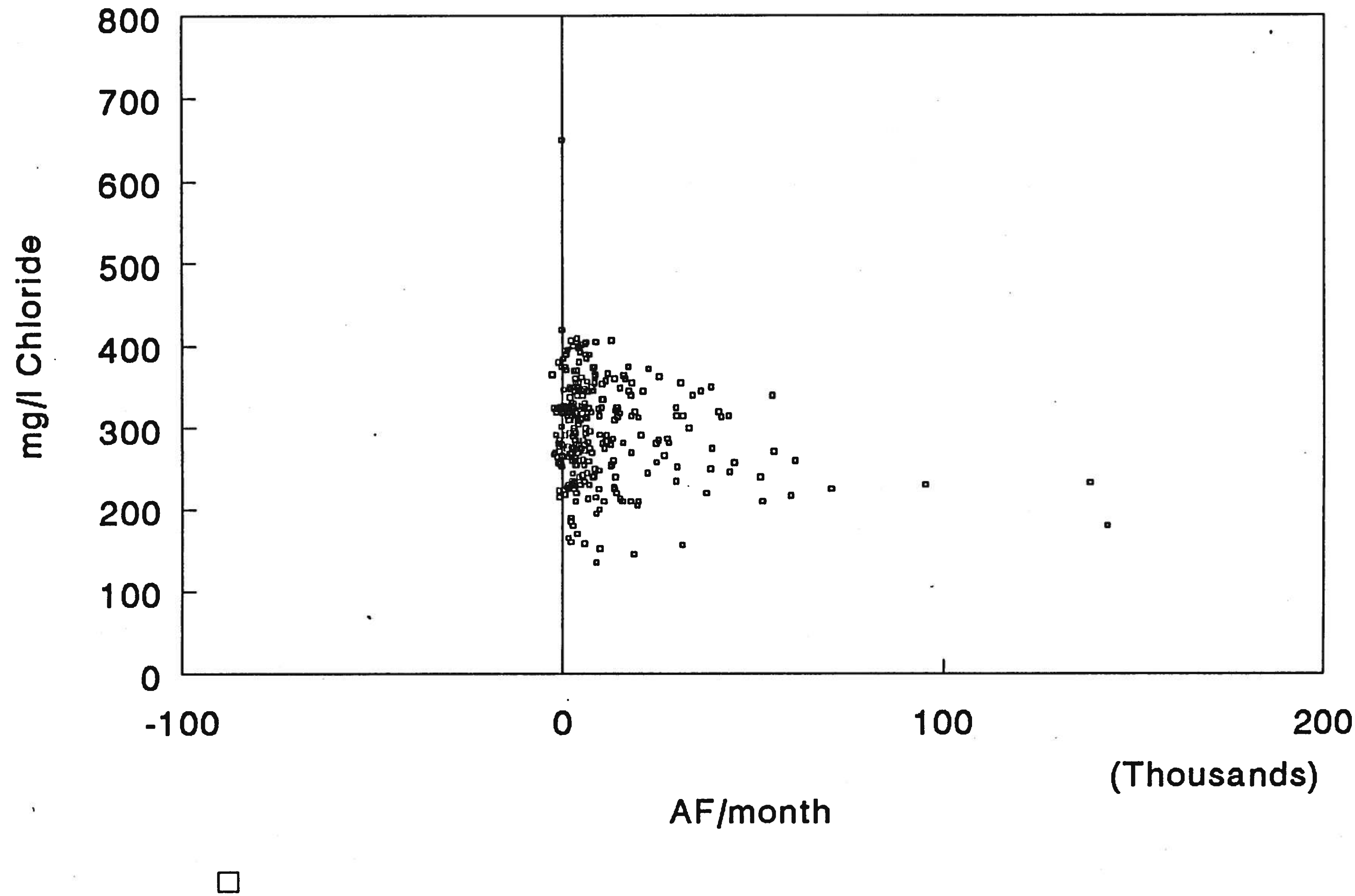
LAKE MEREDITH
Yearly Salt Inflow



LAKE MEREDITH
Monthly Salt Inflow

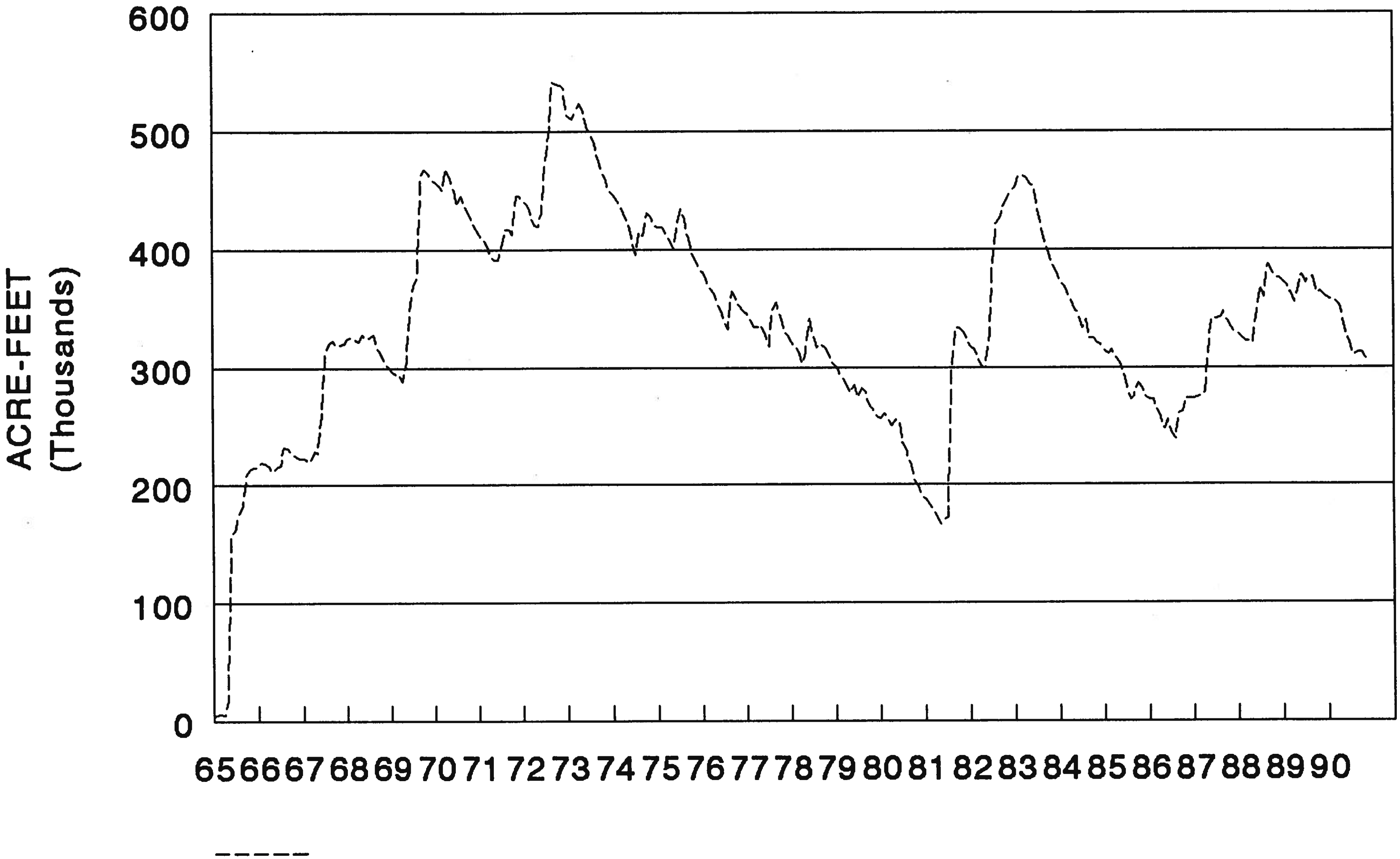


LAKE MEREDITH
Salt Concentration vs. Inflow



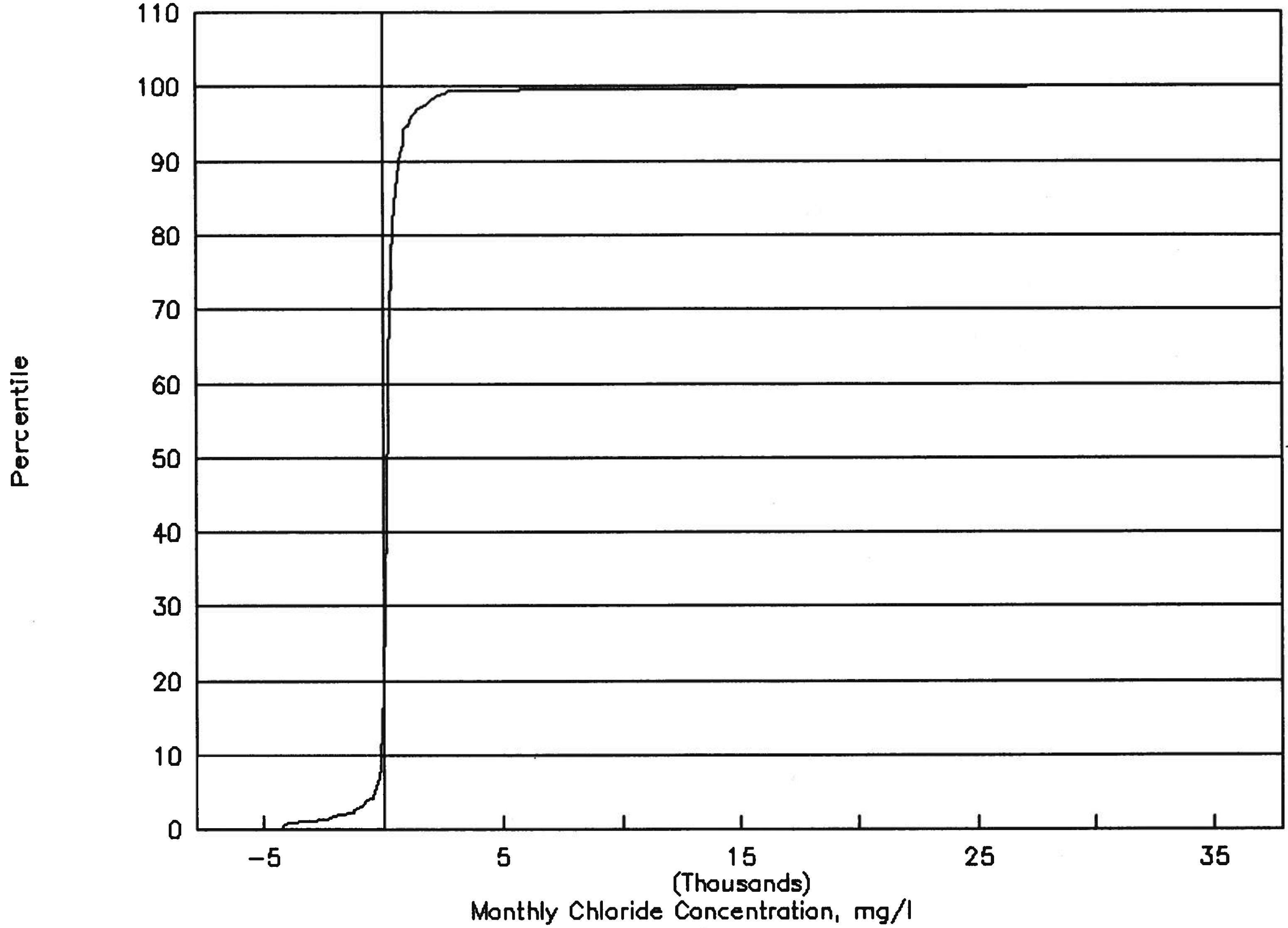
LAKE MEREDITH

Historical Storage



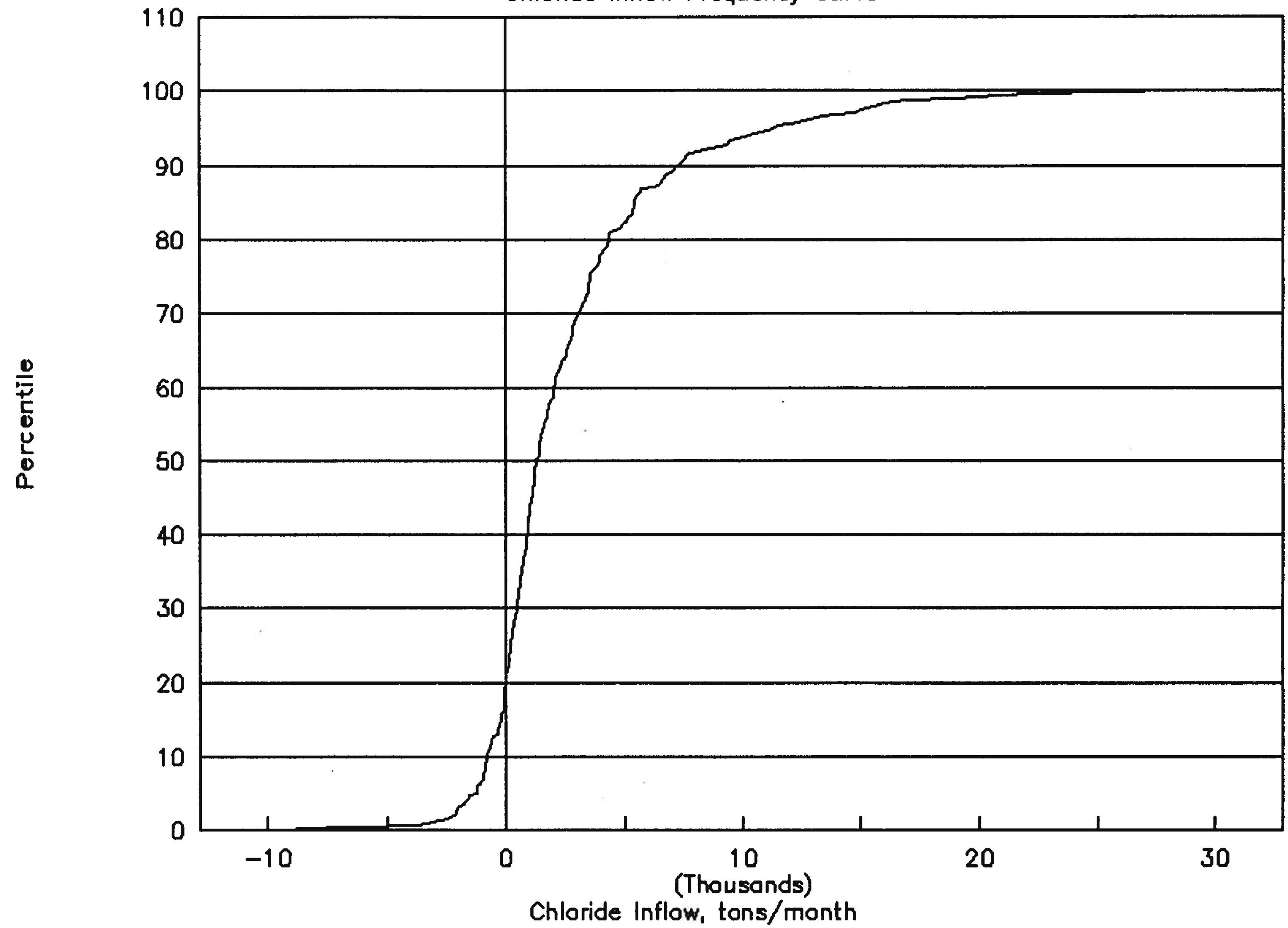
LAKE MEREDITH

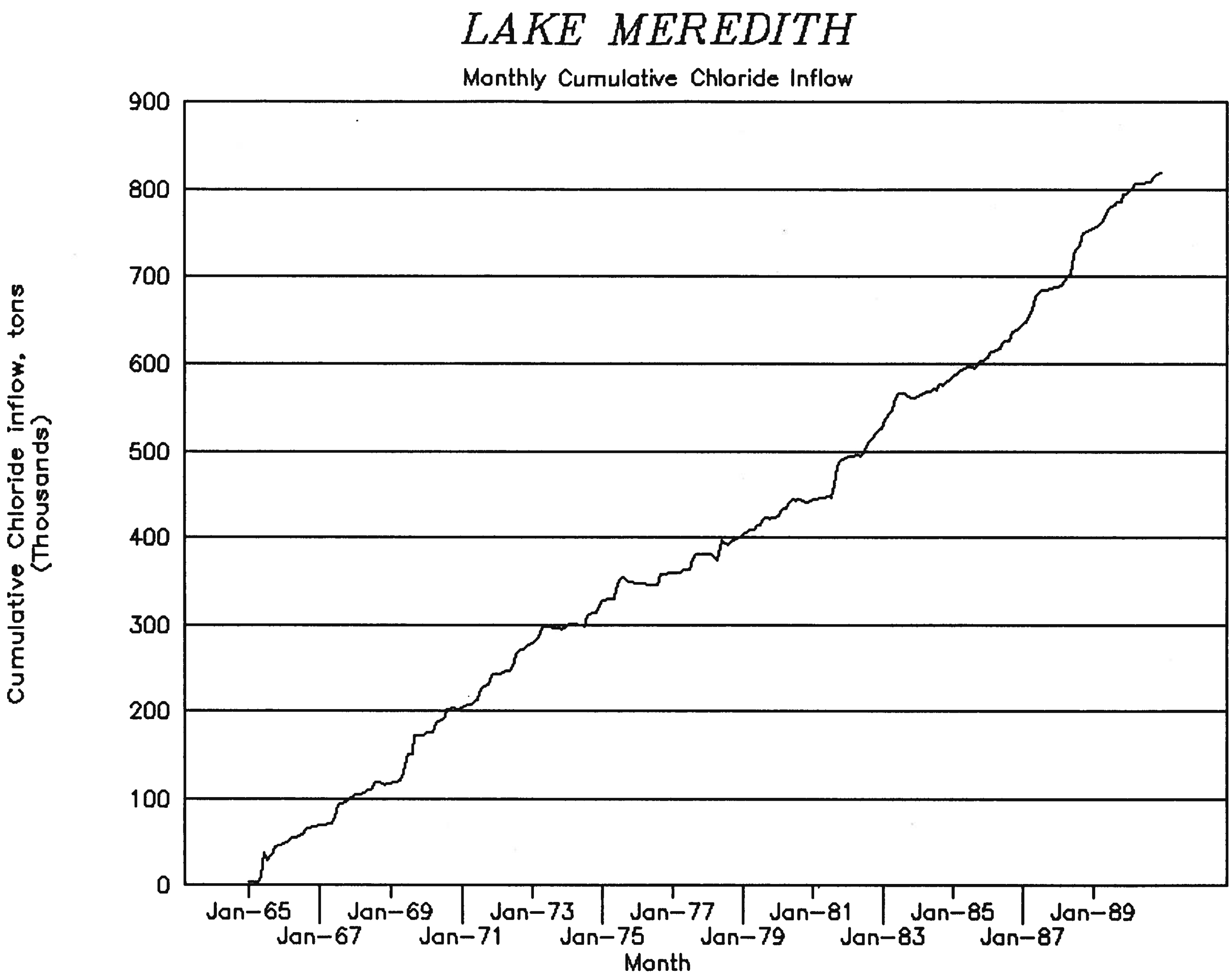
Chloride Concentration Frequency Curve



LAKE MEREDITH

Chloride Inflow Frequency Curve




LAKE MEREDITH
Monthly Cumulative Chloride Inflow
Cumulative Chloride inflow, tons
(Thousands)
0
100
200
300
400
500
600
700
800
900
Jan-65
Jan-67
Jan-69
Jan-71
Jan-73
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Month

CRMWA Monitoring of Canadian River and Tributaries, 1970–1991, Page 1

STATION	Conchas Reservoir Spilling water	Conchas Reservoir	Ute Lake Discharge	Ute Lake	Ute Lake	Ute Lake	Ute Lake	Ute Lake	Ute Reservoir Releasing water	Ute Reservoir	Ute Reservoir	Below Ute Dam 1/4 mile
RIVER MILE	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25
SAMPLE DATE	4-28-87	4-26-91	08-13-71	10-03-73	04-12-77	02-24-81	08-24-81	02-10-83	04-28-87	07-27-90	04-26-91	01-28-72
Alkalinity, P. (as Ca CO_3), mg/l		8	0		10.0	14	8	0			14	0
Alkalinity, M. (as $CaCO_3$), mg/l		140	180		352.6	234	170	160			176	320
Bicarbonate, mg/l			220									460
Calcium, mg/l			56									184
Calcium (as $CaCO_3$), mg/l		180				52.0					130	
Carbonate, mg/l			0									
Chloride, mg/l	25	5	38	10	48.0	33.0	29.0	25	40	45	40	1500
Conductivity, umhos/cm	964	804		990	1100	250		750	990	952	969	
Conductivity, Field, umhos/cm							700					
Conductivity, Lab, umhos/cm							650					
Hardness, Total (as $CaCO_3$), mg/l		304	140								258	380
Hydroxide, mg/l												
Magnesium, mg/l			34									96
Magnesium (as $CaCO_3$), mg/l		124									128	
Manganese, mg/l												0
pH, pH units	8.12	8.30	7.8	7.9	8.58	8.29	8.3	8.04	7.91	8.22	8.37	7.6
Phosphate, mg/l												0
Silica, mg/l												
Sodium, mg/l						21.45	18.8					
Sulfate, mg/l		263	160	200	350.0	103		109			225	230
Temperature, °C							26					
Total Dissolved Solids, mg/l												
Total Dissolved Solids, Calculated , mg/l			589			458						

CRMWA Monitoring of Canadian River and Tributaries, 1970–1991, Page 2

STATION	River Below Ute Dam	River at Hwy 54	River at Hwy 54	River at Hwy 54	River at Hwy 54	River at Hwy 54	Canadian River at Hwy 54	River at Hwy 54	River at Hwy 54	River at Hwy 54	River at Hwy 54
RIVER MILE	?	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
SAMPLE DATE	11–17–70	11–17–70	04–20–71	01–28–72	10–03–73	04–12–77	02–24–81	08–24–81	02–10–83	03–14–85	04–28–87
Alkalinity, P. (as Ca CO_3), mg/l	0	0	0	0		4.0		0	14		
Alkalinity, M. (as $CaCO_3$), mg/l	344	372	344	360		328.0	372	148	238		
Bicarbonate, mg/l	420	454	420	436							
Calcium, mg/l	104	166	325	345							
Calcium (as $CaCO_3$), mg/l							346.0				
Carbonate, mg/l	0	0	0								
Chloride, mg/l	1740	3050	3075	3300	3100	3100.0	3450	55.0	1200	4900	55
Conductivity, umhos/cm					11200	9500	5600		5000	11738	996
Conductivity, Field, umhos/cm								700			
Conductivity, Lab, umhos/cm								650			
Hardness, Total (as $CaCO_3$), mg/l	435	655	660	660							
Hydroxide, mg/l	0	0									
Magnesium, mg/l	42	58	124	130							
Magnesium (as $CaCO_3$), mg/l											
Manganese, mg/l			0	0							
pH, pH units	7.60	8.10	7.9	7.7	7.5	8.31	7.68	8.0	7.78	8.1	8.16
Phosphate, mg/l			0	0							
Silica, mg/l			13.5								
Sodium, mg/l							2242.5	35.7			
Sulfate, mg/l	360	440	450	460	387.5	737.5	1360		2725		
Temperature, °C								25			
Total Dissolved Solids, mg/l	3929	6222									
Total Dissolved Solids, Calculated , mg/l			6347.79				7770				

CRMWA Monitoring of Canadian River and Tributaries, 1970–1991, Page 3

STATION	River at Hwy 54	Canadian River at Hwy 54	River on Terry Ranch State Line	River at State Line	River at State Line	River at State Line	River at State Line	River at Hwy 385	River at Hwy 385	River at Hwy 385	Canadian River at Hwy 385	River at Highway 87–287
RIVER MILE	2.2	2.2	30	30	30	30	30	70	70	70	70	100
SAMPLE DATE	07–27–90	04–26–91	05–28–74	10–03–73	04–12–77	08–24–81	07–27–90	08–24–81	03–14–85	04–28–87	04–26–91	08–24–81
Alkalinity, P. (as Ca CO_3), mg/l		2			8.0	4		6			6	0
Alkalinity, M. (as $CaCO_3$), mg/l		326			222.0	166		176			232	180
Bicarbonate, mg/l												
Calcium, mg/l											529	
Calcium (as $CaCO_3$), mg/l		300										
Carbonate, mg/l												
Chloride, mg/l	2400	2450	1287.5	862.5	2250.0	205.0	1250	255.0	850	110	1300	260.0
Conductivity, umhos/cm	7660	7868	5500	4600	8400		4408		5440	1122	4996	
Conductivity, Field, umhos/cm						1250		1500				1600
Conductivity, Lab, umhos/cm						1100		1400				1400
Hardness, Total (as $CaCO_3$), mg/l		550									540	
Hydroxide, mg/l												
Magnesium, mg/l												
Magnesium (as $CaCO_3$), mg/l		250									11	
Manganese, mg/l												
pH, pH units	7.86	8.05		7.8	8.54	8.0	8.17	8.1	7.90	8.19	8.23	7.9
Phosphate, mg/l												
Silica, mg/l												
Sodium, mg/l						133.2		165.7				169.0
Sulfate, mg/l		388	550	475	437.0						388	
Temperature, °C						25		22				24

CRMWA Monitoring of Canadian River and Tributaries, 1970–1991, Page 4

STATION	River at Highway 87–287	Canadian River at Hwy 87–287	Revuelto Creek	Revuelto Creek	Revuelto Creek at Hwy 39	Revuelto Creek	Revuelto Creek At Hwy 39	Punta de Agua at Hwy 762	Punta de Agua Creek	Punta de Agua Creek at Hwy 767	Big Blue Creek at Hwy 1913
RIVER MILE	100	100	–	–	–	–	–	–	–	–	–
SAMPLE DATE	03–14–85	04–26–91	04–20–71	02–24–81	08–24–81	02–10–83	4–26–91	08–24–81	02–10–83	04–26–91	04–26–91
Alkalinity, P. (as Ca CO_3), mg/l		0	0	10	6	0	4	16	24	16	8
Alkalinity, M. (as $CaCO_3$), mg/l		154	178	256	178	140	172	264	322	330	240
Bicarbonate, mg/l			217								
Calcium, mg/l			160								
Calcium (as $CaCO_3$), mg/l		450		136.0			170			100	120
Carbonate, mg/l			0								
Chloride, mg/l	900	1465	46	450	135.0	10	75	25.0	<.5	10	5.0
Conductivity, umhos/cm	3240	6640		1400		600	1724		800	827	697
Conductivity, Field, umhos/cm					1400			750			
Conductivity, Lab, umhos/cm					1200			700			
Hardness, Total (as $CaCO_3$), mg/l		772	290				392			308	230
Hydroxide, mg/l											
Magnesium, mg/l			44								
Magnesium (as $CaCO_3$), mg/l		322					222			22	110
Manganese, mg/l			0								
pH, pH units	7.89	7.89	8.1	8.01	8.3	8.18	7.90	8.1	8.28	8.47	8.16
Phosphate, mg/l			0								
Silica, mg/l			12.0								
Sodium, mg/l				292.5	87.7			16.2			
Sulfate, mg/l		700	360	637		94	500		71	150	225
Temperature, °C					30			25			
Total Dissolved Solids, mg/l											
Total Dissolved Solids, Calculated , mg/l			891.93	1781							

Notes:

Ashby Lewis's 1973 River Survey is reported separately at Tab 8.

River mile designations are approximate, based on small–scale maps.

Some analyses include the temperature at which the conductivity was measured; these temperatures are not included here.

Some analyses report a calculated sodium value; because the method of calculation is not explained, the calculated sodium values have not been included here.

Canadian River Survey - February 10 thru 18 1992

ID	Location	CRMWA Cond.	BEG Cond.	LWA Cond.	BEG Strips Cl (mg/l)	BEG Cl (mg/l)	CRMWA Cl (mg/l)	BEG Sulfate (mg/l)	CRMWA Sulfate (mg/l)	CRMWA Flow (cfs)	CRMWA Temp (C)	LWA Temp (C)	CRMWA pH	Date	Cl Loading (Tons/Yr)	Notes
0	Ute Reservoir				45	49		281								
1	Ute Toe Drain	1283.6	975	1230			137.5		225	~.5-1	14	13.5	8.4	2/10/92		
2	Gate chamber ?	832.15	675	770			20		210			13		2/10/92		
3	Leakage through gate		725	880								14		2/10/92		
4	Seepage from S Bank Below Dam	776.8	650	710			10		210		10	9	8.4	2/10/92		
5	Waterfall below Spillway	212.4	775	820			25		220		13	10.5	8.2	2/10/92		
6	100 yds down form toe	1741.2	1790	2200							14	15.5	7.6	2/10/92		
7	200 yds	6664		2350	2678	2370		555			14	13.5		2/10/92		
8		2496	2300	2620	670	717	800	349	220	2.35	10	18.5	7.6	2/10/92	1851	
9		2610	2250	2000								16		2/10/92		
10		4008	3990	3550								15		2/10/92		
11		4940	4290	4550	1958	1750	2000	439	260		12	12	7.5	2/10/92		
12		4576		4550							10	11	7.6	2/10/92		
13		4636		5000	2138	1630		436			10	15	7.6	2/10/92		
14		4740		4500			2000		250		10	11	7.7	2/10/92		cond. varies with depth
15		4756	4300	4450							9.5	10	7.8	2/10/92		cond. varies with depth
16		4908	4600	4750							10	11	7.6	2/10/92		cond. varies with depth
17		5020	4675	4980	2138	1890	2020	451	225	3.84	10	11	7.8	2/10/92	7635	cond. varies with depth
18	Hwy 54 Bridge	5354	4800	5000							8	7.5	7.6	2/11/92		
19		4448	4150	4720							7	8.5	7.9	2/11/92		
20	150yds down from OW1	4498	4525	5000							8	8	7.8	2/11/92		
21		5750	5600	5900			2800		250		8	9	8.1	2/11/92		
22		5744	5800	5850								8.5		2/11/92		
23	Just above old & new RR bridge	5924	4680	5800						4.031		8		2/11/92		
24	Between RR Bridges (closer to new)	5300	6000	6000								8.5		2/11/92		
25		6564	6300	6500			2900		265		10	8.5		2/11/92		
26		6500		8000								6		2/11/92		
27	Oxbow 400yds down from RR Bridges	33400	43500	50000	6000+	21010	16500	2010	350	0.086				2/11/92		
28		7512	7200	6900								9		2/11/92		pH meter recalibrated
29		8050	8000	8000								10		2/11/92		
30	In River	8344		8000								10		2/11/92		
30B	Pool 3' from river	14000		14500								11		2/11/92		
30C	Pool 40' from river	10000		10000								7		2/11/92		
31		8116	5700	5600	4150	3415		615				9		2/11/92		upstream pool was 15500 cond.
31A		8172					2400			4.687	10			2/11/92	11073	cond. varies with depth

Canadian River Survey - February 10 thru 18 1992

ID	Location	CRMWA Cond.	BEG Cond.	LWA Cond.	BEG Strips Cl (mg/l)	BEG Cl (mg/l)	CRMWA Cl (mg/l)	BEG Sulfate (mg/l)	CRMWA Sulfate (mg/l)	CRMWA Flow (cfs)	CRMWA Temp (C)	LWA Temp (C)	CRMWA pH	Date	Cl Loading (Tons/Yr)	Notes
32		8592	7600	7500								9.5		2/11/92		
32B	Large puddle 15' N of river	28000	16900	25200								11		2/11/92		
33		9296	8500	9200								10.5		2/11/92		
34	Oxbow @ N wall	45680		>50000	6000+	24350	23000	2520	320	0.000		11		2/11/92		
35				9200								11		2/11/92		
36			8600	9200								11		2/11/92		
37			9500	10000								12		2/11/92		
38			9000	9500								10		2/11/92		
39			10000	10000								11		2/11/92		
40	Revuelto Creek		1690	1800	570	153	70	757	310	6.763		13.5		2/11/92	466	
41	Below Revuelto		5800	6000			2450		300	12.881		13		2/11/92	31065	7500 cond. in River
41A	Pool on N bank of river			14750	> 6000	5650		1120		0				2/11/92		CRMWA cond meter quit working
42			5900	6000								13		2/11/92		
42A	Pool on S river wall		28500	19700								12		2/11/92		
43	Average of evening and next morning		4725	5750								10.5		2/11&12/92		
44			5100	5000								8		2/12/92		
44A														2/12/92		
45			5300	5500								8		2/12/92		
46			6000	6150			2600		360			9		2/12/92		
47			6000	6000								9		2/12/92		
48			6000	6000								9.5		2/12/92		
49			5900	6100								11.5		2/12/92		
50			6000	6000			2400		320	12.991	10	10.5	8.4	2/12/92	30691	
51			6300	5900								13		2/12/92		
51A	Pool on N Bank			1310								12.5		2/12/92		
52			6100	5900								13.5		2/12/92		
53			5500	5900								14		2/12/92		
54			6500	6800			2450		675		15	14.5		2/12/92		
55			6200	6500								14.5		2/12/92		
56			6200	6500			2300		900			15		2/12/92		
57			5000	5900	2680		2400		425	12.084	9	7.5	8.4	2/13/92	28547	
58			5200	5900								8.5		2/13/92		
59			5000	5500								9		2/13/92		
60			4600	5200	2500	7870	8050	790	350			9.5		2/13/92		
60A	Unnamed tributary		15500	16200								9		2/13/92		

Canadian River Survey - February 10 thru 18 1992

ID	Location	CRMWA Cond.	BEG Cond.	LWA Cond.	BEG Strips Cl (mg/l)	BEG Cl (mg/l)	CRMWA Cl (mg/l)	BEG Sulfate (mg/l)	CRMWA Sulfate (mg/l)	CRMWA Flow (cfs)	CRMWA Temp (C)	LWA Temp (C)	CRMWA pH	Date	Cl Loading (Tons/Yr)	Notes
61			4900	5500								9		2/13/92		
62			6000	6000								10		2/13/92		
63			5000	5900								10		2/13/92		
64			5100	5100								10.5		2/13/92		
	In Rana Canyon 150yds up			1000								13.5		2/13/92		
65			5100	5900								11.5		2/13/92		
66			5000	5200								11.5		2/13/92		
66A	Spring on N wall		380	380						¯.02		15		2/13/92		
67	State Line		5000	4800	2500		2100		725	21.576	12	11.5	8.3	2/13/92	44601	
68			5100	5500								11.5		2/13/92		
69				4480								8		2/14/92		
70			3125	4510			1900		250	23.337	10	9	8.4	2/14/92	43647	
71			3710	4750								11		2/14/92		
72			4700	4850			1750					13	8.2	2/14/92		
73			4650	4820						23.084		14		2/14/92		
74			4225	4800								14		2/14/92		
74A	Trujillo	774	780	800			25			¯.04		18	8.2	2/14/92		
75			4258	4570								13		2/15/92		
76			4520	4670	2000	1560		538		24.716		14		2/15/92		
77			4300	4750								14		2/15/92		
78			4275	4350			1600					14	8.4	2/15/92		
79			4125	4220								17	8.1	2/15/92		
80			3000	3450	1500		1500			27.163	8	6	8.5	2/16/92	40106	
81			2850	3420								7		2/16/92		
82			2300	3050	1046	919	1200	482				7	8.4	2/16/92		
83			3375	3510								9		2/16/92		
84A			4700		1145	1060	1250	1090					8.2	2/16/92		
84B			3400		1250	1200	1250	563					8.1	2/16/92		
85	Punta de Agua		650	710	< 45	33	20	66		6.360		13	8.5	2/16/92	125	
86	Below Punta		3000	3010			1250			36.769		14	8.4	2/16/92	45242	
87			3200	3300								14		2/16/92		
88A	Alamosa Creek		2500	3220								15		2/16/92		
88B			1500											2/16/92		
88C			2900											2/16/92		
89			3150	3210	1200							14		2/16/92		

Canadian River Survey - February 10 thru 18 1992

ID	Location	CRMWA Cond.	BEG Cond.	LWA Cond.	BEG Strips Cl (mg/l)	BEG Cl (mg/l)	CRMWA Cl (mg/l)	BEG Sulfate (mg/l)	CRMWA Sulfate (mg/l)	CRMWA Flow (cfs)	CRMWA Temp (C)	LWA Temp (C)	CRMWA pH	Date	Cl Loading (Tons/Yr)	Notes
90			2150	2310			1000			34.161		3	8.8	2/17/92	33627	
91			2250	2300								4		2/17/92		
92	Spring S of River		1000	1020	< 300	217		78				9		2/17/92		
93	River @ Sierrita de la Cruz		2450	2450								9		2/17/92		
94			2110	2110			1250				6	9	8.2	2/17/92		
95			2690	2790	935		1100					9	8.3	2/17/92		
96A	Seeps 150ft up from Lahey		12500	12500	5500	4910		2160				11		2/17/92		
96B	Lahey Creek		13000	13200			5000			~.04	16	16	7.7	2/17/92		
96C	100ft downstream	3000												2/17/92		
96D	In river before Lahey	2900		2900										2/17/92		
97			2300	2300										2/17/92		
98			3200	3200	1250	1000		652				14		2/17/92		
98A	Puddles in Horse Creek		1280	1280								14		2/17/92		
99	River @ W Amarillo			3250								14		2/17/92		
99A	W Amarillo Creek			2180	436		500			~.08		10	8.2	2/17/92		
100	River @ E Amarillo		3200	3200								12		2/17/92		
	E Amarillo Creek		1700	1700								13		2/17/92		
101	Hwy 287-87		2300	2500			1050			34.838	2	2	8.4	2/18/92	36007	
102	Bonita Creek	2520	2410	2500								3		2/18/92		
103	Chicken Creek		240	220			20			0.903	3	3	8.4	2/18/92	18	
103A	River @ Chicken Creek	2500	2500	2500								3		2/18/92		

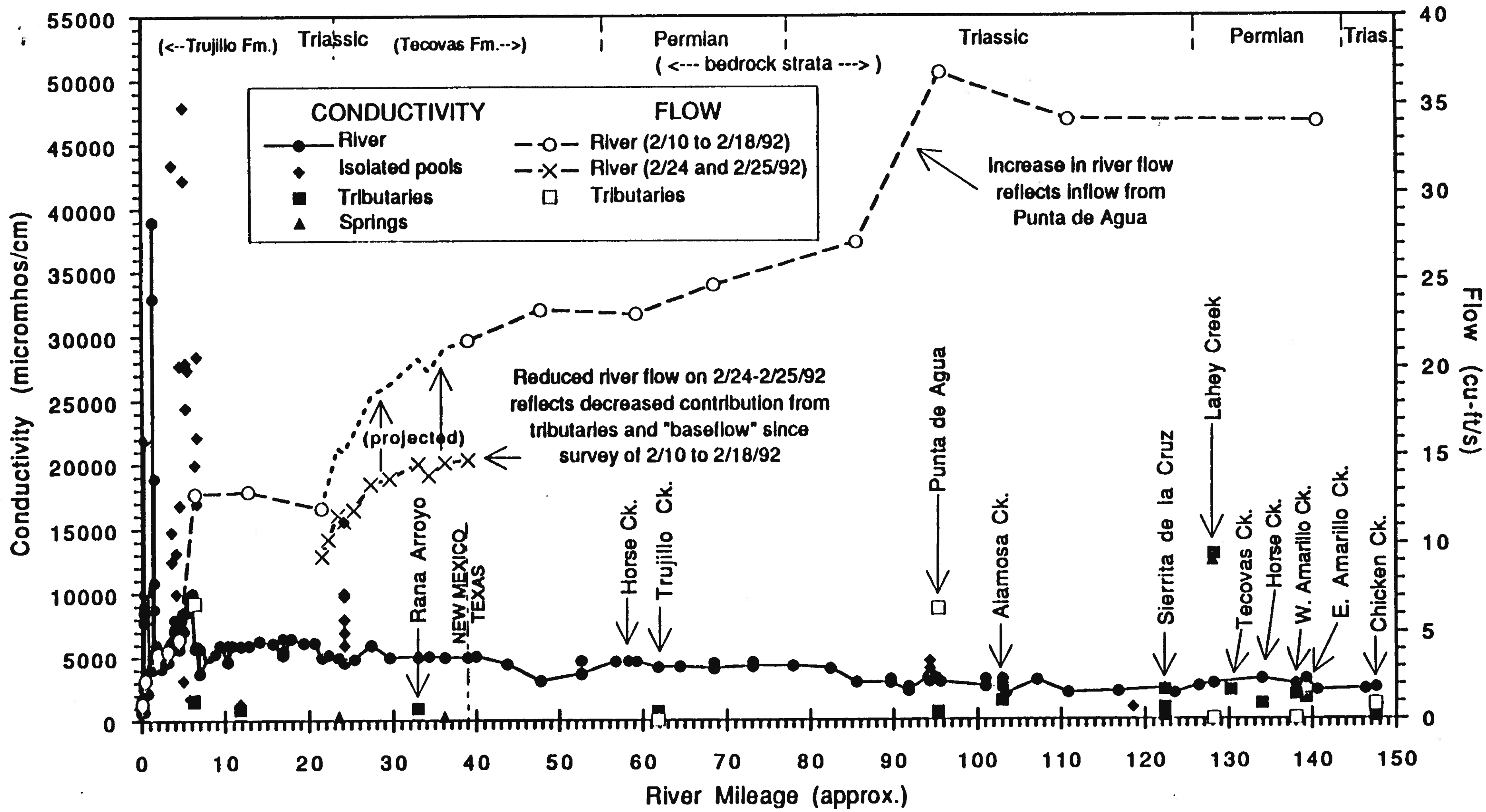


Figure 5. Plot of conductivity (scale on left) and flow (scale on right) along entire length of Canadian River survey, between Ute Reservoir, New Mexico and Lake Meredith, Texas; measurements taken in field 2/10 through 2/18/92 (main survey), and 2/24 and 2/25/92 (detailed survey between sites 57 and 67, inclusive) (see tables 1,2, 3, and 4 for data). The exposed bedrock along the various stretches of the river is indicated at the top of the plot.

Table 1. Conductivity of waters in Canadian River, Ute Reservoir, NM to Lake Meridith, TX.

Survey Site No. (1)	River Mileage (2)	Conductivity (3)	Location and Remarks
0*	0.00	(not measured)	Ute Reservoir, from State park area on south shore, about 0.1 mi from dam; 2/13/92
1	0.00	975	Toe drain outlet, Ute Dam; 2/10/92
2	0.00	675	Secondary drain outlet, Ute Dam gateworks?; 2/10/92
3	0.00	725	Outlet channel from Ute Dam gate; 2/10/92
4	0.00	650	At base of canyon wall, near south abutment of dam; 2/10/92
5	0.22	775	Spillway, at canyon rim; 2/10/92
6	0.09	1790	Pool in river; 2/10/92
7*	0.22	2500	Pool in river (probe 6" from bank, on bottom, 3" depth); 2/10/92
"	0.22	7800	" (probe 4 ft from bank, in mud on bottom, 1.5 ft depth); 2/10/92
"	0.22	9000	" (probe 6 ft from bank, in mud on bottom, 2.5-3 ft depth); 2/10/92
"	0.22	10000	" (probe 8 ft from bank, in mud on bottom, 3-4 ft depth); 2/10/92
"	0.22	22000**	" (probe in middle of channel in mud on bottom); 2/10/92
7A	0.22	810	"Tributary" from spillway; downstream from Site 5; 2/10/92
7B	0.22	3000	River,10 ft downstream from Site 7A (probe suspended to 1 ft depth in water 1.5 ft deep); 2/10/92
"	0.22	8500	" (probe in mud on bottom, 1.5 ft depth); 2/10/92
8*	0.37	2300	River, below point where all sources join; 2/10/92
9	0.71	2250	Pool in river (probe 2 ft from bank, suspended to 0.5 ft depth in water 1.5 ft deep); 2/10/92
"	0.71	10200	" (probe 8 ft from bank, in mud on bottom, 3.5-4 ft depth); 2/10/92
10	0.82	3990	Riffle in river, at exit from beaver pond; 2/10/92
11*	1.03	4290	Riffle in river; 2/10/92
12	1.27	4100	Pool in river (probe 5-6 ft from bank, on bottom, 1.5 ft depth); 2/10/92
"	1.27	33000	" (probe in middle of channel, on bottom, >2 ft depth); 2/10/92
"	1.27	39000	" (probe in middle of channel, on bottom, >2 ft depth); 2/10/92
13*	1.42	8900	River (probe 1-1.5 ft from bank, on bottom, 1 ft depth); 2/10/92
"	1.42	10900	" (probe 8 ft from bank, on bottom, 2-2.5 ft depth); 2/10/92
"	1.42	19000	" (probe 18-20 ft from bank, on bottom, 4? ft depth); 2/10/92

(continued on next page)

Table 1 (continued).

Survey Site No. (1)	River Mileage (2)	Conductivity (3)	Location and Remarks
14	1.55	5200	Pool in river (probe 3 ft from bank, suspended to 0.5 ft depth in water 1 ft deep); 2/10/92
"	1.55	4600	" (probe 3 ft from bank, on bottom, 1 ft depth); 2/10/92
"	1.55	5500	" (probe 10 ft from bank, on bottom, 1.5-2 ft depth); 2/10/92
"	1.55	6100	" (probe 20 ft from bank, on bottom, 3? ft depth); 2/10/92
15	1.68	4300	Riffle and pool section (probe 3 ft from bank, suspended to 6" depth in water 8-12" deep); 2/10/92
16	1.83	4600	Pool in river (probe 3 ft from bank, on bottom, 1 ft depth); 2/10/92
"	1.83	4550	" (probe 4 ft from bank, suspended to 8" depth in water 1-1.5 ft deep); 2/10/92
17*	1.91	4675	River, at gauging station just upstream from NM Hwy. 54 bridge; 2/10/92
18	2.11	4800	Pool in river, under NM Hwy. 54 bridge (probe 2 ft from bank, on bottom, 1 ft depth); 2/10/92
"	2.11	4800	" (probe 8 ft from bank, on bottom, 2-2.5 ft depth); 2/11/92
19	2.33	4150	Pool in river (probe 3 ft from south bank, on bottom, 6-8" depth); 2/11/92
"	2.33	4150	" (probe 12 ft from south bank, on bottom, 1.5 ft depth); 2/11/92
20	2.60	4525	Riffle in river; 2/11/92
21	2.71	5600	Pool in north channel of 2 channels (probe 6 ft from N bank, on bottom, 8-12" depth); 2/11/92
"	2.71	5600	" (probe 10-12 ft from N bank, on bottom, 1-1.5 ft depth); 2/11/92
"	2.71	5600	Pool in south channel of 2 channels (probe middle of 10-ft channel, on bottom, 1.5 ft depth); 2/11/92
22	2.97	5800	Riffle in river (channel 8 ft wide; probe on sandy bottom, 6" depth); 2/11/92
23	3.08	4680	Deep riffle section of river; 2/11/92
24	3.27	6000	Braided section of river ~50 ft upstream from railroad bridge (two channels, same conductivity); 2/11/92
25	3.46	6300	Riffle section of river, 500-600 ft downstream from bridge (~8 ft wide, 1 ft deep, gravel bottom); 2/11/92
28	3.83	7200	River; 2/11/92
29	4.00	8000	Deep, murky green pool in river (probe 5 ft from north bank, on bottom, 2.5-3 ft depth); 2/11/92
"	4.00	8000	" (probe suspended to 6" in water 2 ft depth); 2/11/92
30.2	4.11	7500	River; water murky green; 2/11/92
31*	4.41	5700	Flowing pool section of river (probe 6 ft from bank, on rippled, sandy bottom, 6-8" depth); 2/11/92
32	4.56	7600	Flowing pool section of river (probe 6 ft from bank, on sandy bottom, 6-8" depth); 2/11/92

(continued on next page)

Table 1 (continued).

Survey Site No. (1)	River Mileage (2)	Conductivity (3)	Location and Remarks
33	4.91	8500	Slowly-flowing pool section of river, 3 ft deep (probe 6 ft from N bank, on sandy bottom, 1 ft depth); 2/11/92
34D	4.99	7200	Flowing riffle and pool section of river (probe on sandy bottom, 8" depth); 2/11/92
36	5.42	8600	Riffle in river (probe on sandy bottom, 6-12" depth); 2/11/92
37	5.60	9500	Murky green pool (3 ft deep?) in marshy section of river; 2/11/92
38B	5.77	9000	Murky green pool (2-3 ft deep?); 2/11/92
39	5.96	10000	Murky green pool (20-25 ft wide, >3 ft deep); 2/11/92
41	6.31	5800	River, 200-300 ft downstream from confluence with Revuelto Creek; 2/11/92
41B	6.35	6000	River, ~100-200 ft downstream from site 41; 2/11/92
42	6.56	5900	River; 2/11/92
43	6.91	6000	South channel of 2 channels (probe on bottom, 2-3 ft depth); 2/11/92
"	6.91	5700	Northth channel of 2 channels (probe on bottom, 1 ft depth); 2/11/92
"	6.91	3730	" ; revisited on 2/12/92
44	7.99	5100	River; 2/12/92
45	8.68	5300	Riffle in river; 2/12/92
46	9.34	6000	River; 2/12/92
47	10.27	6000	River; 2/12/92
"	10.27	4690	River; 2/12/92
48	10.72	6000	River; 2/12/92
49	11.80	5900	River; 2/12/92
50	12.72	6000	River; 2/12/92
51	14.04	6300	River; 2/12/92
52	15.59	6100	River, at Tuscocoillo Canyon; 2/12/92
53	16.77	5200	River; 2/12/92
"	16.77	6500	River; 2/12/92
"	16.77	5500	River; 2/12/92
54	17.72	6500	River, where tributary from Cottonwood tank enters; 2/12/92

(continued on next page)

Table 1 (continued).

Survey Site No. (1)	River Mileage (2)	Conductivity (3)	Location and Remarks
55	19.24	6200	River; 2/12/92
56	20.51	6200	River, opposite mouth of small, unnamed tributary; 2/12/92
57	21.44	5000	River; 2/13/92
58	22.24	5200	River; 2/13/92
59B	23.34	5000	River at spring; 2/13/92
60A	24.09	4600	River; 2/13/92
61	25.23	4900	River; 2/13/92
62	27.32	6000	River; 2/13/92
63	29.53	5000	River; 2/13/92
64	32.91	5100	River, ~0.25 mi downstream from mouth of Rana Canyon; 2/13/92
64A	32.91	5000	River, ~0.5 mi downstream from mouth of Rana Canyon; 2/13/92
65	34.18	5100	River; 2/13/92
66	36.14	5000	River; 2/13/92
67	38.94	5000	River, ~0.1 mi upstream from New Mexico-Texas State line; 2/13/92
68	39.87	5100	River, at fenceline, ~0.75 mi downstream from New Mexico-Texas State line; 2/13/92
69	43.70	4480**	River, just downstream from point where two braids rejoin; 2/14/92
70	47.71	3125	River; 2/14/92
71	52.57	3710	River, adjacent to mouth of Nara Visa Arroyo; 2/14/92
"	52.57	4750**	"
72	56.77	4700	River channel, beneath Permian outcrop with active seep; 2/14/92
72B	58.23	4725	River, across from mouth of Horse Creek; 2/14/92
73	59.16	4650	River; 2/14/92
74	61.85	4225	River immediately downstream from mouth of Trujillo Creek (flowing - see Table 4); 2/14/92
75	64.47	4258	River; 2/15/92
76*	68.44	4110	River; 2/15/92
"	68.44	4520	"

(continued on next page)

Table 1 (continued).

Survey Site No. (1)	River Mileage (2)	Conductivity (3)	Location and Remarks
77	73.08	4300	River; 2/15/92
"	73.08	4575	"
78	77.86	4275	River; 2/15/92
"	77.86	4325	"
79	82.39	4125	River; 2/15/92
80	85.53	3000	River; just downstream from Old Farm Crossing; 2/16/92
81	89.68	2950	River, near Many Post Camp; 2/16/92
"	89.68	3250	"
82*	91.83	2300	River, at mouth of Goodnight Canyon; 2/16/92
"	91.83	2675	"
83	94.09	3375	River, just downstream from Torrey House ruins; 2/16/92
83A	94.31	3100	River, across from area of heavy, white crust on bank sediments; 2/16/92
84B*	95.06	3400	River, across from area of heavy, white crust on bank sediments, farther downstream; 2/16/92
86	95.62	3000	River, immediately downstream from Punta de Agua (flowing - see Table 4); 2/16/92
87	100.98	3200	River; 2/16/92
"	100.98	2675	"
88A	102.99	2500	River, at mouth of Alamosa Creek; 2/16/92
88C	103.03	2500	River, just downstream from confluence Alamosa Creek and Canadian River (probe on bottom); 2/16/92
"	103.03	3200	" (probe on bottom); 2/16/92
"	103.03	2900	" (probe suspended in water column); 2/16/92
88.1	103.46	2100	River; 2/16/92
89	107.20	3150	River, at railroad bridge; 2/16/92
90	110.93	2150	River; 2/17/92
91	116.83	2250	River, adjacent to gravel pits and railroad track (to south); 2/17/92
93	122.36	2450	River, at mouth of Sierrita de la Cruz; 2/17/92
94	123.48	2110**	River; 2/17/92

(continued on next page)

Table 1 (continued).

Survey Site No. (1)	River Mileage (2)	Conductivity (3)	Location and Remarks
95	126.39	2690	River, just downstream from suspended pipeline; 2/17/92
96C	128.11	2900**	River, at mouth of Lahey Creek; 2/17/92
98*	133.90	2910	River, across from mouth of Horse Creek; 2/17/92
99	138.05	2800	River, at mouth of West Amarillo Creek; 2/17/92
100	139.20	3200**	River, at mouth of East Amarillo Creek; 2/17/92
101	140.53	2300	River, under hwy 87-287 bridge; 2/18/92
102	146.32	2410	River, in vicinity of Bonita Creek; 2/18/92
103A	147.53	2500**	River, near mouth of Chicken Creek; 2/18/92

Notes:

(1) asterisk (*) denotes sites at which water samples were collected and analyzed; multiple entries for a single site indicate repeat measurements at that site;

(2) mileage from Ute Dam, increasing in downstream direction;

(3) conductivity in micromhos/cm, measured by Bureau of Economic Geology (values marked by two asterisks (**) were measured by Lee Wilson Associates).

Table 2. Conductivity of waters in isolated pools, tributaries, and springs along Canadian River, Ute Reservoir, NM to Lake Meridith, TX.

Survey Site No. (1)	River Mileage (2)	Conductivity (3) Isolated Pools	Tributaries	Springs	Location (4)	Remarks
26A	3.55	14800			Isolated pool in riverbed (S)	Water is milky, grayish-green, with fetid odor; 2/11/92
26B	3.55	12500			Isolated pool in riverbed (S)	Water is relatively clear; 2/11/92
27*	3.64	43500			Abandoned channel in riverbed (S)	Water in channel is seeping from riverbed sediments and entering river; 2/11/92
30.1	4.11	13200			Pool, mostly connected to river (S)	Water is murky yellowish-green, with rust-brown film around edges; 2/11/92
30A	4.11	10000			Isolated pool, base of canyon wall (S)	2/11/92
32A	4.56	16900			Isolated pool in riverbed (N)	2/11/92
"	4.56	27800			"	"
34A	4.99	48000			Isolated pool in riverbed (N)	Water is murky, yellowish-brown, with rusty brown mud film on bottom; 2/11/92
34B	4.99	3200			Isolated pool in riverbed (N)	Water is clear; 2/11/92
34C*	4.99	42300			Isolated pool in riverbed (N)	Pool is contiguous with pool at site 34A; 2/11/92
35A	5.23	24500			Isolated pool in riverbed (S)	2/11/92
35B	5.23	28000			Isolated pool in riverbed (S)	2/11/92
36B	5.42	27500			Semi-isolated pool connecting to river (N)	Some flow from pool into river; 2/11/92
38	5.77	1800			Semi-isolated pool connecting to river (S)	Water in pool is clear; 2/11/92
40*	6.26		1690		Revuelto Creek (S)	Tributary flowing on 2/11/92 (see Table 4)
40B	6.26		1550		"	2/11/92
41A*	6.31	20000			Isolated pool in riverbed (N)	2/11/92
42A	6.55	28500			Isolated pool in riverbed (S)	Conductivity probe suspended in water; 2/11/92
"	6.55	22200			"	Conductivity probe in mud on bottom of pool; 2/11/92
42B	6.55	17000			Semi-isolated pool connecting to river (S)	2/11/92
49A	11.80		900		Pool in unnamed tributary (S)	2/12/92
49B	11.80	1340			Isolated pool in riverbed (S)	Pool is along portion of tributary channel that crosses riverbed; 2/12/92
59A	23.53			395	Spring at base of canyon wall (N)	Spring is at or near contact of Trujillo sandstone with underlying Tecovas mudstone; flowing on 2/13/92
60B	24.09	15500			Pool connecting to river (S)	Pool receives flow from tributary (site 60C); 2/13/92
"	24.09	9800			"	"
60C*	24.09	6000			Pool in unnamed tributary (S)	Tributary flowing on 2/13/92 (see Table 4)
"	24.09	7000			"	"
"	24.09	8000			"	"
"	24.09	10000			"	"
64	32.91		1000**		Rana Arroyo (S)	Tributary flowing on 2/13/92 (flow not measured)
66A	36.14			380**	Spring? (N)	Spring flowing on 2/13/92
74A	61.85		780		Trujillo Creek (S)	Tributary flowing on 2/14/92 (see Table 4)

(continued on next page)

Table 2 (continued).

Survey Site No. (1)	River Mileage (2)	Conductivity (3) Isolated Pools	Tributaries	Springs	Location (4)	Remarks
84A*	94.31	4700			Isolated pool in riverbed (S)	Conductivity probe suspended in water; water is murky greenish-brown; 2/16/92
"	94.31	4075			"	Conductivity probe in mud on bottom; 2/16/92
85*	95.34		650		Punta de Agua (N)	Tributary flowing on 2/16/92 (see Table 4)
88B	102.99		1500		Alamosa Creek (S)	Isolated pool at mouth of creek; 2/16/92
92*	118.57	1000			Isolated pool flowing into river (S)	Flowing on 2/17/92; spring source?
93A	122.36		2350		Sierrita de la Cruz (S)	Not flowing; measured in river water backed-up into tributary channel; 2/17/92
93B	122.36		975		"	Isolated pool in dry portion of tributary, upstream from site 93A; 2/17/92
93C	122.36		325		"	Puddle on tributary flood plain, about 5 ft above tributary channel bottom; 2/17/92
96A*	127.92			12500	Pool below seep from canyon wall (N)	Seepage from strata just above Alibates dolomite; 2/17/92
96B	128.11		13000		Lahey Creek (N)	Tributary flowing on 2/17/92 (see Table 4)
97	130.17		2300		Tecovas Creek (S)	Isolated pool at mouth of creek - creek water?; 2/17/92
98A	133.90		1280**		Horse Creek (S)	Isolated pool at mouth of creek; 2/17/92
99A*	138.05		2025		West Amarillo Creek (S)	Flowing? on 2/17/92; measurements in pool at mouth of creek; creek sometimes carries discharge from helium plant near Amarillo
100A	139.20		1700**		East Amarillo Creek (S)	Isolated pool at mouth of creek; 2/17/92
103	147.53		240**		Chicken Creek (S)	Tributary flowing on 2/18/92 (see Table 4)

Notes:

(1) asterisk (*) denotes sites at which water samples were collected and analyzed; multiple entries for a single site indicate repeat measurements at that site;

(2) mileage from Ute Dam, increasing in downstream direction;

(3) conductivity in micromhos/cm, measured by Bureau of Economic Geology (values marked by two asterisks (**) were measured by Lee Wilson Associates);

(4) "(N)" and "(S)" denote features on the north- and south sides of the river, respectively; "semi-isolated" refers to pools which are connected to the Canadian River, but appear to have sufficient flow to prevent backflow of river water.

Table 7: Results of chemical analyses from 20 water samples collected during the February '92 conductivity survey of the Canadian River between Ute Reservoir, New Mexico, and Lake Meredith, Texas.

ID	STATE	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	HCO3 (mg/L)	SO4 (mg/L)	Cl (mg/L)	Br (mg/L)
0	NM	43.3	34.8	131	6.5	216	281	49	0.1
7	NM	123.0	58.4	1840	7.7	457	555	2370	0.42
8	NM	67.1	41.7	625	5.1	353	349	717	0.44
11	NM	99.9	54.3	1310	6.9	387	439	1750	0.32
13	NM	96.9	52.4	1250	7.1	375	436	1630	0.43
17	NM	103.0	56.2	1420	7.7	389	451	1890	0.38
27	NM	609.0	169.0	14140	37.6	775	2010	21010	0.48
31	NM	153.0	72.3	2434	10.4	485	615	3415	0.2
34	NM	782.0	200.0	16950	43.3	997	2520	24350	0.46
40	NM	76.8	66.5	407	3.4	355	757	153	0.49
41a	NM	303.0	111.0	3920	15.3	803	1120	5650	0.38
60	NM	279.0	113.0	5050	16.1	642	790	7870	0.1
76	TX	121.0	69.5	1110	7.2	377	538	1560	0.27
82	TX	36.7	59.0	757	6.3	251	482	919	0.34
84a	TX	208.0	112.0	1370	11.5	1419	1090	1060	0.7
84b	TX	110.0	63.3	918	6.8	316	563	1200	0.23
85	TX	53.7	48.6	78	6.5	469	66	33	0.1
92	TX	47.0	21.2	247	1.8	415	78	217	0.1
96a	TX	719.0	172.0	3390	6.5	191	2160	4910	0.1
98	TX	118.0	63.1	764	6.5	280	652	1000	0.27

State of Texas Data, CRMWA samples

Request for data has been made to State.

Other Safe Drinking Water Act Data

As yet, no request has been made regarding these data.

EPA and State Intensive Surveys

Data have been obtained; expectation is that selected tabulations will be photocopied and included here at some point in time. References include: Kirkpatrick (1976), EPA (1977), Dutton (1978), Ottmers (1986), Smolka (1988), Potter and Davis (1989), and TWC (1990).

Discharges from Amarillo River Road Water Reclamation Plant to East Amarillo Creek, 1981–1991

	January			February			March			April			May			June		
	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging
1991	19.872	14	1.4	3.140	5	0.6	1.271	2	0.6	17.044	12	1.4	18.569	10	1.9	2.999	4	0.7
1990	21.892	10	2.2	17.204	13	1.3	13.910	8	1.7	37.566	17	2.2	16.325	13	1.3	0	0	
1989	53.142	25	2.1	43.387	22	2.0	20.025	14	1.4	12.726	7	1.8	16.311	7	2.3	71.672	25	2.9
1988	83.763	28	3.0	26.462	13	2.0	6.003	6	1.0	57.671	21	2.7	24.111	18	1.3	55.533	29	1.9
1987	32.836	22	1.5	67.15	22	3.1	100.388	28	3.6	71.117	26	2.7	114.742	30	3.8	58.181	28	2.1
1986	103.797	29	3.6	119.109	26	4.6	48.438	22	2.2	8.895	8	1.1	65.178	19	3.4	50.223	27	1.9
1985	20.374	12	1.7	19.618	11	1.8	41.226	20	2.1	28.552	15	1.9	154.676	28	5.5	43.255	12	3.6
1984	143.377	30	4.8	51.076	22	2.3	92.170	21	4.4	30.047	11	2.7	0.240	1	0.2	17.799	11	1.6
1983	97.466	31	3.1	81.593	28	2.9	125.114	31	4.0	72.49	20	3.6	16.989	11	1.5	29.369	14	2.1
1982	0.203	1	0.2	9.324	9	1.0	10.037	7	1.4	0	0		0.581	1	0.6	4.808	3	1.6
1981	0	0		0.564	1	0.6	0	0		0	0		0	0		1.749	1	1.7
TOTAL	576.722	202	2.9	438.627	172	2.6	458.582	159	2.9	336.108	137	2.5	427.722	138	3.1	335.588	154	2.2

Discharges from Amarillo River Road Water Reclamation Plant to East Amarillo Creek, 1981 – 1991

	July			August			September			October			November			December		
	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging	Discharge (MG)	Number of Days	MGD when Discharging
1991	7.861	5	1.6	5.521	2	2.8	3.923	4	1.0	0	0		22.494	10	2.2	36.694	17	2.2
1990	0	0		0	0		0	0		52.205	21	2.5	1.667	2	0.8	16.883	11	1.5
1989	0.621	1	0.6	13.802	10	1.4	90.523	24	3.8	5.019	5	1.0	49.255	16	3.1	63.762	24	2.7
1988	46.481	27	1.7	100.043	30	3.3	141.297	29	4.9	37.027	22	1.7	35.618	26	1.4	26.325	12	2.2
1987	29.536	17	1.7	48.597	25	1.9	72.084	29	2.5	120.191	29	4.1	26.121	20	1.3	25.169	15	1.7
1986	4.846	6	0.8	3.056	5	0.6	13.263	7	1.9	79.920	28	2.9	58.662	20	2.9	41.380	23	1.8
1985	6.692	33	0.2	9.126	10	0.9	38.273	19	2.0	60.014	22	2.7	4.303	4	1.1	43.088	18	2.4
1984	0	0		4.376	4	1.1	12.614	4	3.2	5.968	3	2.0	6.557	4	1.6	24.843	13	1.9
1983	2.235	2	1.1	0	0		14.618	10	1.5	46.762	18	2.6	77.448	28	2.8	60.214	26	2.3
1982	2.971	5	0.6	1.192	2	0.6	40.794	21	1.9	19.574	12	1.6	43.315	22	2.0	52.756	21	2.5
1981	7.912	6	1.3	9.604	7	1.4	20.028	9	2.2	28.267	15	1.9	20.279	11	1.8	0	0	
TOTAL	109.155	102	1.1	195.317	95	2.1	447.417	156	2.9	454.947	175	2.6	345.719	163	2.1	391.114	180	2.2

City of Amarillo

January 10, 1992

Mr. Tom Parker
Lee Wilson and Associates
P. O. Box 931
Santa Fe, New Mexico 87504

Mr. Parker:

Enclosed are some of the information you requested which pertains to your ongoing Lake Meredith impact study.

Effluent discharge volumes from the River Road Water Reclamation Plant have been found going back thru 1981. Records prior to this time have not been located. As you probably know, this plant discharges to East Amarillo Creek, which flows into the Canadian River and then on to Lake Meredith.

The plant, during this period of time, was permitted at 20 mg/L for both Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS). Except for infrequent process problems which causes these numbers to exceed the limits, the plant typically treats effluent in the 5-15 mg/L range. Total dissolved solids (TDS) historically range around 1000-1400 mg/L, with 1100-1200 mg/L being the mean.

Chloride ion is not routinely analyzed for because it has not been found to fluctuate very much. Numbers have been collected ranging between 200-400 mg/L, with typical numbers falling between 300-350 mg/L.

Hope you can glean some value base from this information and if I can be of any further assistance, please contact me at (806) 383-2253.

Cordially,

Terry M. Tucker

Terry M. Tucker
Chemist/Biologist

TMT:bg
Enclosure
ccs: Duane Warren
River Road Files

?:TERRY\LETTERS\PARKER

Amarillo STP discharges to E. Amarillo Creek, 1956–1978, from USGS annual water resources data books for Texas

Water Year[1]	Discharge, AF
1957	6990[2]
1958	6920[2]
1959	8890[2]
1960	8990[2]
1961	8430
1962	8190
1963	8660
1964	7190
1965	5780[2]
1966	6720[2]
1967	7005[2]
1968	6120[2]
1969	6180[2]
1970	6470
1971	6200
1972	6290
1973	6660
1974	6620
1975	7760
1976	5680
1977	3620
1978	0.7

1 Water year begins October 1 of previous year and ends September 30 of year identified.

2 At least one instantaneous discharge rate reported.

Additional basic data

Reserved for additional data that may be acquired.

HGC (1984) figures and tables related to surface water quantity

Figure 24: Flow duration curve: Canadian River at Logan

Figure 25: Flow duration curve: Revuelto Creek, 1959 - Present

Figure 26: Flow duration curve: Canadian River at State Line, 1969 - 1983

Figure 27: Flow duration curve: Canadian River at Tascosa, 1968 - 1977

Figure 28: Flow duration curve: Canadian River near Amarillo

FIgure 29: Average yearly flow in Canadian River at Amarillo, 1939 - 1981

Table 3: Flow-measurement stations in study area

Table 4: Summary of correlations between Canadian River flow at Amarillo and at various upstream stations

Table 5: Summary of gains in Canadian River flow between Ute Dam and Lake Meredith

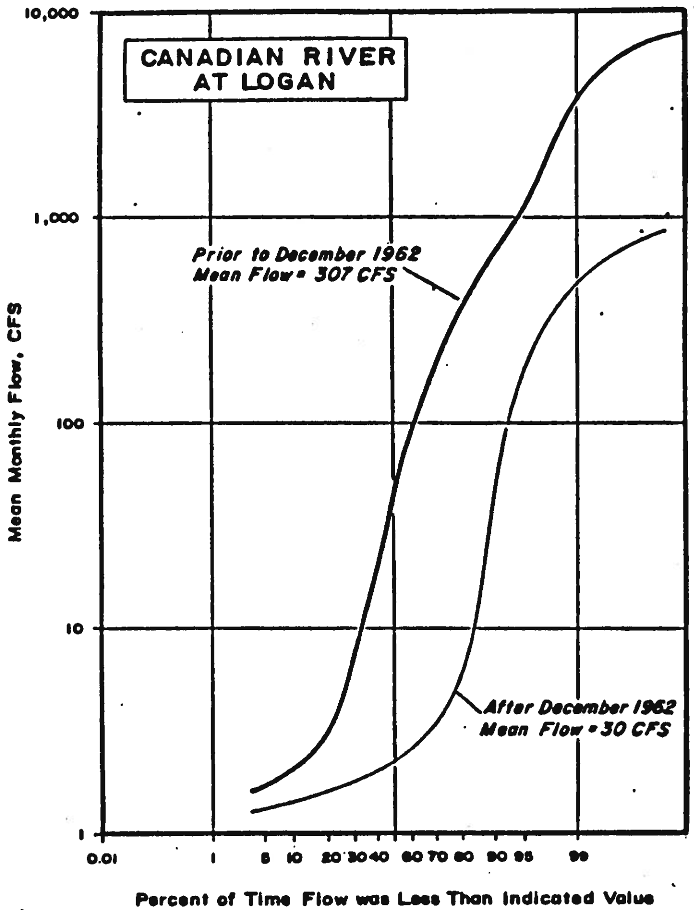


Figure 24

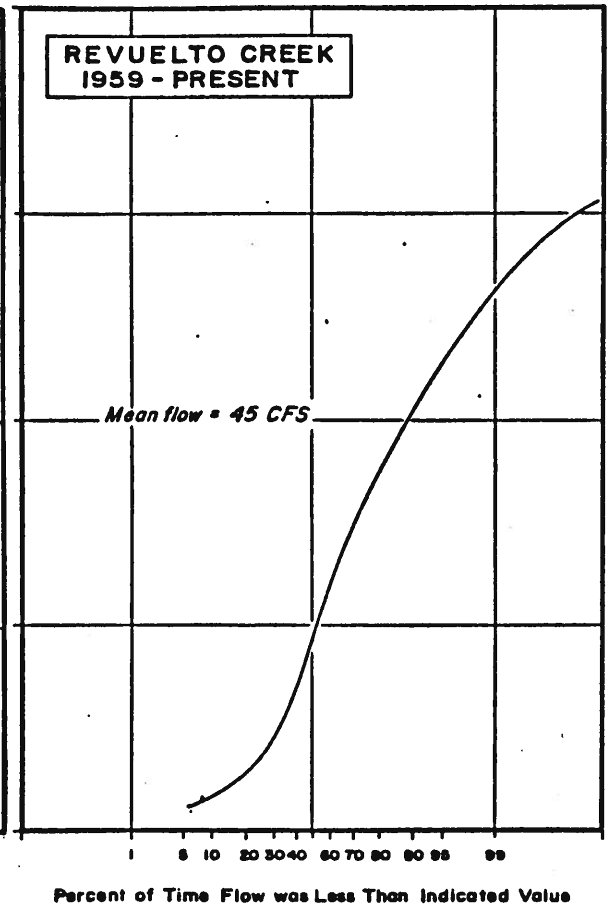


Figure 25

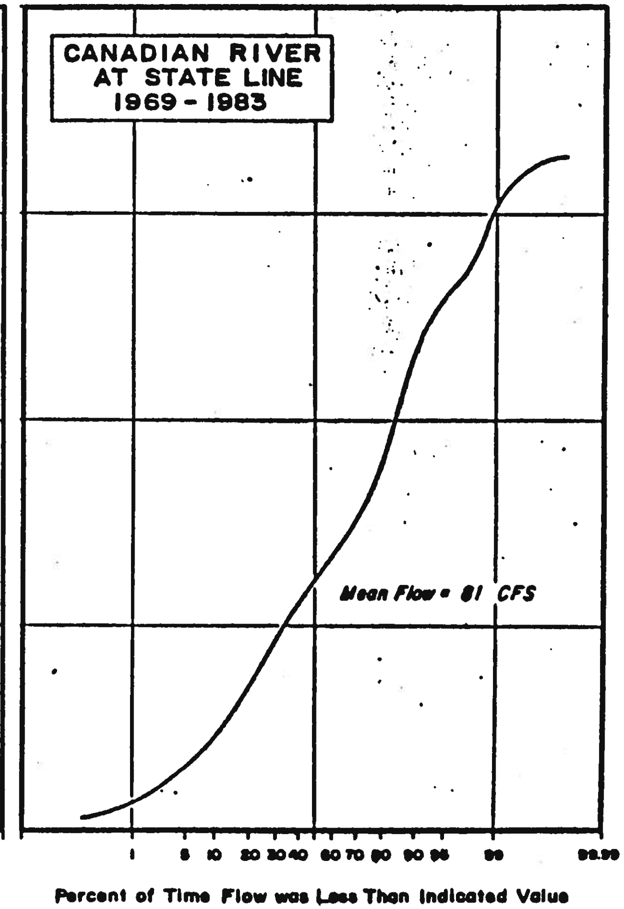


Figure 26

Flow duration curves

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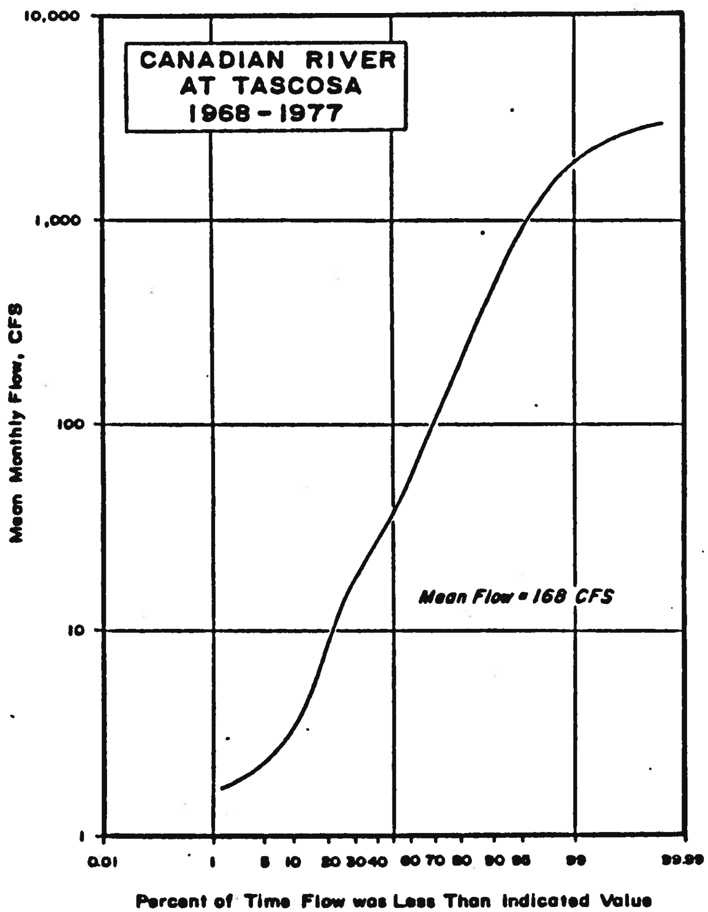


Figure 27

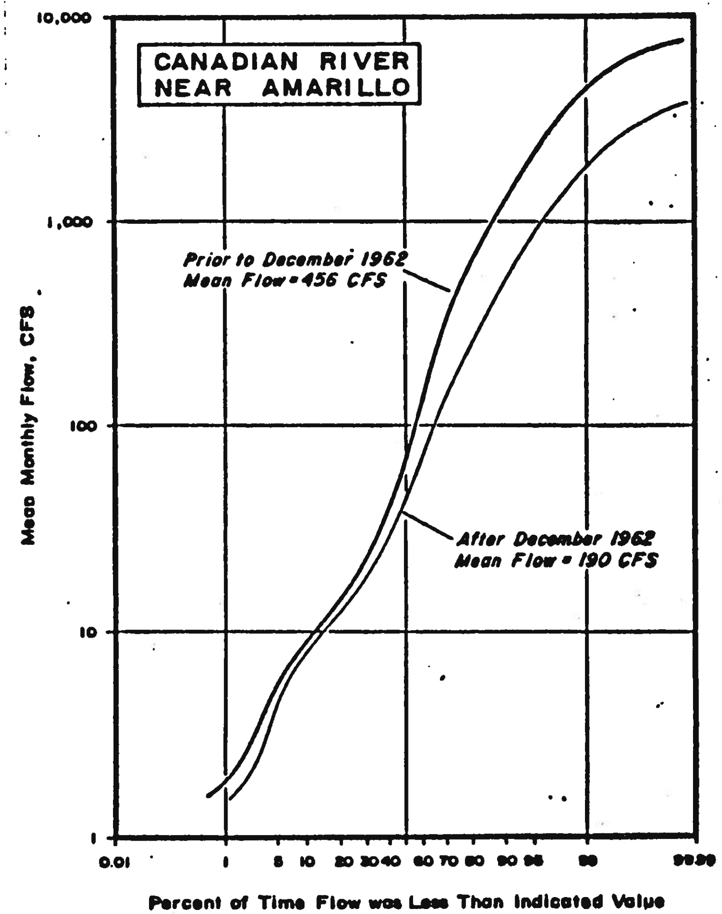


Figure 28

Flow duration curves

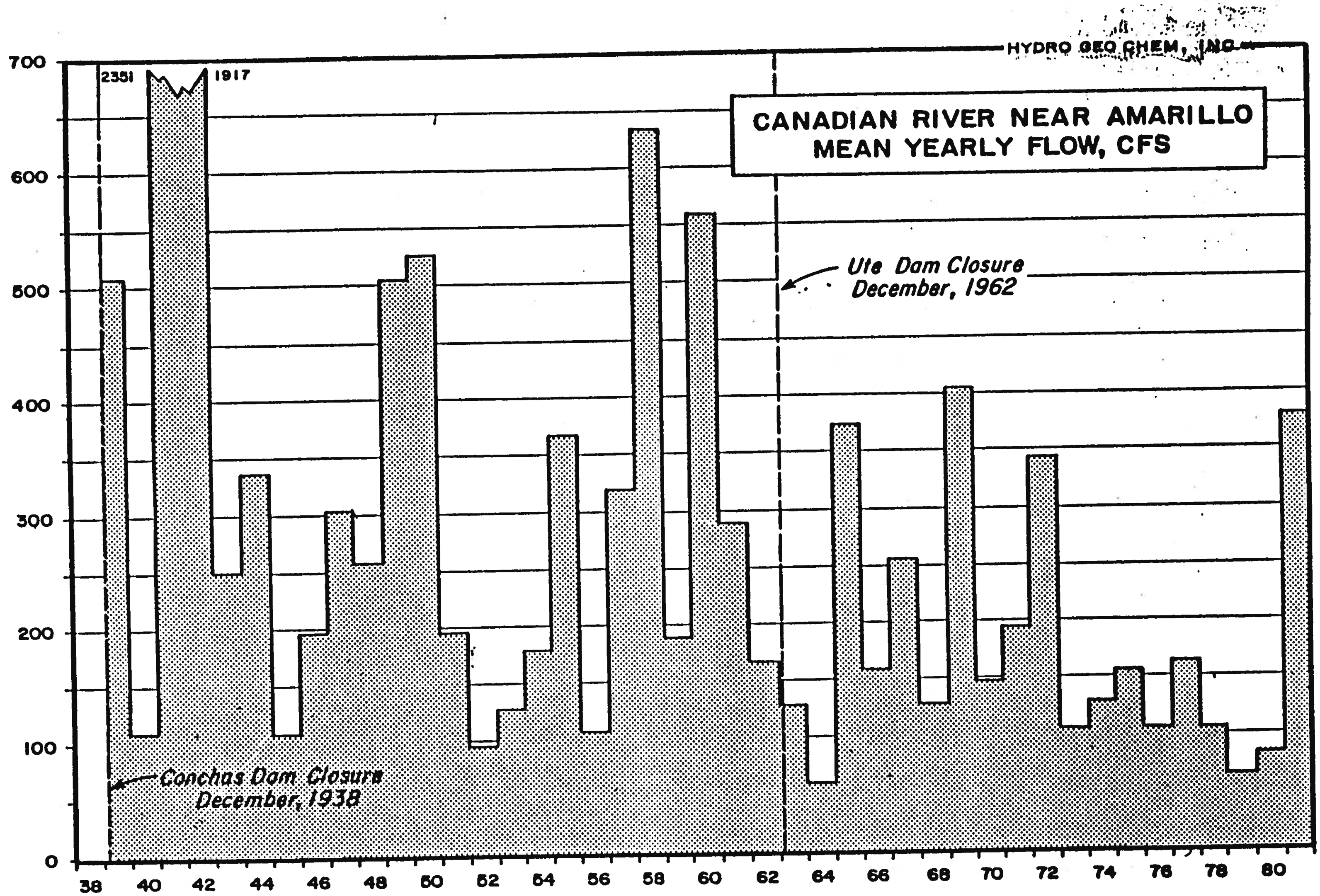


Figure 29. Average yearly flow in Canadian River at Amarillo, 1939-1981

ject. Figure 25 shows the flow-duration curve for Revuelto Creek. Mean monthly flow is 45 cfs and the median is 8 cfs. As expected, flows in Revuelto Creek and the Canadian River at Logan show no correlation. Their combined mean flow is 75 cfs. The combined median flow for the period since Ute Dam was closed is 10 cfs.

Table 3: Flow-measurement stations in study area

USGS Station	Location	Period of Record (water years)
-	Ute Reservoir Toe Drain	1969?-present (periodic measurements taken, only)
7227000	Canadian River at Logan (near Hwy 54 bridge)	1909-1910; 1912-1915. 1924-1925; 1927-present
7227100	Revuelto Creek near Logan (at Hwy 39 bridge)	1959-present
7227140	Canadian River above State Line	1969-present (periodic measurements taken, only)
7227470	Canadian River at Tascosa	1968-1977
7227500	Canadian River nr Amarillo (at Hwy 87-287 bridge)	1924-1926; 1938-present

Flows are periodically measured near the New Mexico - Texas state line, about 40 river miles downstream from Ute Dam; however, no gaging station is maintained there. Figure 26 shows the flow-duration curve for this station, based on 127 flow measurements since 1969. The mean measured flow is 81 cfs and the median is 13 cfs.

The correlation between combined daily flows upstream at the Revuelto and

Table 4: Summary of correlations between Canadian River flow at Amarillo and at various upstream stations

Correlation between	Mean Flow at Amarillo (cfs)	Mean Flow at other station (cfs)	Correlation coefficient (r^2)
Amarillo and Logan, prior to 1962	456	307	0.81
Amarillo and Logan, after 1962	190	30	0.39
Amarillo and Tascosa, 1968 to 1977	196	168	0.90
Amarillo and (Logan plus Revuelto), 1959 to 1981	196	92	0.60
Amarillo and State Line, 1969 to 1981	173	81	-

Table 5: Summary of gains in Canadian River flow between Ute Dam and Lake Meredith

	Flow Gain	From
1.	30 cfs	below Ute Dam, of which about 2 cfs is from seepage and groundwater inflow, the rest from the few occasions of flow over the spillway.
2.	45 cfs	from Revuelto Creek, primarily from irrigation return (about 8 cfs) and flood flows.
3.	5 cfs	between Revuelto Creek and State Line, primarily from groundwater inflow.
4.	87 cfs	between State Line and Tascosa, primarily from flood flows, probably from the Punta de Agua drainage.
5.	22 cfs	between Tascosa and Amarillo, mostly from ~~groundwater~~ groundwater inflow, some from irrigation return, little from flood flows.

Total: 190 cfs at Amarillo gage

<u>HGC (1984) figures and tables related to surface water quality</u>

Figure 32: Stiff diagrams of Triassic water

Figure 36: Ranges in chloride concentrations in CRMWA piezometers

Figure 37: TDS and chlorides in river water, October 1983

Figure 38: TDS, chlorides and specific conductance in river water, January 1984

Figure 39: TDS, chlorides and specific conductance in river water, Feburary 1984

Figure 40: Chloride load and mean flow for Canadian River at Tascosa

Figure 41: Chloride load and mean flow for Canadian River at Amarillo

Figure 42: Chloride measurements in Lake Meredith

Figure 43: Bromide/chloride ratios of surface and groundwater

Figure 44: Sodium/chloride ratios of surface and groundwater

Figure 45: Stable isotopic distributions

Figure 46: Calculated chloride concentration in Lake Meredith

Table 7: Average chemical characteristics of Canadian River water

Table 8: Average (1969 to 1982) monthly water and salt budget parameters used to predict long-term chloride concentration

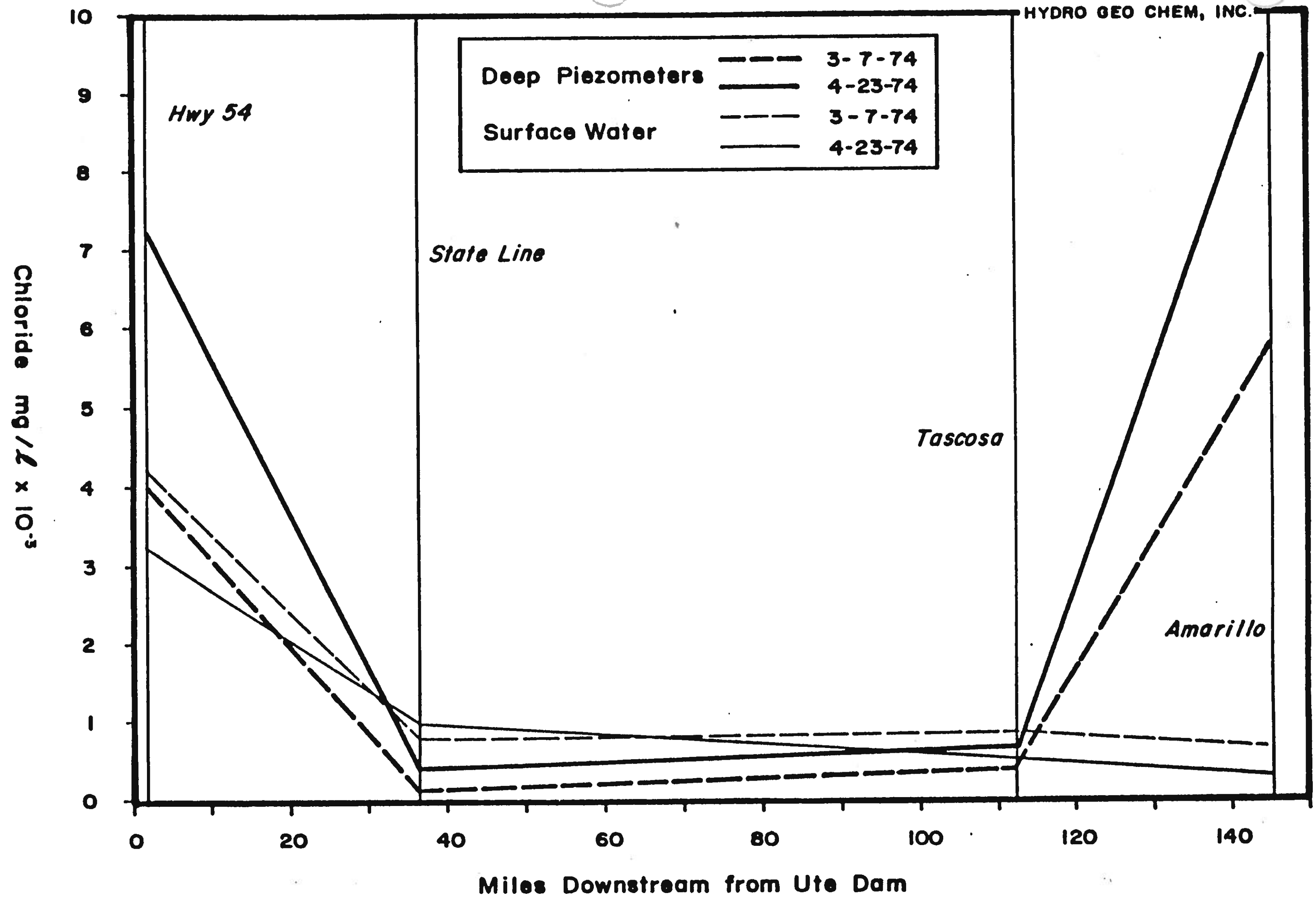


Figure 36: Ranges in chloride concentrations in CRMWA piezometers

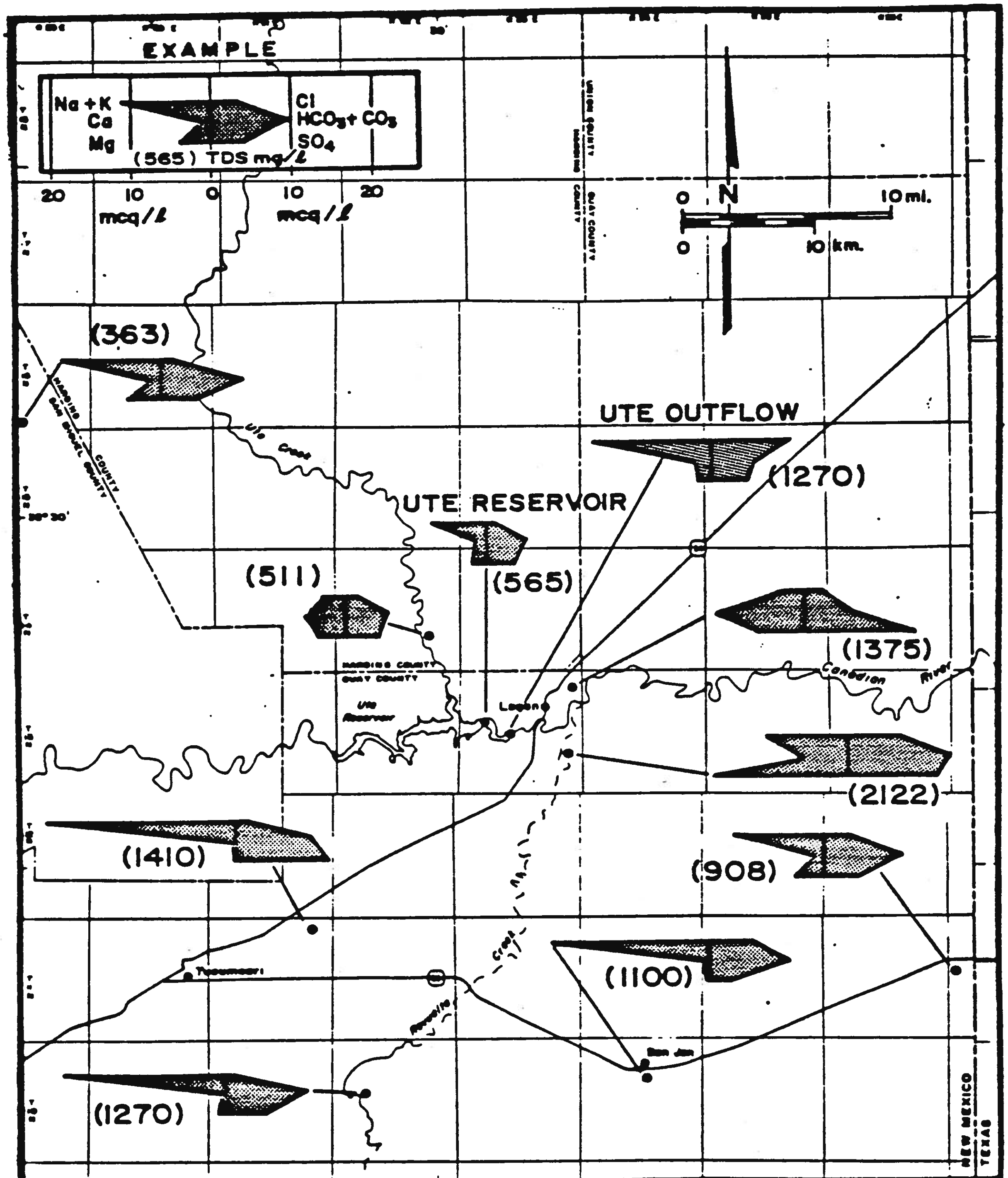


Figure 32. Stiff diagrams of Triassic water

Figure 37

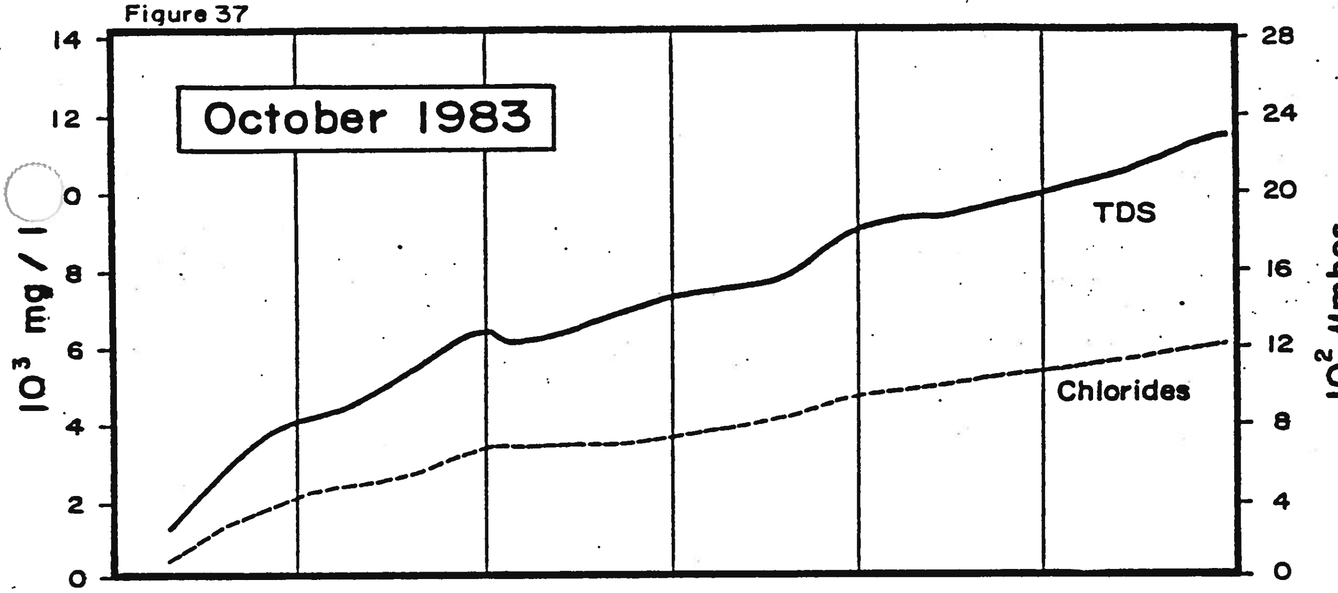


Figure 38

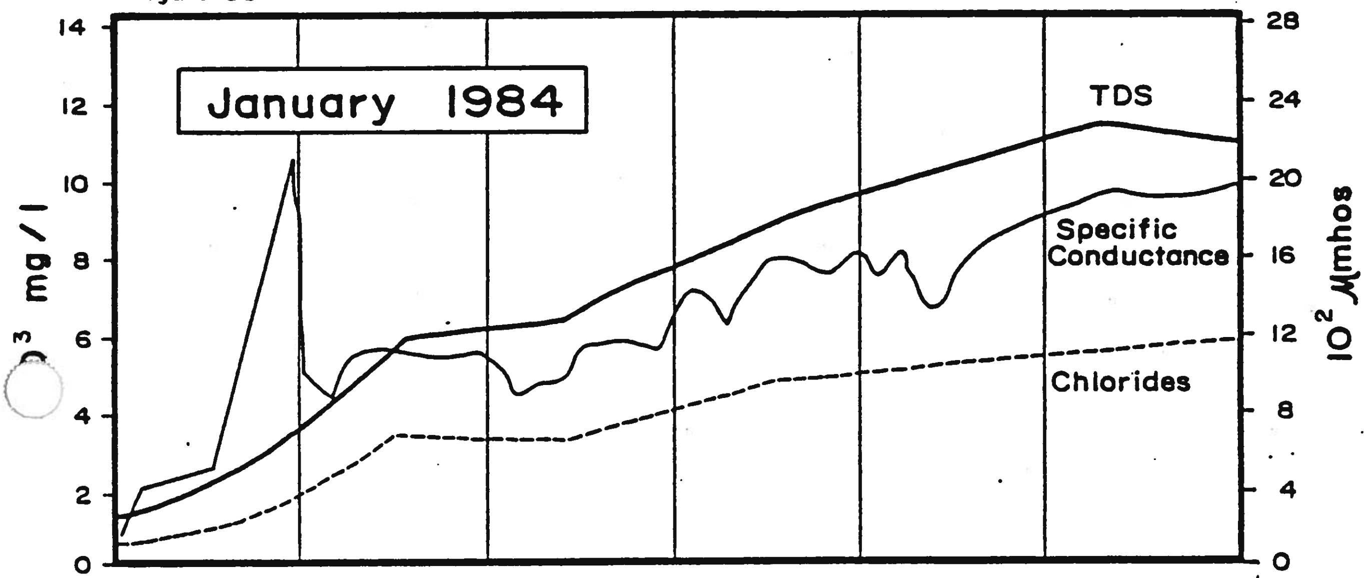
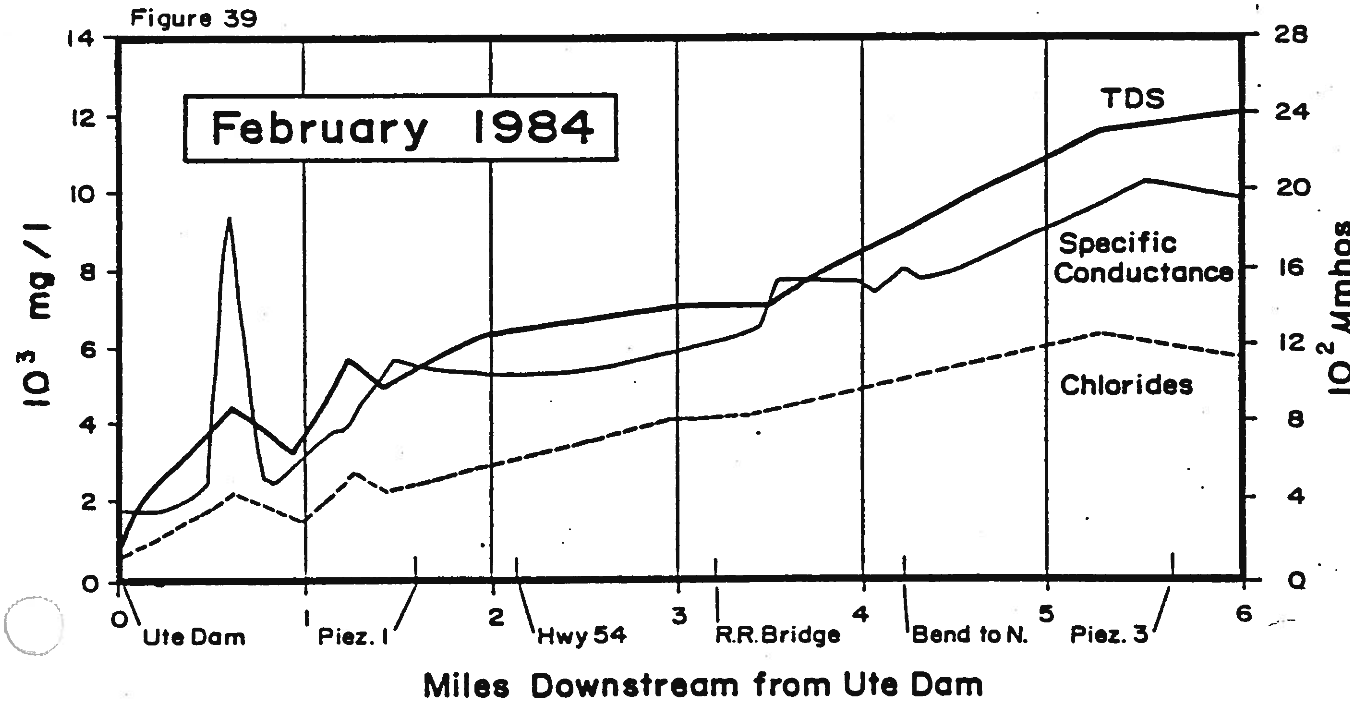


Figure 39



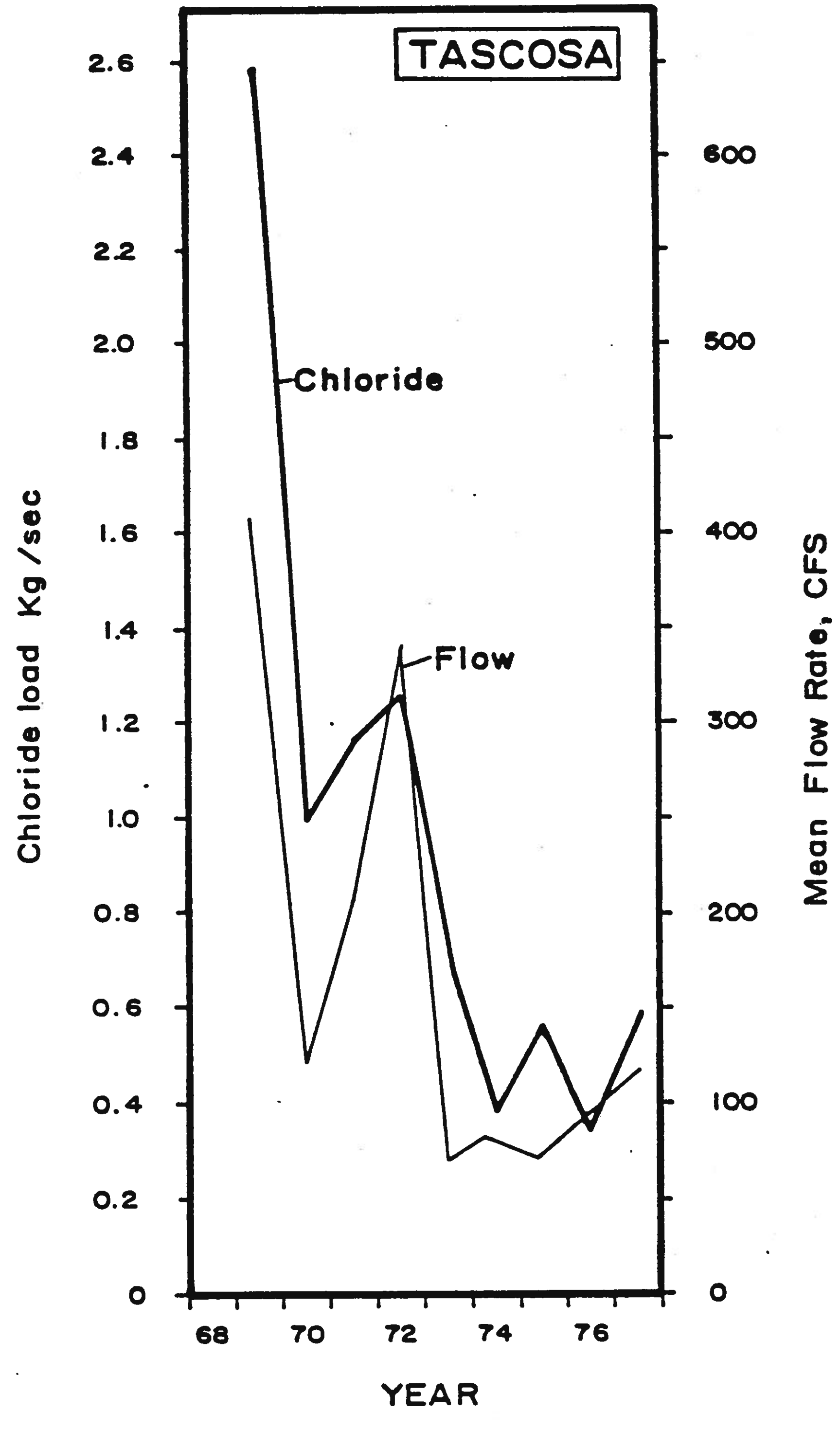


Figure 40. Chloride load and mean flow for Canadian River at Tascosa

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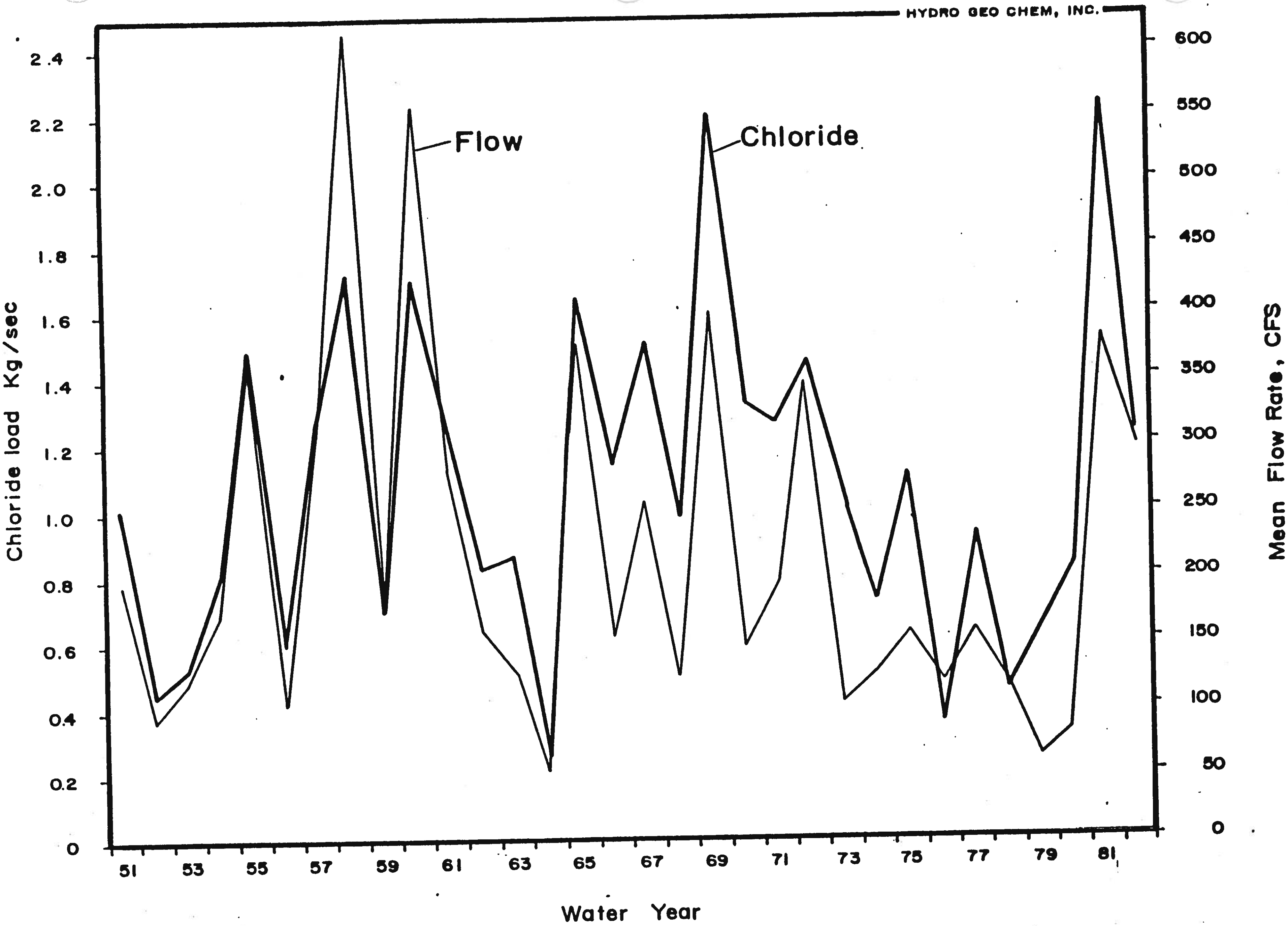


Figure 41. Chloride load and mean flow for Canadian River at Amarillo

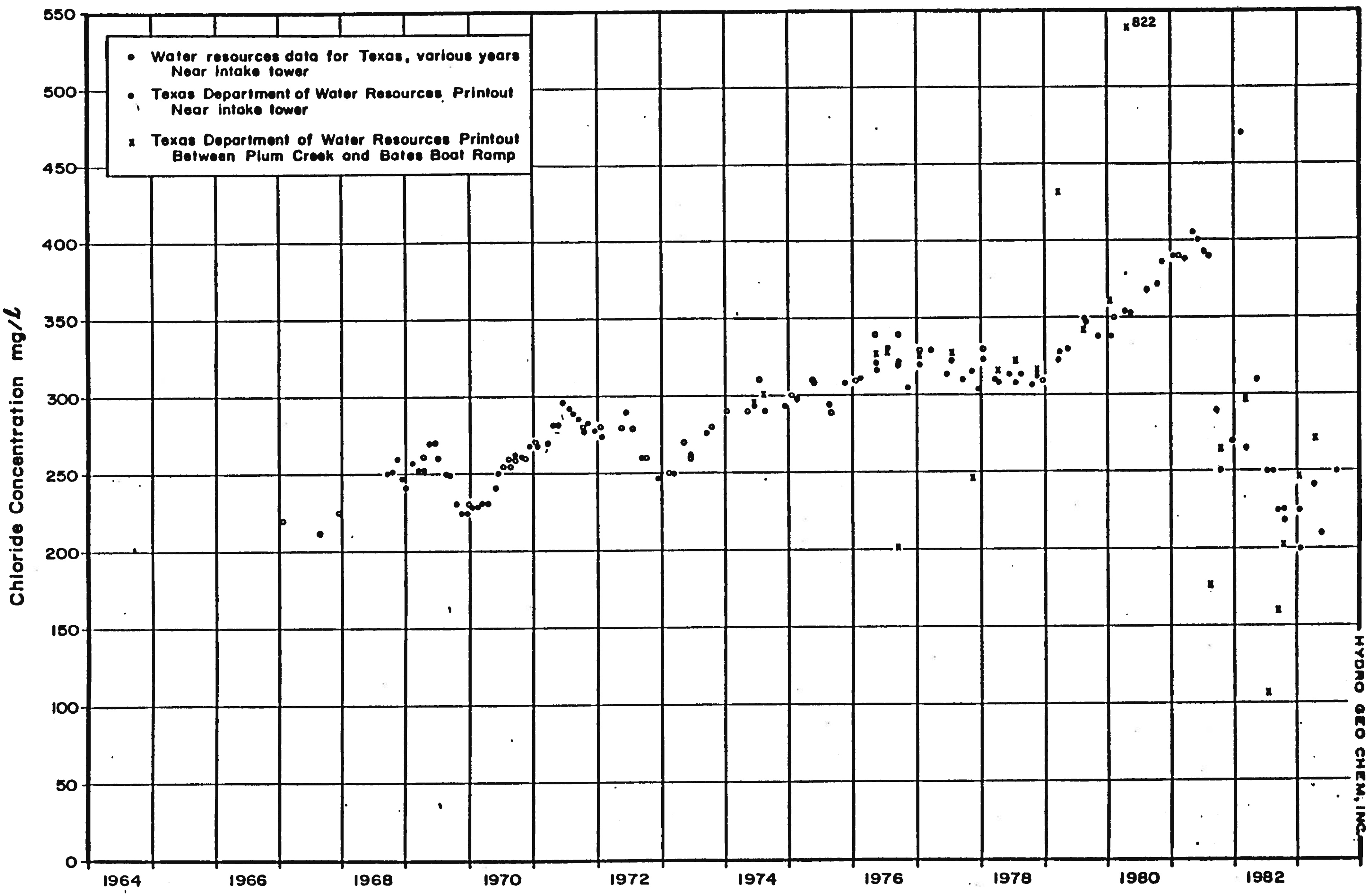


Figure 42. Chloride measurements in Lake Meredith

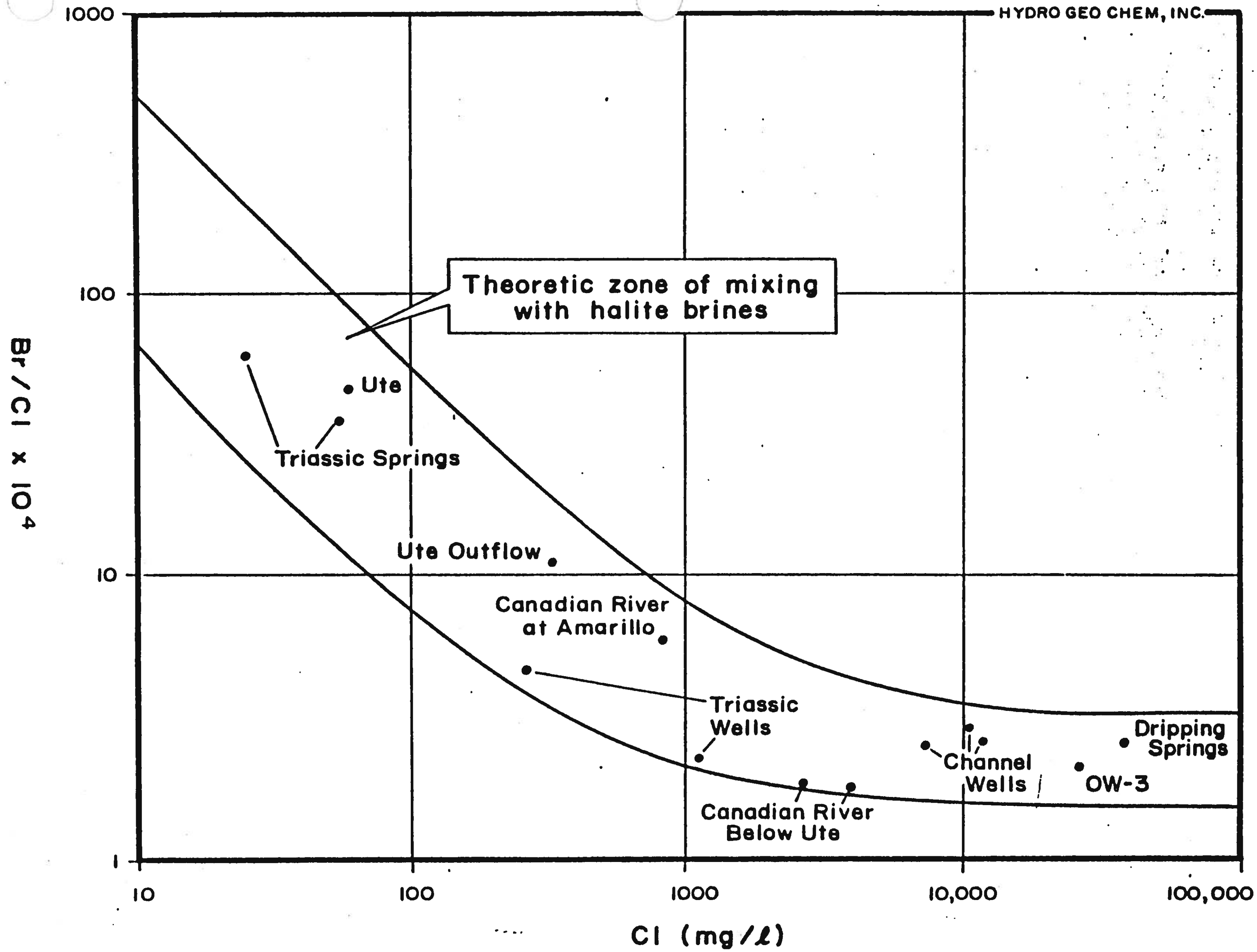


Figure 43. Bromide/chloride ratios of surface and groundwater

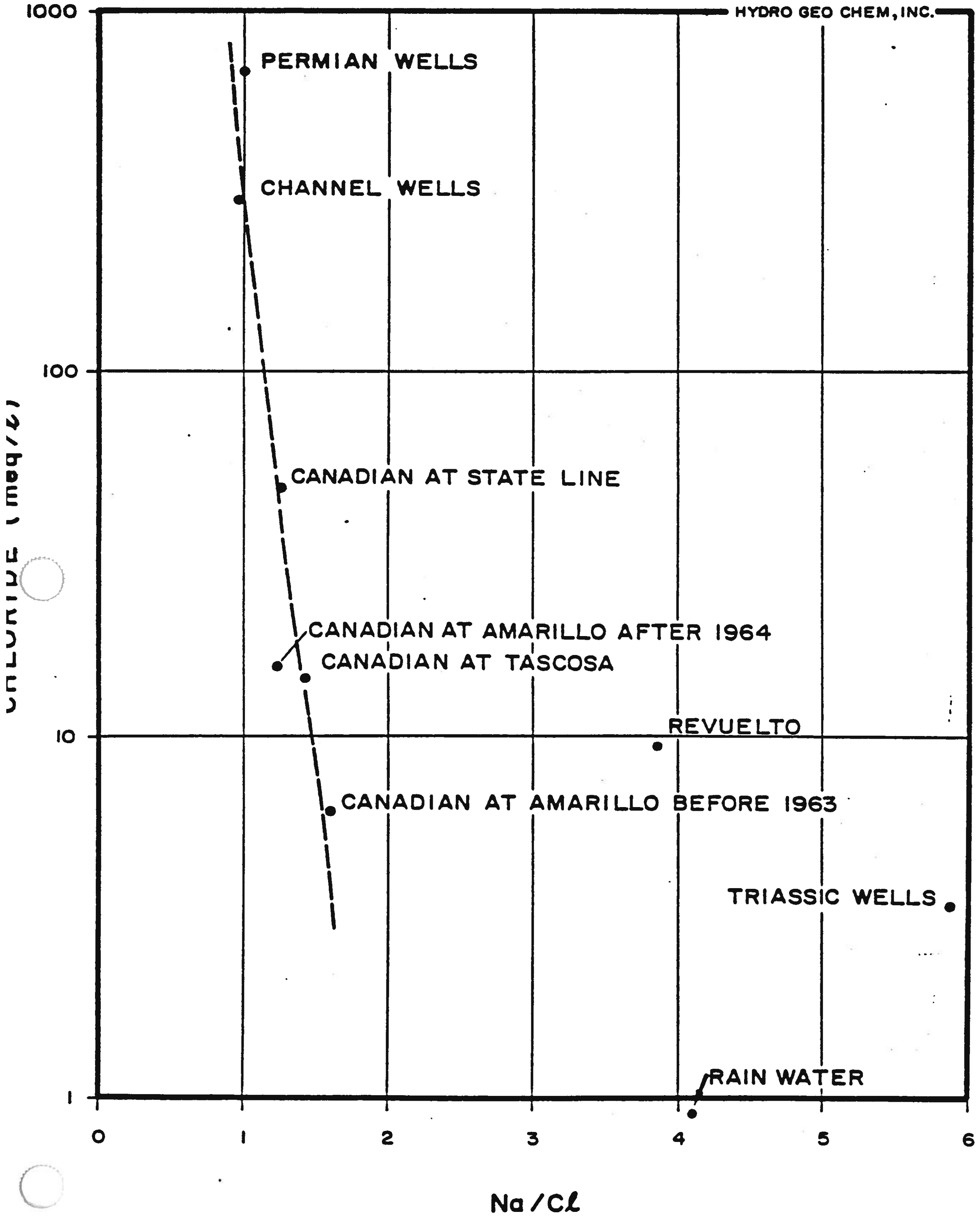


Figure 44. Sodium/chloride ratios of surface and groundwater

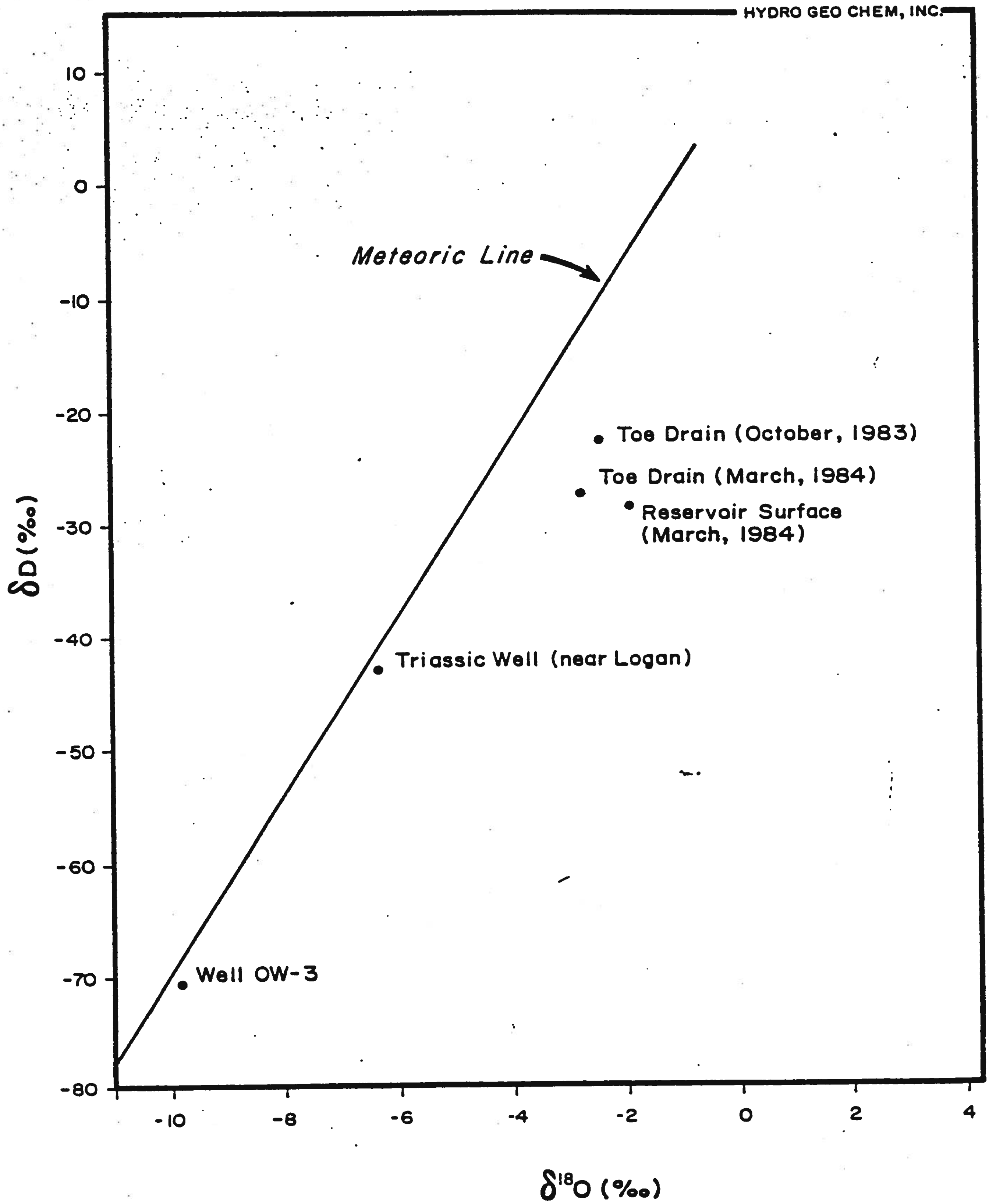


Figure 45. Stable isotopic distributions

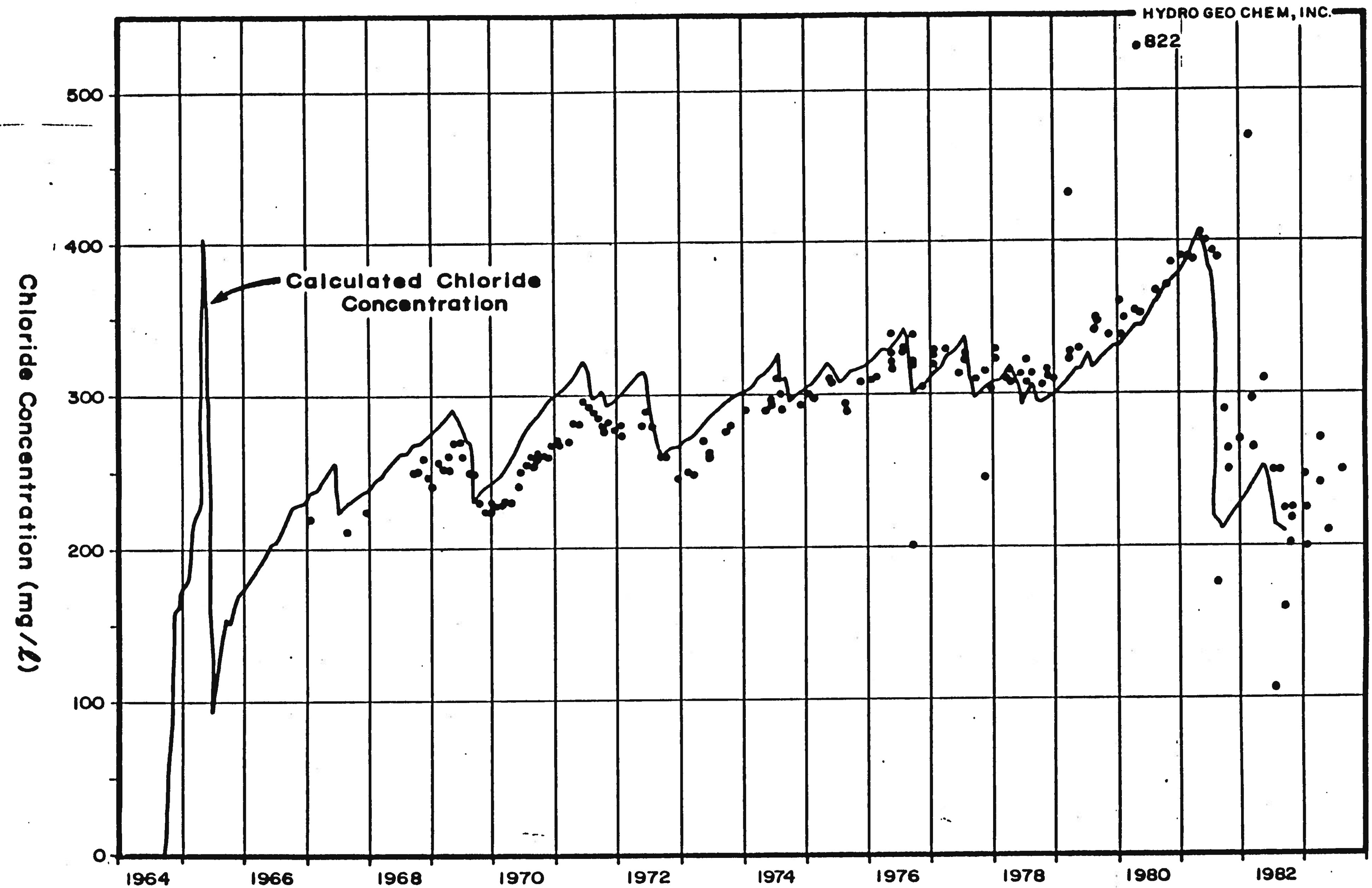


Figure 46. Calculated chloride concentration in Lake Meredith

It should be noted that during each of these surveys no brine seeps or springs were seen. The increase in salinity in the river water comes from brine which seeps into the bottom of the channel deposits, as the water chemistry from the piezometers verifies. Assuming that areas of brine inflow to the channel deposits result in degradation of the river water immediately downstream, then the three areas of stream quality degradation probably correspond to three areas of brine inflow. It may also be possible that at the railroad bridge, excavation due to bridge construction and to a buried cable nearby have disturbed the channel sediments such that the brine is forced to the surface in the area.

Some of the important water quality characteristics measured at Ute Dam and at the Revuelto Creek, State Line, Tascosa, and Amarillo stations are listed in Table 7. Chloride loads were computed using weighted average chloride concentrations and average flows, both on a monthly basis. Selected analyses are listed in Appendix B, Table B.1.

Table 7: Average chemical characteristics of Canadian River water

Station	No. Samples	Averages (mg/l) Cl	Na	SO_4	Avg Cl Load (kg/sec)		Water Type
Ute Dam	2	330	340	190		0.009	Na-Cl
Revuelto	325	218	96	410	Entire Record (59-83):	0.08	$Na-SO_4$
State Line	121	1728	1000	373	Entire Record (69-83):	0.80	Na-Cl
					During overlap w/Tascosa:	0.95	
Tascosa	113	530	413	290	Entire Record (68-77):	0.96	Na-Cl
Amarillo	384	320	442	268	During overlap w/Tascosa:	1.15	$Na-Cl-SO_4$
					Prior to Ute Dam (1962):	1.02	
					After Ute Dam (1962):	1.07	
					Entire Record (50-82):	1.05	

centration increased by only an additional 2 mg/l. Thus we can say that the steady state chloride concentration will be about 400 mg/l given the above conditions.

The same calculations were made with TDS and sulfate. The calculated steady state concentrations are 1,550 mg/l for TDS and 360 mg/l for sulfates. These values may be low because of continuing dissolution of some minerals within the reservoir.

Table 8: Average (1969 to 1982) monthly water and salt budget parameters used to predict long-term chloride concentration

Month	Change in Storage	Diversions	Amarillo Flow	Amarillo Chloride	Pan Evap. (in.)	Precip. (in.)
January	-4015	-4380	1993	647	3.044	0.26
February	-3115	-4273	2259	618	3.954	0.46
March	-4315	-4972	1880	589	6.815	1.00
April	-4231	-5724	4469	455	9.947	0.96
May	-2500	-6134	8777	314	11.387	2.64
June	3194	-6860	29514	208	13.546	3.25
July	2624	-7726	24562	273	14.405	2.29
August	19871	-7151	34580	172	12.554	2.93
September	5579	-6135	23716	214	9.206	1.83
October	-4961	-5470	9660	311	7.692	1.16
November	-2677	-4379	3696	468	4.184	0.64
December	-5454	-4763	1520	620	2.812	0.26

This calculation, of course, ignores exceptional flow conditions, such as those which produced the high salinities from 1978 to 1981. Such events would temporarily cause salinities to rise above the long-term average. Also not accounted for is long-term climatic changes which would cause the average values listed in Table 8 to become invalid.

HGC (1984) water balance for Lake Meredith Reservoir

Most of the data on this worksheet have been taken from Appendix C in HGC (1984). Based on the description of water balance model at page 96-97 of the report, and on information provided at the top of Table C.1, "inflow" flow in the Canadian River at Amarillo plus rain on the reservoir surface. Therefore, we have added a column "Precip AF" which equals rain on the reservoir surface, and which is calculated as Inflow minus Amarillo Flow.

We have added a further column, "Area Acres" equal to precipitation in AF times 12 (to give acre inches), divided by precipitation in inches. The resulting area data plot against month-end storage to produce a reasonable area-storage curve. Some refinement of this plot is still required, and the acreage values need to be compared to actual CRMWA records.

Based on the model, the "outflow" term should be the sum of diversions, seepage through the dam and reservoir evaporation. And, evaporation in acre-feet should equal pan evaporation in inches, divided by 12, and multiplied by area. When this calculation is made, the resulting estimate of evaporation often is greater than the value of outflow. On this basis, either: 1) we don't yet understand the HGC methodology; or 2) there is an error in the HGC water balance. At this time, no effort is planned to resolve the problem, as we would recommend CRMWA modify its own water balance (**TAB 13**), for example by adding in dam seepage, in order to characterize hydrologic conditions at Meredith.

Table C.1: Monthly water–budget results for Lake Meredith

Date	Lake Meredith Month–end Storage	Change in Storage	Amarillo Flow	Precip. (in.)	Inflow	Pan Evap. (in.)	Diver–sion	Out–Flow	Resi–dual	Precip (AF)	Area (acres)
OCT 64	2220	2220	732	0.44 *	750	7.629 *	0	238	1708	18	491
NOV 64	3280	1060	1160	0.57 *	1189	4.184 *	0	165	37	29	611
DEC 64	4100	820	524	0.48 *	552	2.812 *	0	137	405	28	700
JAN 65	4460	360	429	0.35 *	452	3.044 *	0	167	75	23	789
FEB 65	4890	430	388	0.19	401	3.954 *	0	223	252	13	821
MAR 65	5570	680	594	0.92	659	6.815 *	0	365	386	65	848
APR 65	5060	−510	332	0.39	358	9.947 *	0	490	−378	26	800
MAY 65	17710	12650	21330	4.10	21843	11.387 *	0	1044	−8149	513	1501
JUN 65	157400	139690	195200	8.63	199587	13.546 *	0	5014	−54883	4387	6100
JUL 65	162800	5400	14650	0.37	14841	14.405 *	0	5407	−4035	191	6195
AUG 65	176400	13600	24170	2.90	25741	12.554 *	0	4966	−7174	1571	6501
SEP 65	181900	5500	13170	0.95	13693	9.206 *	0	3754	−4439	523	6606
OCT 65	210100	28200	42380	0.84	42842	7.629 *	0	3147	−11495	462	6600
NOV 65	214300	4200	11250	0.01 *	11256	4.184 *	0	1958	−5098	6	7200
DEC 65	214700	400	2420	0.68	2828	2.812 *	0	1410	−1018	408	7200
JAN 66	216100	1400	666	0.32	858	3.044 *	0	1507	2049	192	7200
FEB 66	219000	2900	2830	0.92	3382	3.954 *	0	1889	1407	552	7200
MAR 66	218400	−600	2090	0.00 *	2090	6.815 *	0	3091	401	0	7200
APR 66	215900	−2500	559	0.40	799	9.947 *	0	4406	1107	240	7200
MAY 66	211600	−4300	813	0.02	825	11.387 *	0	4942	−183	12	7200
JUN 66	214800	3200	10660	4.39	13257	17.000	0	7266	−2791	2597	7099
JUL 66	216700	1900	8420	1.91	9602	17.390	0	7532	−170	1182	7426
AUG 66	228500	11800	26050	4.24	28629	10.930	0	4886	−11943	2579	7299
SEP 66	231400	2900	6320	1.14	7033	7.730	0	3620	−513	713	7505
OCT 66	227600	−3800	593	0.60	963	8.090	0	3727	−1036	370	7400
NOV 66	225000	−2600	656	0.01	662	6.040	0	3032	−230	6	7200
DEC 66	223300	−1700	756	0.03	774	4.080	190	1969	−505	18	7200
JAN 67	222900	−400	1510	0.01	1516	5.110	0	2413	497	6	7200
FEB 67	222200	−700	858	0.20	980	3.760	5	1854	174	122	7320
MAR 67	220600	−1600	688	0.20	808	5.750	21	2964	556	120	7200
APR 67	228900	8300	14490	2.58	16081	8.250	320	4372	−3409	1591	7400
MAY 67	225800	−3100	2570	1.37	3415	9.730	576	4972	−1543	845	7401
JUN 67	259100	33300	30870	3.19	32997	8.350	537	4804	5107	2127	8001
JUL 67	312400	53300	99410	5.33	103319	8.000	653	4518	−45501	3909	8801
AUG 67	320800	8400	19820	2.63	21793	7.670	132	5289	−8103	1973	9002
SEP 67	322900	2100	13890	0.45	14228	5.800	977	3331	−8797	338	9013
OCT 67	320700	−2200	19470	0.41	19778	6.580	0	3740	−18237	308	9015
NOV 67	319300	−1400	6180	0.26	6373	2.510	0	1586	−6187	193	8908
DEC 67	320200	900	4940	0.23	5113	1.870	0	1267	−2945	173	9026

Table C.1: Monthly water–budget results for Lake Meredith

Date	Lake Meredith Month–end Storage	Change in Storage	Amarillo Flow	Precip. (in.)	Inflow	Pan Evap. (in.)	Diver–sion	Out–Flow	Resi–dual	Precip (AF)	Area (acres)
JAN 68	324800	4600	5210	1.05	5998	2.730	0	1719	321	788	9006
FEB 68	326600	1800	2640	0.39	2936	2.710	0	1727	592	296	9108
MAR 68	325200	−1400	1100	0.33	1348	3.410	803	2879	131	248	9018
APR 68	322400	−2800	662	1.54	1817	12.000	930	7516	2899	1155	9000
MAY 68	328200	5800	11630	2.26	13344	10.150	2740	8417	873	1714	9101
JUN 68	326200	−2000	7570	4.13	10702	12.000	3554	10213	−2489	3132	9100
JUL 68	325300	−900	14450	1.03	15223	11.036	4240	10320	−5803	773	9006
AUG 68	328000	2700	16070	3.01	18353	11.758	3734	10264	−5388	2283	9102
SEP 68	317600	−10400	1270	0.15	1381	10.809	4326	10220	−1561	111	8880
OCT 68	312900	−4700	3830	1.44	4898	8.739	3562	8382	−1216	1068	8900
NOV 68	306800	−6100	988	0.52	1369	3.816	3862	6100	−1369	381	8792
DEC 68	300700	−6100	408	0.26 *	597	1.975	4192	5471	−1226	189	8723
JAN 69	296900	−3800	919	0.01	926	4.136	3694	6042	1316	7	8400
FEB 69	294500	−2400	2740	1.86	4073	4.460	3576	6086	−387	1333	8600
MAR 69	294900	400	3180	0.55	3574	3.205	2354	4235	1061	394	8596
APR 69	288300	−6600	184	0.36	439	9.334	5243	10141	3102	255	8500
MAY 69	305400	17100	33130	3.90	35958	10.592	4458	10110	−8748	2828	8702
JUN 69	354200	48800	76870	4.07	80092	12.112	6068	13082	−18210	3222	9500
JUL 69	369700	15500	38950	2.36	40858	13.567	7128	15113	−10245	1908	9702
AUG 69	376600	6900	29910	3.37	32634	14.114	6997	15291	−10443	2724	9700
SEP 69	463000	86400	105400	2.49	107745	7.128	4332	9389	−11955	2345	11301
OCT 69	468500	5500	23900	1.64	25458	5.550	4594	8647	−11311	1558	11400
NOV 69	464500	−4000	4670	0.44	5084	3.842	4699	7590	−1494	414	11291
DEC 69	459900	−4600	2970	0.07	3035	2.664	4486	6582	−1053	65	11143
JAN 70	457700	−2200	3400	0.02 *	3419	2.279	3320	5165	−454	19	11400
FEB 70	454400	−3300	1320	0.00 *	1320	4.919	3688	7225	2605	0	11400
MAR 70	450400	−4000	1790	0.52	2271	4.517	2862	6139	−132	481	11100
APR 70	469700	19300	29710	0.58	30261	9.224	4868	11364	403	551	11400
MAY 70	461200	−8500	2440	0.26	2685	16.008	5793	16704	5519	245	11308
JUN 70	450900	−10300	1340	0.73	2015	16.204	6180	17024	4709	675	11096
JUL 70	438100	−12800	6340	1.60	7793	17.938	7098	18850	−1744	1453	10898
AUG 70	445600	7500	19960	1.60	21427	15.344	7445	17640	3713	1467	11003
SEP 70	438300	−7300	8980	0.42	9362	11.320	5490	13034	−3628	382	10914
OCT 70	430900	−7400	4380	0.58	4897	6.756	4609	9166	−3132	517	10697
NOV 70	424700	−6200	1870	0.36	2191	6.008	3947	8037	−354	321	10700
DEC 70	417500	−7200	921	0.00 *	921	3.950	4844	7623	−498	0	10600

Table C.1: Monthly water–budget results for Lake Meredith

Date	Lake Meredith Month–end Storage	Change in Storage	Amarillo Flow	Precip. (in.)	Inflow	Pan Evap. (in.)	Diver–sion	Out–Flow	Resi–dual	Precip (AF)	Area (acres)
JAN 71	412700	−4800	1350	0.11 *	1446	4.329	5047	8032	1786	96	10473
FEB 71	410100	−2600	1560	0.99	2459	4.763	3991	7366	2306	899	10897
MAR 71	403200	−6900	750	0.08 *	819	8.944	4923	10624	2905	69	10350
APR 71	396100	−7100	1650	0.66	2206	11.612	5256	12418	3113	556	10109
MAY 71	391500	−4600	9620	0.77	10262	14.646	6601	15462	600	642	10005
JUN 71	391300	−200	20950	2.34	22900	16.866	6046	16202	−6898	1950	10000
JUL 71	400700	9400	36950	2.49	39067	15.510	6709	16261	−13405	2117	10202
AUG 71	416800	16100	45220	2.13	47084	11.238	5282	12499	−18485	1864	10501
SEP 71	416800	0	17150	4.03	20676	10.207	6502	13087	−7589	3526	10499
OCT 71	413000	−3800	4340	2.06	6125	7.710	4923	9931	5	1785	10398
NOV 71	445400	32400	22140	2.46	24395	5.473	4003	7864	15869	2255	11000
DEC 71	445400	0	4070	0.47	4501	2.206	3753	5518	1017	431	11004
JAN 72	442000	−3400	3910	0.47 *	4037	4.329	3326	6425	−1013	127	10900
FEB 72	438000	−4000	1890	0.05	1935	4.784	4001	7358	1423	45	10800
MAR 72	431200	−6800	858	0.20	1036	10.459	4837	11705	3869	178	10680
APR 72	420900	−10300	648	0.04 *	683	13.075	6253	14674	3691	35	10500
MAY 72	420100	−800	5430	2.13	7312	11.145	5196	12424	4312	1882	10603
JUN 72	430500	10400	8790	3.08	11562	12.483	6512	14719	13557	2772	10800
JUL 72	472500	42000	81440	3.13	84153	11.471	6376	13665	−28487	2713	10401
AUG 72	503000	30500	56270	1.72	57976	12.385	6714	15689	−11787	1706	11902
SEP 72	542700	39700	61630	0.31	61956	9.698	5623	13151	−9104	326	12619
OCT 72	539400	−3300	17010	1.36	18438	7.013	6440	11995	−9743	1428	12600
NOV 72	538600	−800	3010	1.70	4781	2.139	1544	3501	−2080	1771	12501
DEC 72	536100	−2500	1900	0.19	2098	0.961	4604	5702	1104	198	12505
JAN 73	534300	−1800	2570	0.24	2818	1.844	3944	5671	1053	248	12400
FEB 73	531200	−3100	2190	0.28	2479	2.993	3837	6396	816	289	12386
MAR 73	536800	5600	8650	4.37	13202	5.714	4171	8734	1132	4552	12500
APR 73	545300	8500	14940	2.26	17313	7.185	4438	10119	1306	2373	12600
MAY 73	537900	−7400	1470	1.05	2564	11.427	4995	13724	3760	1094	12503
JUN 73	525400	−12500	389	0.73	1137	15.227	6546	17862	4225	748	12296
JUL 73	520400	−5000	14420	2.60	17063	13.441	6647	16600	−5464	2643	12198
AUG 73	510900	−9500	11940	0.77	12716	14.395	6404	16949	−5268	776	12094
SEP 73	498600	−12300	884	2.53	3393	8.752	5437	11890	−3803	2509	11900
OCT 73	487900	−10700	526	0.91	1413	8.364	5074	11154	−959	887	11697
NOV 73	478300	−9600	557	0.17	720	5.014	4542	8271	−2049	163	11506
DEC 73	470900	−7400	833	0.50	1308	3.293	4714	7266	−1442	475	11400

Table C.1: Monthly water–budget results for Lake Meredith

Date	Lake Meredith Month–end Storage	Change in Storage	Amarillo Flow	Precip. (in.)	Inflow	Pan Evap. (in.)	Diver–sion	Out–Flow	Resi–dual	Precip (AF)	Area (acres)
JAN 74	466900	−4000	1410	0.10	1505	1.691	3967	5453	−52	95	11400
FEB 74	460800	−6100	875	0.20	1063	5.755	4406	8558	1395	188	11280
MAR 74	458900	−1900	5640	2.50	7973	8.795	5432	11534	1660	2333	11198
APR 74	447600	−11300	287	0.23 *	498	12.120	6844	14970	3172	211	11009
MAY 74	442100	−5500	7170	3.10	9986	15.486	7397	17590	2104	2816	10901
JUN 74	429600	−12500	4260	2.03	6070	15.646	8169	18274	−296	1810	10700
JUL 74	413400	−16200	2520	0.91	3316	16.853	8957	19613	97	796	10497
AUG 74	434800	21400	49770	7.30	56340	11.563	6428	14056	−20884	6570	10800
SEP 74	431000	−3800	18960	0.62	19518	6.877	5088	9763	−13555	558	10800
OCT 74	451500	20500	36500	4.69	40838	6.722	4440	9145	−11193	4338	11099
NOV 74	447100	−4400	3650	0.31	3934	4.392	4422	7589	−745	284	10994
DEC 74	441400	−5700	1940	0.44	2340	3.730	4391	7109	−931	400	10909
JAN 75	438300	−3100	3720	0.15	3856	2.511	4425	6368	−589	136	10880
FEB 75	437800	−500	3660	1.12	4668	1.687	3741	5147	−21	1008	10800
MAR 75	433200	−4600	1820	0.19	1989	6.282	4859	9120	2530	169	10674
APR 75	425700	−5700	2830	1.05	3766	9.317	5318	11473	2007	936	10697
MAY 75	419200	−8300	2450	2.6	4725	12.865	6884	15097	2072	2275	10500
JUN 75	436200	17000	31670	3.53	34788	12.557	6992	15093	−2695	3118	10599
JUL 75	456900	17700	18450	5.03	23103	11.545	6509	14337	8934	4653	11101
AUG 75	445700	−8200	10100	0.74	10778	12.842	7373	15962	−3016	678	10995
SEP 75	430600	−15100	1300	2.04	3119	9.550	6432	12732	−5487	1819	10700
OCT 75	418400	−12200	791	0 *	791	9.223	5867	11849	−1142	0	10500
NOV 75	410600	−7800	440	1.27	1541	4.536	4758	7840	−1501	1101	10403
DEC 75	404500	−6100	333	0.06 *	385	2.865	4184	6232	−252	52	10400
JAN 76	398600	−5900	627	0.01 *	636	4.190	3858	6675	139	9	10800
FEB 76	392500	−6100	672	0.16 *	807	6.784	4451	8769	1862	135	10125
MAR 76	385500	−7000	824	1.31	1916	8.697	4790	10181	1265	1092	10003
APR 76	380100	−5400	2160	1.54	3431	9.235	4947	10594	1764	1271	9904
MAY 76	374300	−5800	6540	0.93	7300	10.551	6245	12588	−512	760	9806
JUN 76	364500	−9800	3200	1.01	4008	14.943	7377	16050	2242	808	9600
JUL 76	353500	−11000	3730	1.33	4772	12.951	6964	14364	−1408	1042	9402
AUG 76	349000	−4500	13310	3.64	16131	13.764	8115	15877	−4754	2821	9300
SEP 76	381600	32600	53270	7.64	59573	7.895	5887	10761	−16212	6303	9900
OCT 76	375100	−6500	3580	0.48	3972	7.629 *	4763	9435	−1037	392	9800
NOV 76	369000	−6100	958	0.61 *	1451	4.184 *	4255	6930	−621	493	9698
DEC 76	364400	−4600	772	0.30 *	1012	2.182 *	3698	5225	−387	240	9600

Table C.1: Monthly water–budget results for Lake Meredith

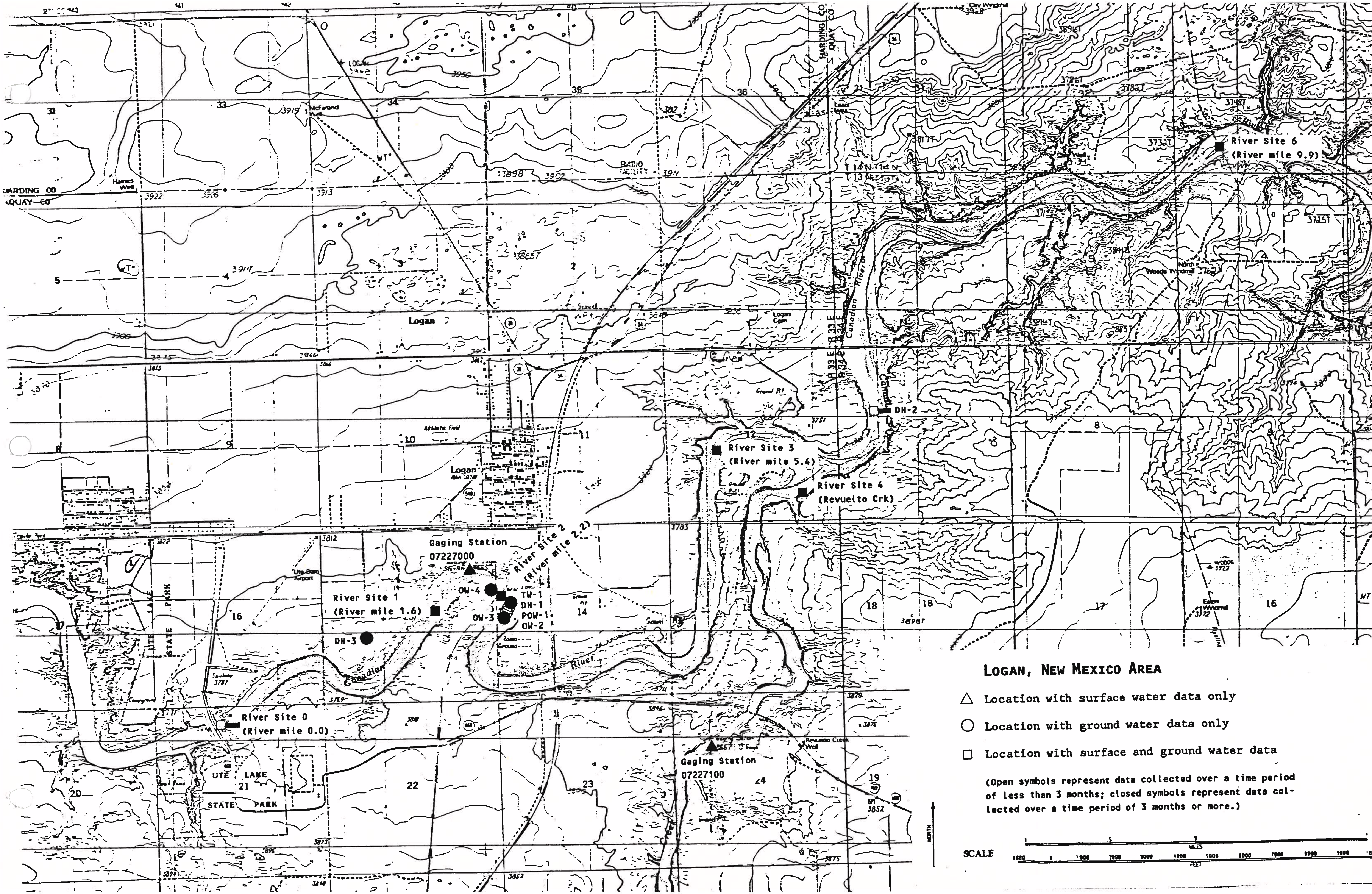
Date	Lake Meredith Month–end Storage	Change in Storage	Amarillo Flow	Precip. (in.)	Inflow	Pan Evap. (in.)	Diver–sion	Out–Flow	Resi–dual	Precip (AF)	Area (acres)
JAN 77	361100	−3300	1560	0.15	1679	3.044 *	3716	5704	726	119	9520
FEB 77	357200	−3900	1600	0.23	1782	3.954 *	4255	6748	1066	182	9496
MAR 77	349200	−8000	220	0.35	494	10.120	5063	10911	2416	274	9394
APR 77	349200	0	9180	1.86	10637	9.947 *	4910	10663	26	1457	9400
MAY 77	353000	3800	7790	5.94	12493	11.387 *	5813	12425	3732	4703	9501
JUN 77	343200	−9800	4350	1.38	5420	14.731	7161	15448	228	1070	9304
JUL 77	332100	−11100	7440	1.62	8682	16.890	8391	17747	−2035	1242	9200
AUG 77	365100	33000	52670	6.80	58110	11.709	6909	13771	−11339	5440	9600
SEP 77	370800	5700	28750	1.12	29655	10.161	6663	12720	−11235	905	9696
OCT 77	358800	−12000	85	0.36	370	7.860	6171	10828	−1542	285	9500
NOV 77	350100	−8700	91	0.15	209	5.356	4439	7674	−1234	118	9440
DEC 77	342200	−7900	106	0.08	168	4.564	5132	7903	−165	62	9300
JAN 78	336100	−6100	292	0.28	507	0.807	4913	5638	−969	215	9214
FEB 78	334300	−1800	357	0.75	926	1.901	4046	5344	2618	569	9104
MAR 78	327800	−6500	507	0.19	650	7.032	5648	9626	2476	143	9032
APR 78	317200	−10600	90	0.63	557	11.990	7077	13584	2427	467	8895
MAY 78	327500	10300	20430	4.1	23539	9.827	6232	11737	−1502	3109	9100
JUN 78	357000	29500	42370	2.88	44650	13.566	6446	14265	−885	2280	9500
JUL 78	342300	−14700	1540	0.92	2253	17.364	8274	17989	1036	713	9300
AUG 78	330900	−11400	2250	2.27	3990	14.298	7010	14975	−415	1740	9198
SEP 78	334900	4000	17380	2.90	19603	10.329	5579	11414	−4189	2223	9199
OCT 78	331800	−3100	7870	0.32	8113	7.616	5426	9758	−1455	243	9113
NOV 78	326700	−5100	988	0.51	1371	2.690	4365	6063	−408	383	9012
DEC78	318900	−7800	370	0.09	437	1.732	5110	6292	−1945	67	8933
JAN 79	314400	−4500	730	0.38	1009	3.044 *	5128	6970	1461	279	8811
FEB 79	309700	−4700	579	0.06	623	3.954 *	4846	7155	1832	44	8800
MAR 79	301400	−5600	473	0.98	1184	6.592	5221	8843	2059	711	8706
APR 79	296500	−7600	310	0.57	719	8.042	6385	10692	2374	409	8611
MAY 79	290700	−5800	1680	4.95	5186	10.315	6756	12140	1154	3506	8499
JUN 79	296500	5800	18960	3.97	21805	11.328	6473	12429	−3576	2845	8599
JUL 79	285600	−10900	332	0.93	983	15.539	8365	16246	4363	651	8400
AUG 79	294900	9300	15370	3.20	17663	11.930	7499	13757	5394	2293	8599
SEP 79	290400	−4500	1940	1.50	3003	9.967	6847	12059	4556	1063	8504
OCT 79	278400	−12000	121	2.43	1802	10.274	7314	12552	−1250	1681	8301
NOV 79	274800	−3600	5080	0.44	5381	3.103	5211	6956	−2025	301	8209
DEC 79	268400	−6400	950	0.14	1045	4.705	5642	8122	678	95	8143

Table C.1: Monthly water–budget results for Lake Meredith

Date	Lake Meredith Month–end Storage	Change in Storage	Amarillo Flow	Precip. (in.)	Inflow	Pan Evap. (in.)	Diver–sion	Out–Flow	Resi–dual	Precip (AF)	Area (acres)
JAN 80	266500	−1900	5330	1.12	6086	2.325	4979	6335	−1651	756	8100
FEB 80	270800	4300	14920	0.42	15204	3.323	5059	6886	−4017	284	8114
MAR 80	269300	−1500	2550	2.67	4352	7.395	6035	9786	3934	1802	8099
APR 80	260100	−9200	1050	1.04	1743	9.207	6374	10925	−19	693	7996
MAY 80	266300	6200	16890	4.31	19799	9.839	6655	11561	−2038	2909	8099
JUN 80	262200	−4100	6870	3.15	8970	15.154	8234	15560	2490	2100	8000
JUL 80	244500	−17700	80	0.67	510	17.926	9804	18100	−110	430	7701
AUG 80	235800	−8700	5940	1.55	6909	16.358	9004	16399	790	969	7502
SEP 80	223700	−12100	2520	0.43	2782	9.882	7210	11650	−3232	262	7312
OCT 80	205100	−18600	35	0.26	189	8.974	6120	10062	−8727	154	7108
NOV 80	198300	−6800	164	0.41	403	3.667	5520	7240	36	239	6995
DEC 80	192900	−5400	1080	0.66	1460	2.982	5660	7079	220	380	6909
JAN 81	187700	−5200	537	0.15	622	2.501	4780	5988	166	85	6800
FEB 81	182600	−5100	247	0.1	303	5.448	4480	6822	1419	56	6720
MAR 81	179200	−3400	816	1.98	1905	6.822	4980	7816	2511	1089	6600
APR 81	171900	−7300	219	1.10	815	10.646	5940	10183	2068	596	6502
MAY 81	166800	−5100	2780	2.88	4316	10.390	6840	10922	1506	1536	6400
JUN 81	171600	4800	18840	3.12	20530	14.119	7820	13380	−2350	1690	6500
JUL 81	172200	600	14340	1.41	15104	13.946	8800	14294	−210	764	6502
AUG 81	300300	128100	184900	4.25	188052	10.536	6730	12482	−47470	3152	8900
SEP 81	334400	34100	50980	2.70	53095	7.696	5940	10458	−8537	2115	9400
OCT 81	333500	−900	7740	2.03	9330	5.643	5370	8763	−1468	1590	9399
NOV 81	329400	−4100	2670	1.35	3716	3.586	5220	7461	−356	1046	9298
DEC 81	324100	−5300	2070	0.06	2117	2.934	5700	7587	170	47	9400
JAN 82	318100	−6000	1710	0.03	1733	5.213	5540	8630	897	23	9200
FEB 82	314500	−3600	1330	0.37	1611	4.827	4750	7601	2391	281	9114
MAR 82	309000	−5500	1290	0.58	1725	8.028	5820	10320	3095	435	9000
APR 82	300700	−8300	1140	0.38	1422	10.506	5800	11537	1815	282	8905
MAY 82	299700	−1000	3830	2.85	5944	9.022	4330	9296	2353	2114	8901
JUN 82	329400	29700	48090	6.20	52895	10.614	5230	11283	−11912	4805	9300
JUL 82	390400	61000	78670	7.48	85153	12.588	7540	15507	−8646	6483	10401
AUG 82	422600	32200	38690	0.57	39208	11.600	8050	15772	8764	518	10905
SEP 82	427800	5200	23100	1.51	24484	9.576	7060	13554	−5730	1384	10999

Table C.1: Averages and Annual Sums for Lake Meredith

Date	Lake Meredith Year–end Storage	Change in Storage	Amarillo Flow	Precip. (in.)	Inflow	Pan Evap. (in.)	Diver–sion	Out–Flow	Resi–dual	Precip (AF)
1964	4100	4100	2416	1.49	2491	14.625	0	540	2150	75
1965	214700	210600	326313	20.33	334501	99.483	0	27945	−95956	8188
1966	223300	8600	60413	13.98	68874	106.407	190	47867	−12407	8461
1967	320200	96900	214696	16.86	226401	73.38	3221	41110	−88388	11705
1968	300700	−19500	65828	16.11	77966	91.133	31943	83228	−14236	12138
1969	459900	159200	322823	21.12	339876	90.704	57629	112308	−68367	17053
1970	417500	−42400	82451	6.67	88562	114.467	60144	137971	7007	6111
1971	445400	27900	165750	18.59	181940	113.504	63036	135264	−18776	16190
1972	536100	90700	242786	14.38	255967	99.942	61426	131008	−34258	13181
1973	470900	−65200	59369	16.41	76126	97.649	60749	134636	−6693	16757
1974	441400	−29500	132982	22.43	153381	109.63	69941	143654	−39228	20399
1975	404500	−36900	77564	17.78	93509	95.78	67342	131250	840	15945
1976	364400	−40100	89643	18.96	105009	103.005	65350	127449	−17659	15366
1977	342200	−22200	113842	20.04	129699	109.723	68623	132542	−19356	15857
1978	318900	−23300	94444	15.84	106596	99.152	70126	126685	−3211	12152
1979	268400	−50500	46525	19.55	60403	98.793	75687	127921	17020	13878
1980	192900	−75500	57429	16.69	68407	107.032	80654	131583	−12324	10978
1981	324100	131200	286139	21.13	299905	94.267	72600	116156	−52551	13766
1982	427800	103700	197850	19.97	214175	81.974	54120	103500	−6973	16325
	340916	22516	138909	16.75	151778	95	50673	104875	−24388	12870


LOGAN, NEW MEXICO AREA
△ Location with surface water data only
○ Location with ground water data only
□ Location with surface and ground water data
(Open symbols represent data collected over a time period of less than 3 months; closed symbols represent data collected over a time period of 3 months or more.)
SCALE
NORTH
River Site 0
(River mile 0.0)
River Site 1
(River mile 1.6)
River Site 2
(River mile 2.2)
River Site 3
(River mile 5.4)
River Site 4
(Revuelto Crk)
River Site 6
(River mile 9.9)
Gaging Station
07227000
Gaging Station
07227100
DH-1
DH-2
DH-3
OW-2
OW-3
OW-4
POW-1
TW-1
Logan
UTE LAKE STATE PARK
Canadian River
HARDING CO
QUAY CO
RADIO FACILITY
Athletic Field
Revuelto Creek Well

7-1654 (7-73)
Water and Power

COMPUTATION SHEET

BY G.G.	DATE 9/26/84	PROJECT Lk Meredith Project	SHEET 1 OF 4
CHKD BY	DATE	FEATURE Canadian River & Revuelto Cr.	
DETAILS Statistical Analyses - Regression - BR Data 5/83 - 8/84			

Table 3- Summary of Statistical Analyses For Grouped Water Samples, All Sampling Sites Near Logan, NM

Group 1- All Surface Water

$y = A + BX$

flow / chlorides (y / x)

Sample size	= 80
Correlation (R)	= -0.279
R squared	= 0.078
Std. Error of Est.	= 22.949
Intercept (A)	= 17.061
Slope (B)	= -0.003

flow / Field Conductance

Sample size	= 80
Correlation (R)	= -0.308
R squared	= 0.095
Std. Error of Est.	= 22.735
Intercept (A)	= 20.045
Slope (B)	= -0.001

flow / TDS

Sample size	= 80
correlation (R)	= -0.286
R squared	= 0.082
Std. Error of Est.	= 22.897
Intercept (A)	= 17.966
Slope (B)	= -0.002

chlorides / Field Conductance

Sample size	= 80
Correlation (R)	= 0.936
R squared	= 0.877
std Error of Est.	= 775.969
Intercept (A)	= -348.662
Slope (B)	= 0.352

chlorides / TDS

Sample size	= 80
Correlation (R)	= 0.869
R squared	= 0.755
Std. Error of Est	= 1095.103
Intercept (A)	= 241.498
Slope (B)	= 0.471

R – 1 – (-1) – closer to 1 better Linear Relationship; – indicates inverse relationship
R^2 – variance – 0-1 small when variables cluster close to mean
std. Error – std dev of y values from predicted y values

7-1654 (7-73)
Water and Power

COMPUTATION SHEET

BY	DATE	PROJECT Lk Meredith Project	SHEET 2 OF 4
CHKD BY	DATE	FEATURE	
DETAILS statistical Analyses - Regression y = A + BX			

Field Conductance / TDS

Sample size	= 80
correlation (R)	= 0.877
R squared	= 0.768
Std. Error of Est.	= 2828.171
Intercept (A)	= 2140.874
slope (B)	= 1.266

Group II - Alluvial Piezometers Canad. R ab Revuelto Cr.

flow / chlorides (y / x)

sample size	= 119
Correlation (R)	= 0.238
R squared	= 0.057
Std Error of Est.	= 1.454
Intercept (A)	= 0.842
slope (B)	= 0.00017

flow / Field Conductance

sample size	= 119
Correlation (R)	= 0.209
R squared	= 0.044
Std. Error of Est.	= 1.464
Intercept (A)	= 0.883
Slope (B)	= 0.00006

flow / TDS

sample size	= 119
correlation (R)	= 0.067
R squared	= 0.004
Std. Error of Est.	= 1.494
Intercept (A)	= 1.935
Slope (B)	= 0.00002

Table 3 (Continued)

Note: Flow data is from the surface stream near the piezometers.

7-1654 (7-73)
Water and Power

COMPUTATION SHEET

BY	DATE	PROJECT LK Meredith Project	SHEET 3 OF 4
CHKD BY	DATE	FEATURE	
DETAILS Statistical Analyses – Regression Y = A + BX			

chlorides / Field Conductance

Sample size	=	119
Correlation (R)	=	0.819
R squared	=	0.670
Std. Error of Est.	=	1235.800
Intercept (A)	=	845.918
Slope (B)	=	0.338

chlorides / TDS

~~Sample~~ sample size	=	119
Correlation (R)	=	0.657
R squared	=	0.432
Std error of Est.	=	1621.740
Intercept (A)	=	3449.726
Slope (B)	=	0.348

Field Conductance / TDS

Sample size	=	119
Correlation (R)	=	0.681
R squared	=	0.464
Std Error of Est	=	3820.136
Intercept (A)	=	10174.063
Slope (B)	=	0.874

Group III Alluvial Piezometers, Revuelto Cr. and Canad. R. Below Revuelto Cr. Y = A + BX

Y / X
flow / chlorides

~~Sample size~~	=	67
Corelation R	=	0.161
R squared	=	0.026
Std ERROR of Est.	=	35.181
Intercept (A)	=	7.598
Slope (B)	=	0.0016

Table 3 (Continued)

7-1654 (7-73)
Water and Power

COMPUTATION SHEET

BY	DATE	PROJECT Ck Meredith Project	SHEET 4 OF 4
CHKD BY	DATE	FEATURE	
DETAILS Statistical Analyses - Regression $Y = A + BX$			

Y / X

flow/Field Conductance
Sample size = 67
Correlation R = 0.030
R Squared = 0.0009
Std. error of Est. = 35.629
Intercept (A) = 13.441
Slope (B) = 0.0001

flow/TDS
Sample size = 67
Correlation (R) = 0.019
R squared = 0.0004
Std. error of Est. = 35.639
Intercept (A) = 14.014
Slope (B) = 0.0001

chlorides/Field Conductance
Sample size = 67
Correlation (R) = 0.974
R squared = 0.948
Std. Error of Est. = 836.877
Intercept (A) = -533.114
Slope (B) = 0.375

chlorides/TDS
Sample size = 67
Correlation (R) = 0.858
R squared = 0.737
Std. Error of Est. = 1892.622
Intercept (A) = 85.511
Slope (B) = 0.471

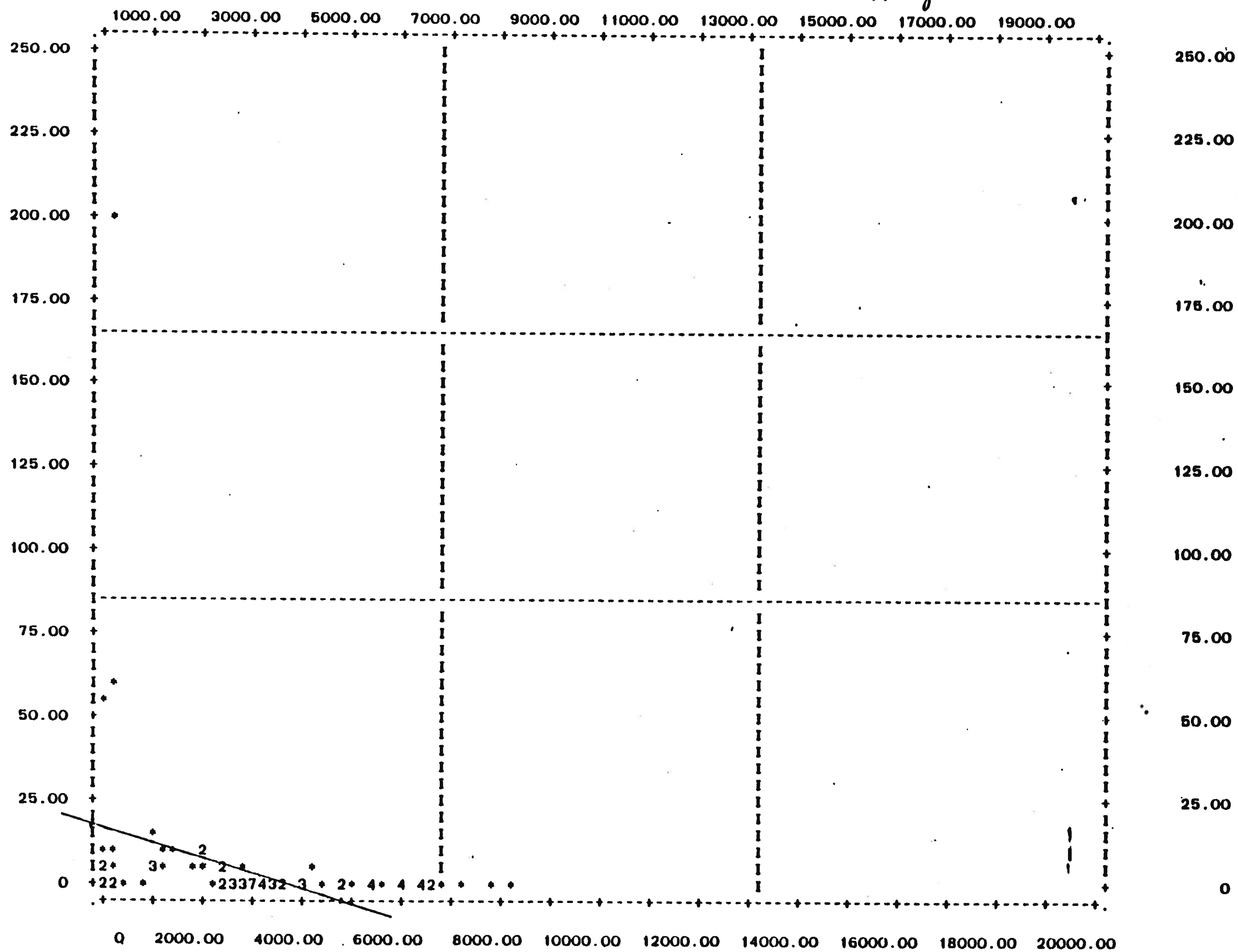
Field Conductance/TDS
Sample size = 67
Correlation (R) = 0.862
R squared = 0.743
Std. Error of Est. = 4851.193
Intercept (A) = 1920.625
Slope (B) = 1.227

Table 3-(continued)

C IAN RIVER NR LOGAN,NM
SC ERGRAM-ALL SURFACE WATER-CANADIAN RIVER NR LOGAN,NM
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S01 S04 S08 S13 S17

Figure 25 – Scattergram, Flow VS Chlorides
Group I Data

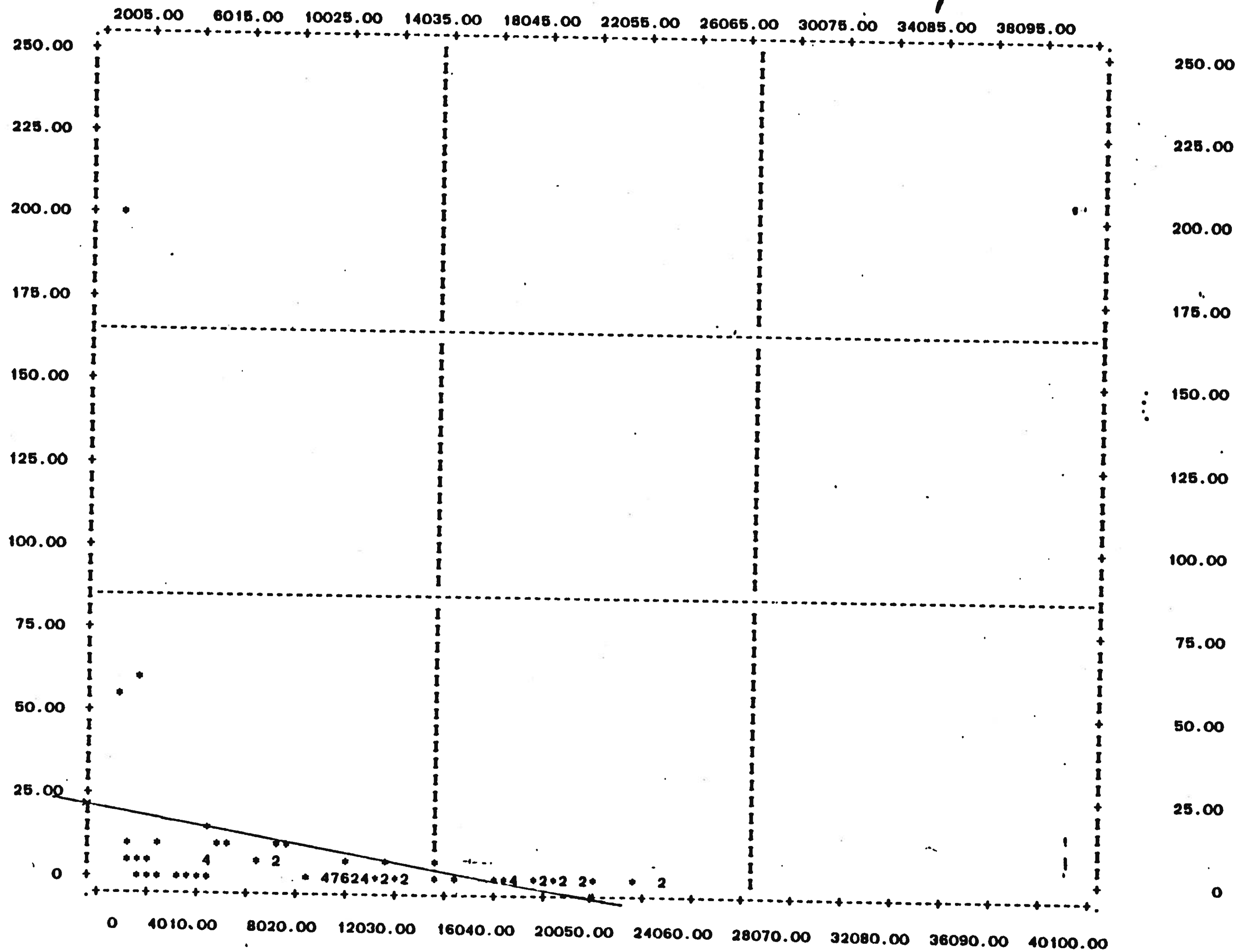
SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR003 CHLORIDES



C[illegible]DIAN RIVER NR LOGAN,NM
[illegible]ERGRAM-ALL SURFACE WATER-CANADIAN RIVER NR LOGAN,NM
F[illegible] NONAME (CREATION DATE = 84/09/23.)
SUBFILE S01 S04 S08 S13 S17

SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR005 FIELD CONDUCTANCE

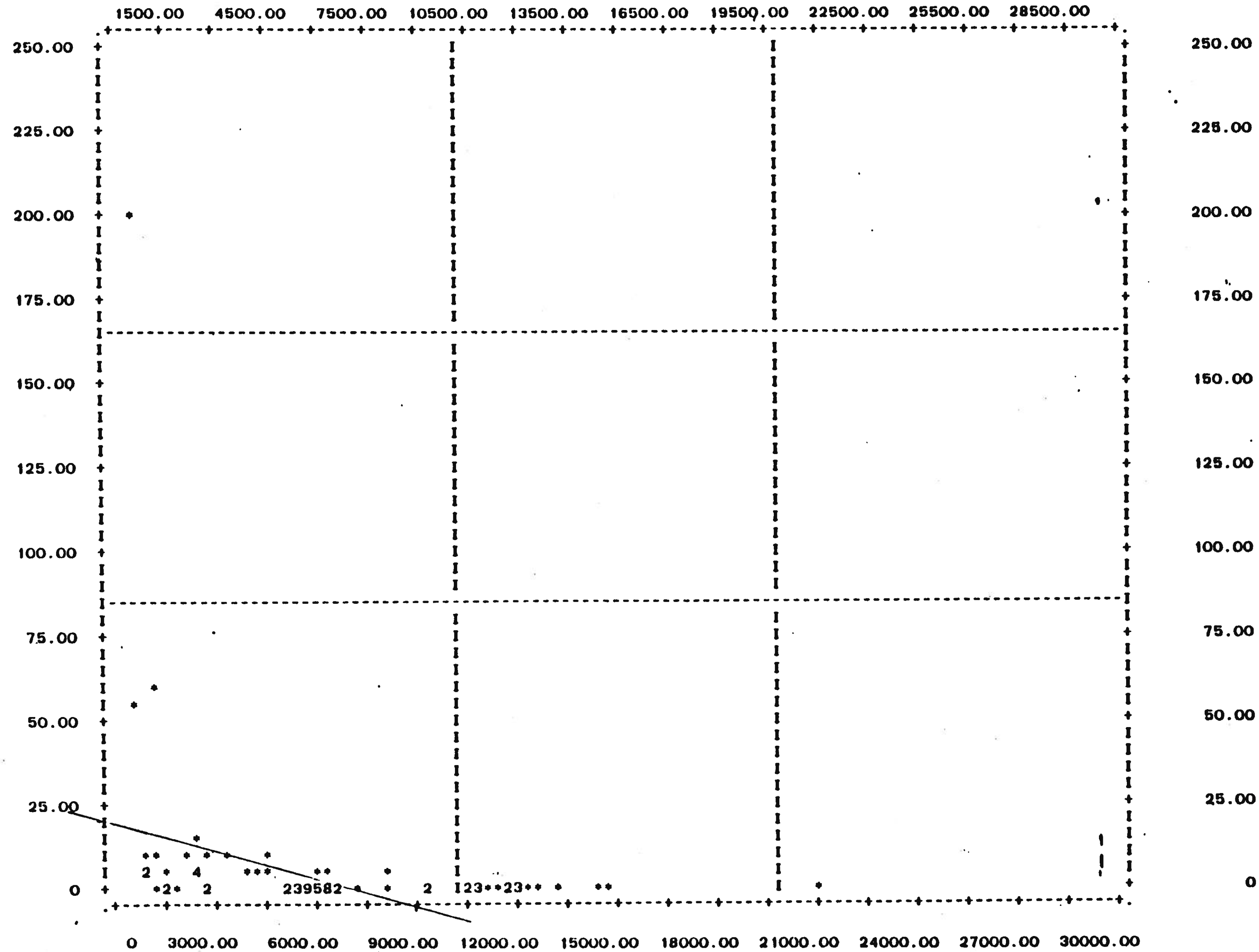
Figure 26 - Scattergram, Flow VS Field Conductance
Group I Data



CAN N RIVER NR LOGAN,NM
SCA GRAM-ALL SURFACE WATER-CANADIAN RIVER NR LOGAN,NM
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S01 S04 S08 S13 S17

Figure 27 - Scattergram, Flow vs TDS
Group I Data

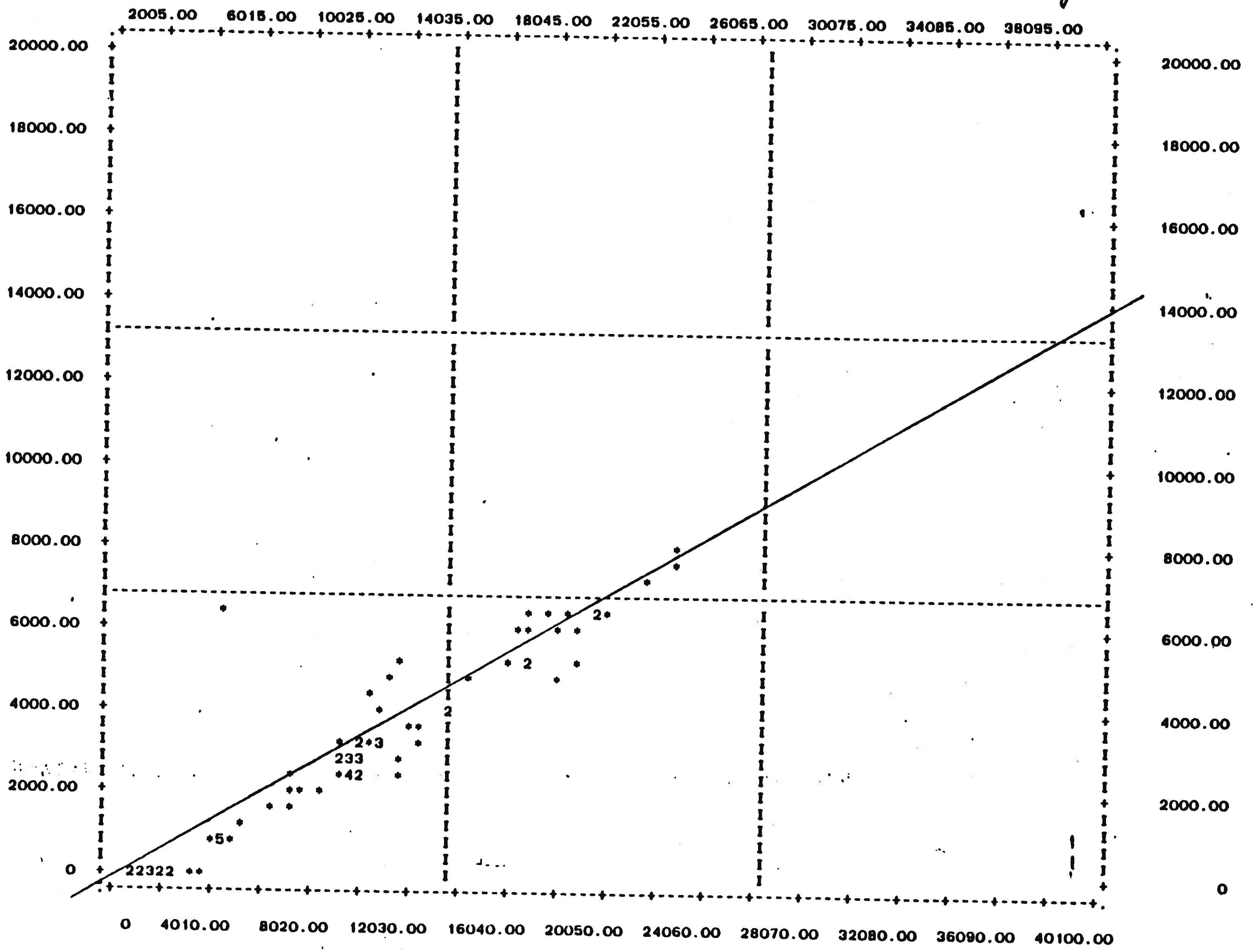
SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR006 TDS



DIAN RIVER NR LOGAN,NM
TERGRAM-ALL SURFACE WATER-CANADIAN RIVER NR LOGAN,NM
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S01 S04 S08 S13 S17

SCATTERGRAM OF (DOWN) VAR003 CHLORIDES
(ACROSS) VAR005 FIELD CONDUCTANCE

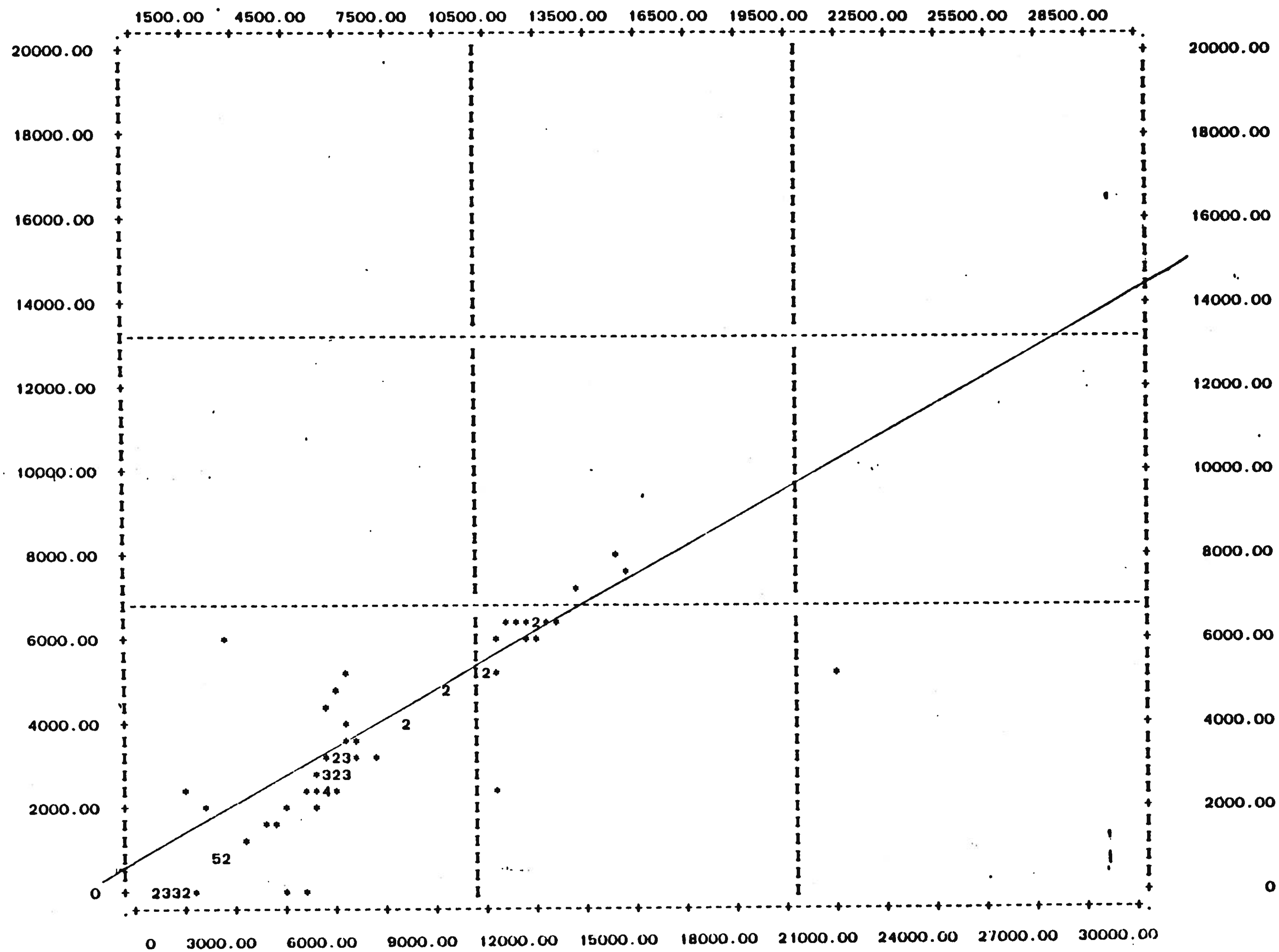
Figure 28 - Scattergram, Chlorides VS Field Conductance Group I Data



CANA RIVER NR LOGAN,NM 84/09/23. 16.52.12. PAGE 11
SCAT RAM-ALL SURFACE WATER-CANADIAN RIVER NR LOGAN,NM
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S01 S04 S08 S13 S17

SCATTERGRAM OF (DOWN) VAR003 CHLORIDES
(ACROSS) VAR006 TDS

Figure 29 - Scattergram, Chlorides vs TDS
Group I Data

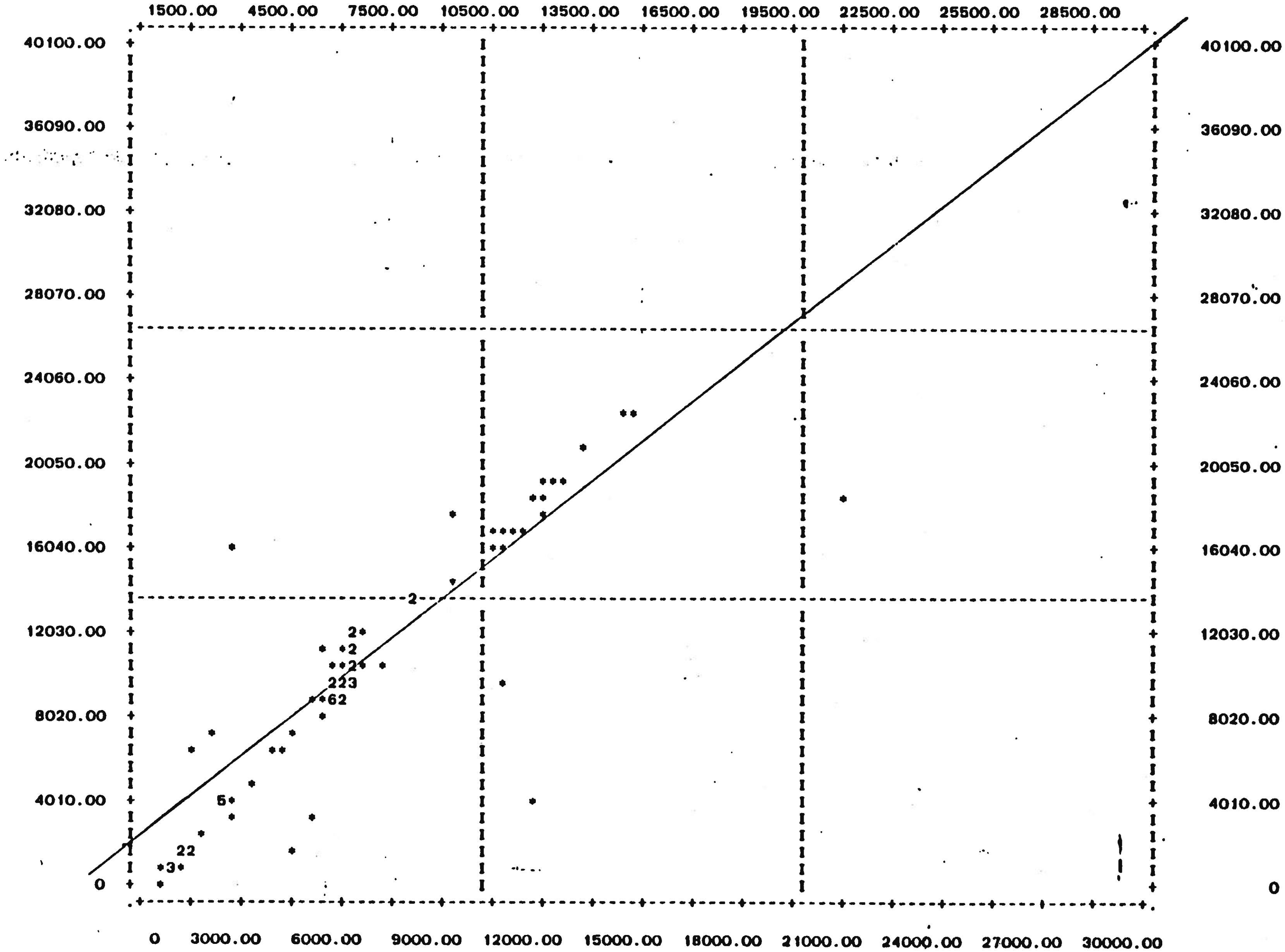


ADIAN RIVER NR LOGAN,NM
ATTERGRAM-ALL SURFACE WATER-CANADIAN RIVER NR LOGAN,NM
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S01 S04 S08 S13 S17

84/09/23. 16.52.12. PAGE 21

Figure 30 - Scattergram, Field Conductance vs TDS
Group I Data

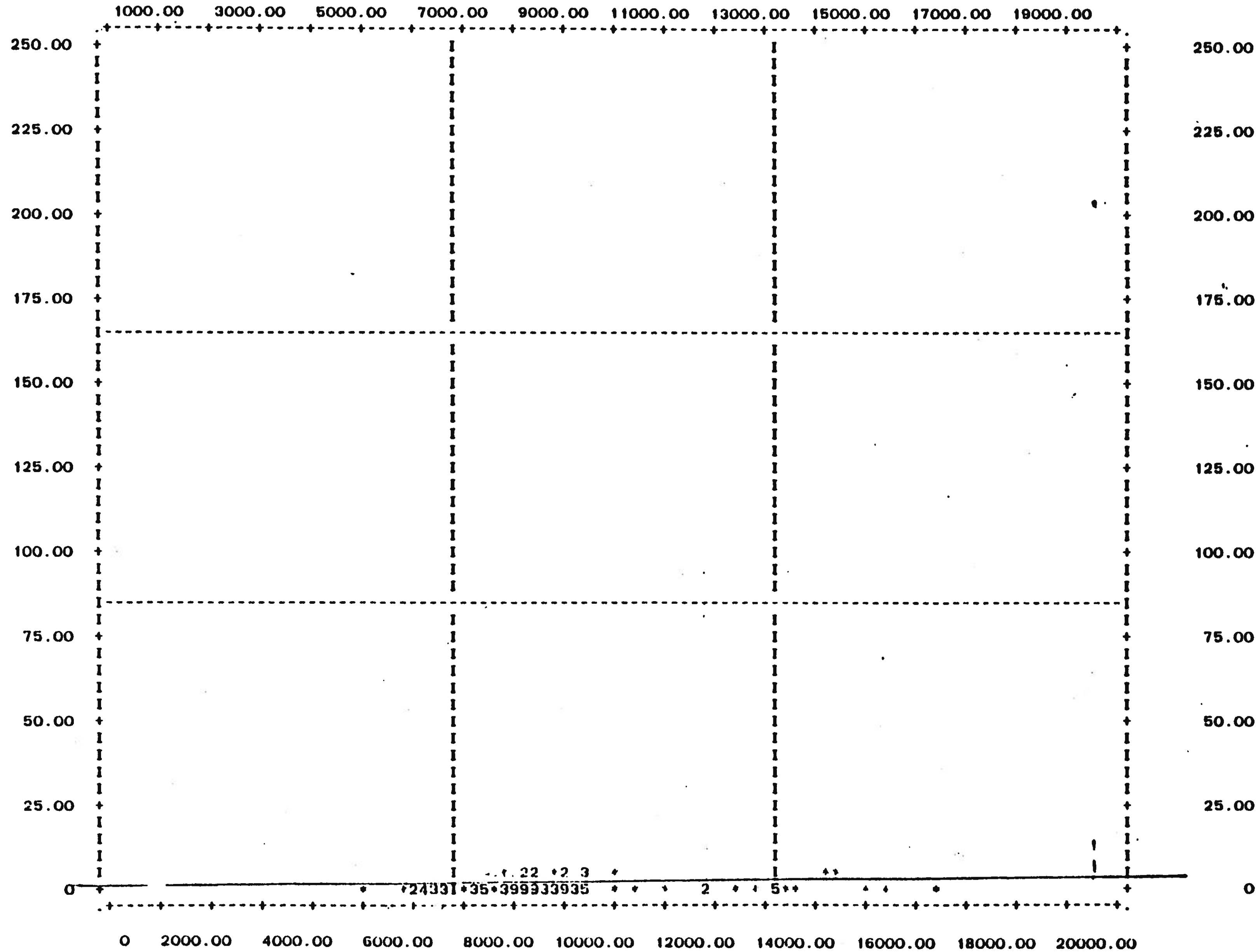
SCATTERGRAM OF (DOWN) VAR005 FIELD CONDUCTANCE
(ACROSS) VAR006 TDS



SCATERGRA ZOMETERS AB REVUELTO CREEK
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S02 S03 S05 S06 S07 S09 S10

SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR003 CHLORIDES

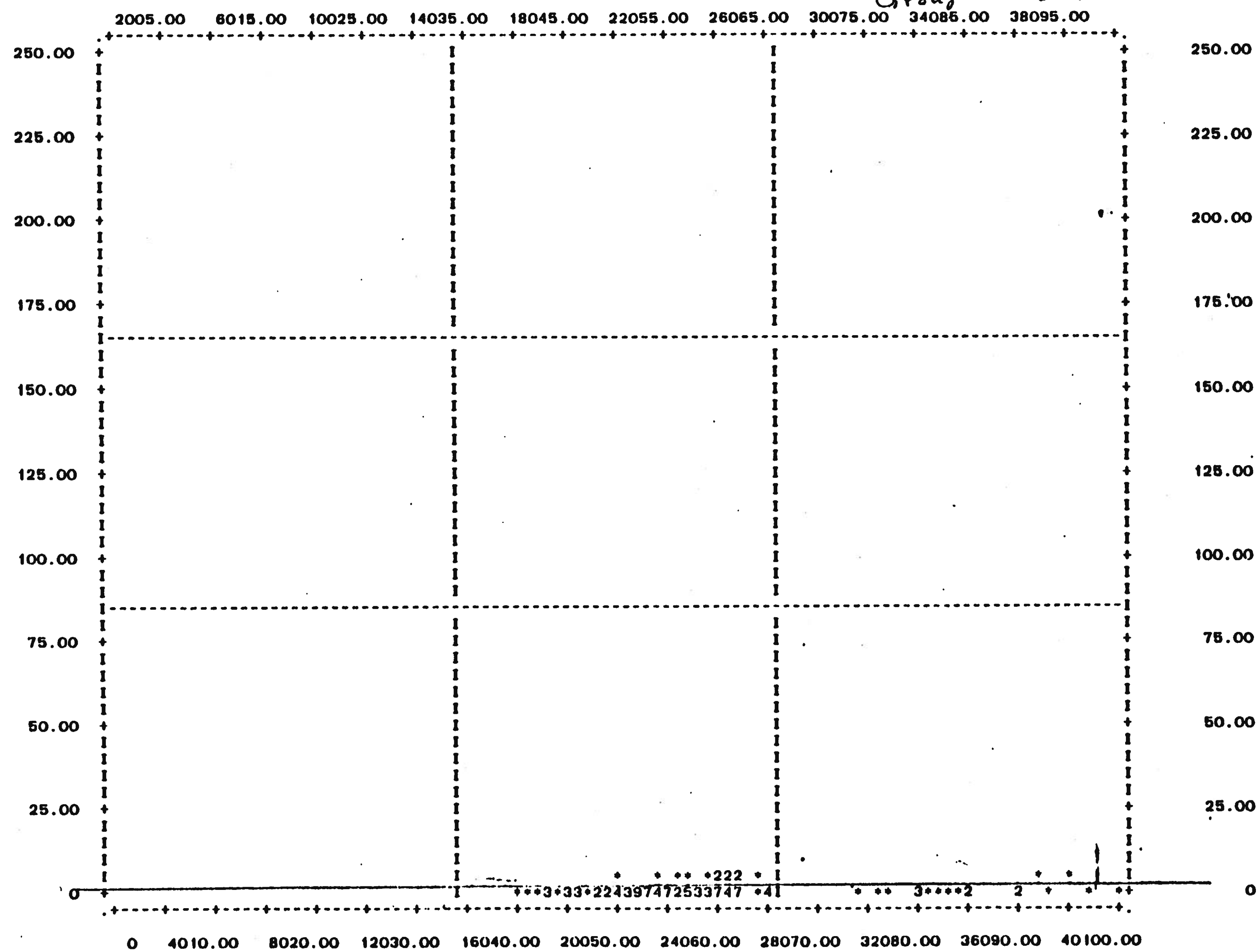
Figure 31 - Scattergram, Flow vs Chlorides Group II Data



SCA RAM-PIEZOMETERS AB REVUELTO CREEK
FIL NONAME (CREATION DATE = 84/09/23.)
SUBFILE S02 S03 S05 S06 S07 S09 S10

SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR005 FIELD CONDUCTANCE

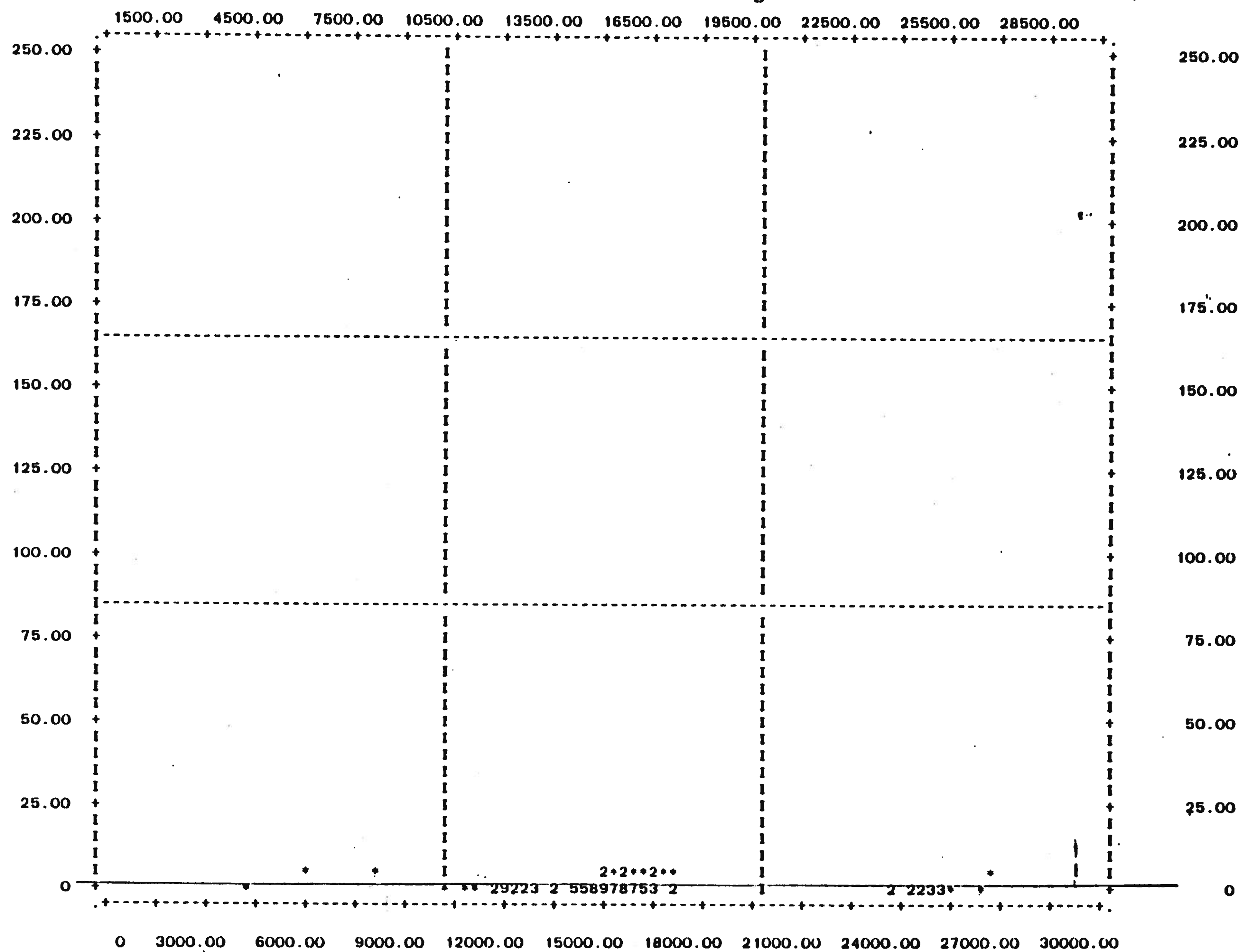
Figure 32 - Scattergram, Flow vs Field Conductance
Group II Data



CANADIAN RIVER NR LOGAN,NM   84/09/23.   16.52.12.   PAGE 41
SCA RAM-PIEZOMETERS AB REVUELTO CREEK
FIL NONAME (CREATION DATE = 84/09/23.)
SUBFILE S02 S03 S05 S06 S07 S09 S10

SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR006 TDS

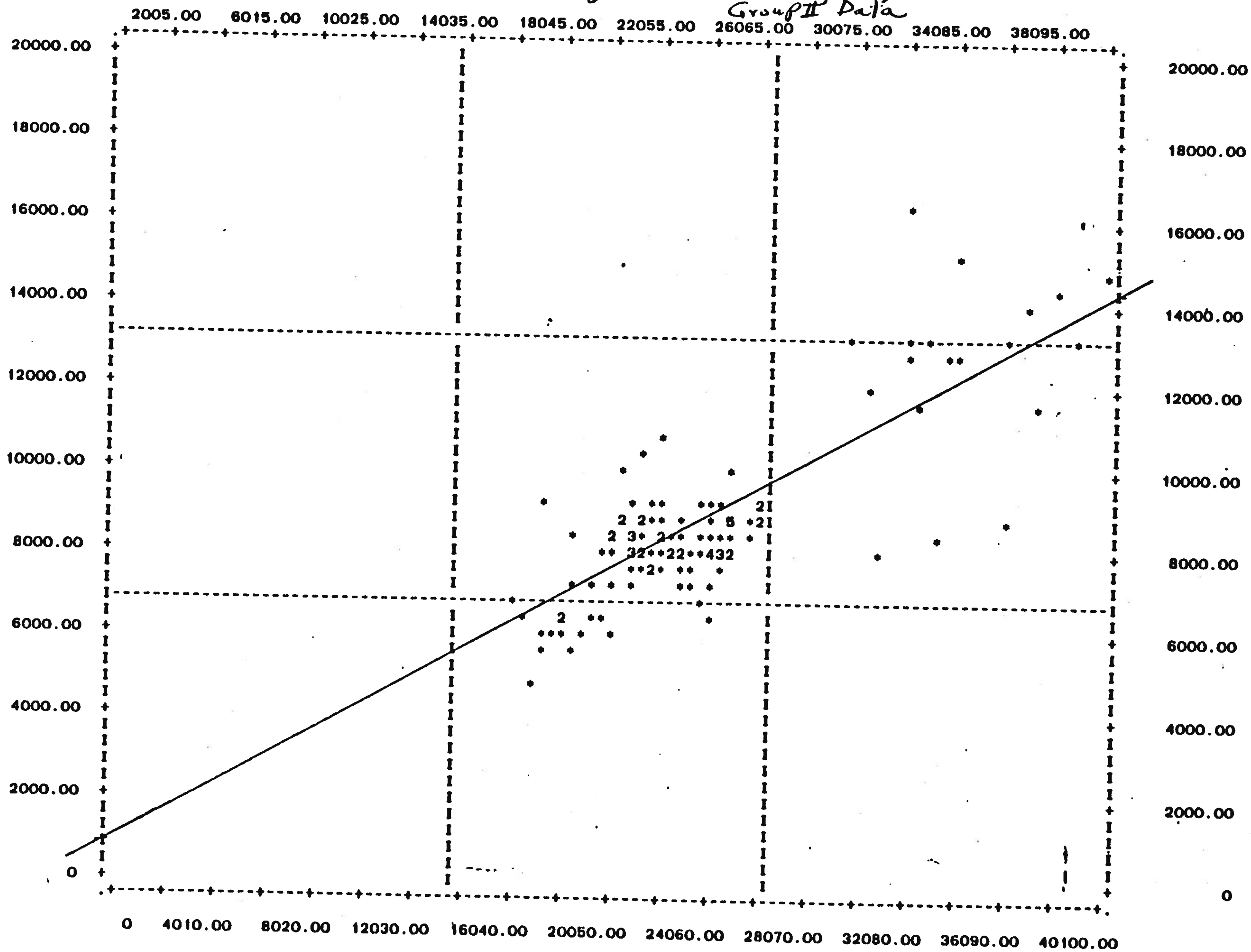
Figure 33 - Scattergram, Flow vs TDS Group II Data



CANADIAN RIVER NR LOGAN,NM
SCATTERGRAM-PIEZOMETERS AB REVUELTO CREEK   84/09/23.   16.52.12.   PAGE 43
NONAME (CREATION DATE = 84/09/23.)
FILE S02 S03 S05 S06 S07 S09 S10

SCATTERGRAM OF (DOWN) VAR003 CHLORIDES
(ACROSS) VAR005 FIELD CONDUCTANCE

Figure 34 - Scattergram, Chlorides vs Field Conductance
Group II Data

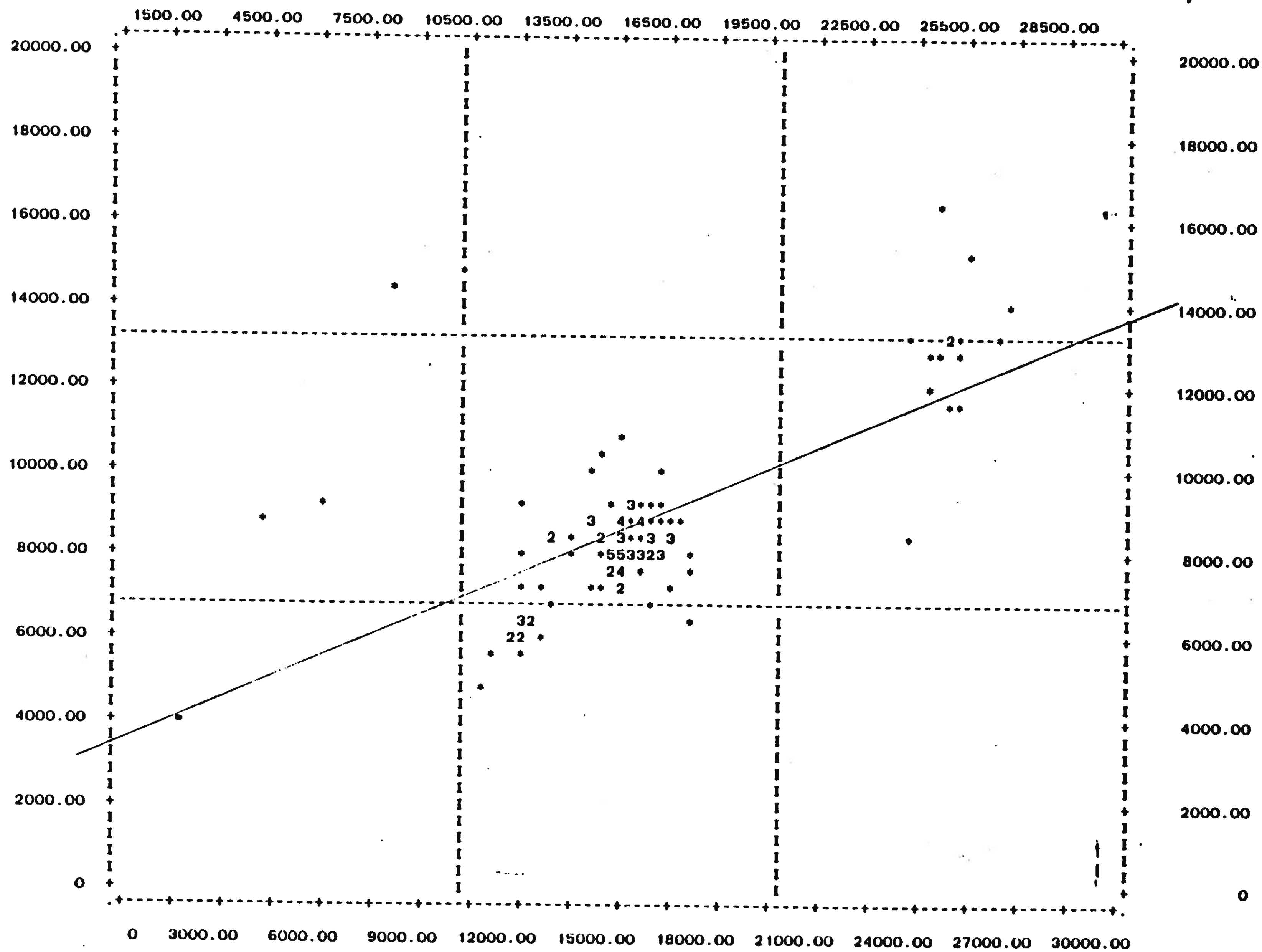


CANADIAN [...]ER NR LOGAN,NM
SCATERGR[...]IEZOMETERS AB REVUELTO CREEK
FILE NA[...]ME (CREATION DATE = 84/09/23.)
SUBFILE S02 S03 S05 S06 S07 S09 S10

84/09/23. 16.52.12. PAGE 46

SCATTERGRAM OF (DOWN) VAR003 CHLORIDES
(ACROSS) VAR006 TDS

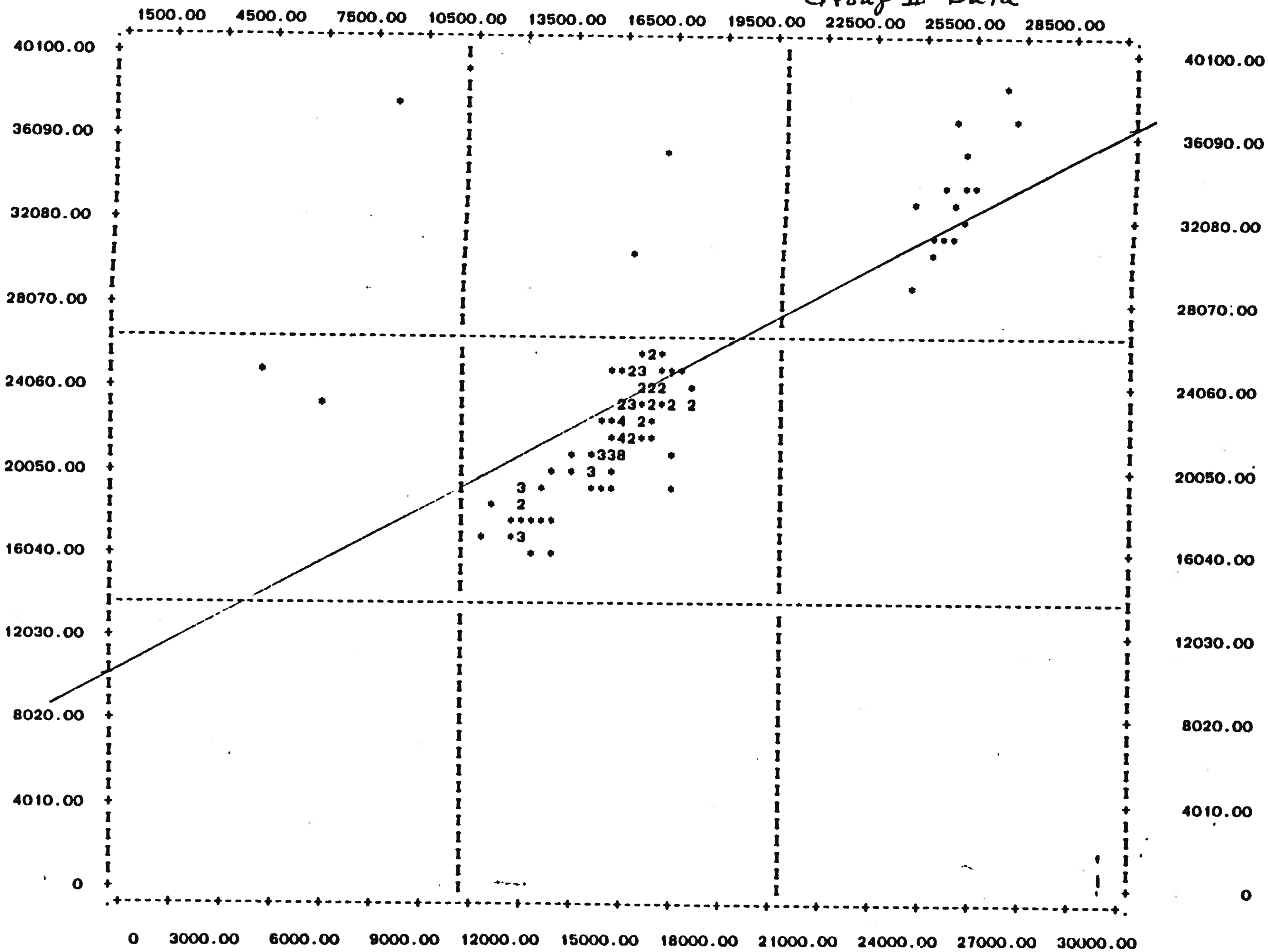
Figure 35 — Scattergram, chlorides vs TDS Group II Data



CANADIAN RIVER NR LOGAN,NM
TERGRAM-PIEZOMETERS AB REVUELTO CREEK
E NONAME (CREATION DATE = 84/09/23.)
SUBFILE S02 S03 S05 S06 S07 S09 S10

SCATTERGRAM OF (DOWN) VAR005 FIELD CONDUCTANCE
(ACROSS) VAR006 TDS

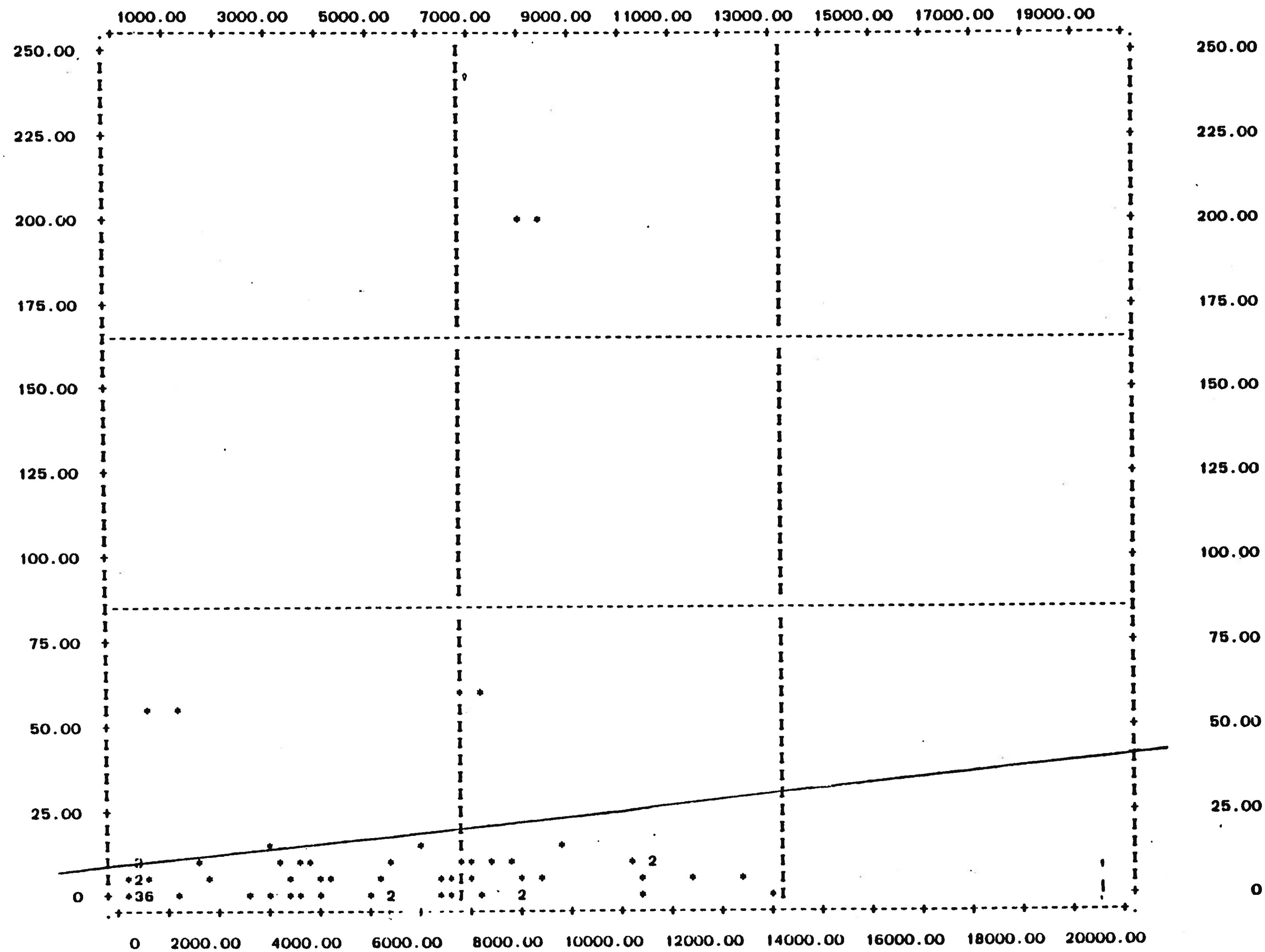
Figure 36 – Scattergram, Field Conductance VS TDS
Group II Data



CANADIAN RIVER NR LOGAN, NM 84/09/23. 16.52.12. PAGE 71
SCATTE M-PIEZOMETERS, REVUELTO CR AND CANAD. R BELOW REV CR
FILE AME (CREATION DATE = 84/09/23.)
SUBFILE S11 S12 S14 S15 S16

SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR003 CHLORIDES

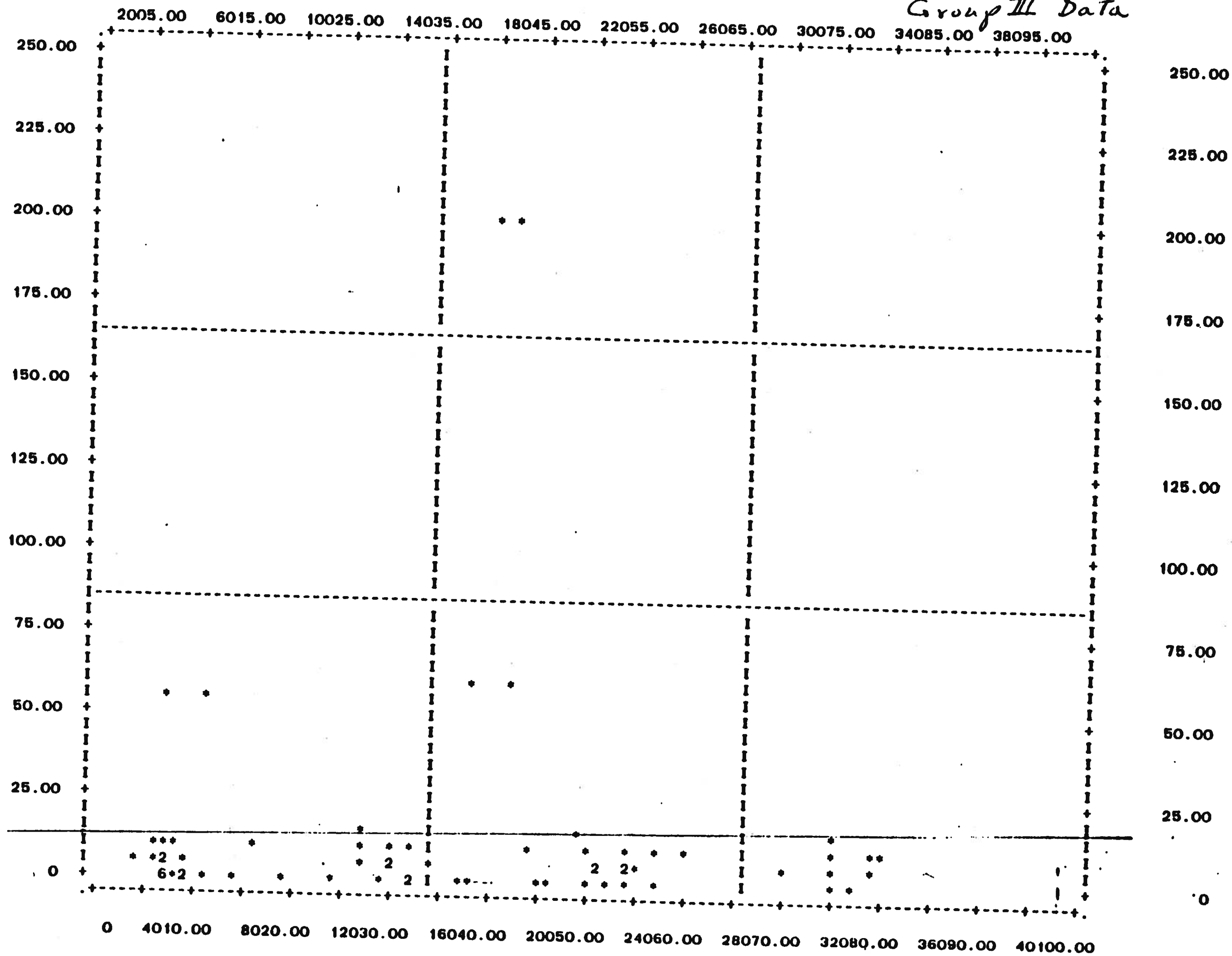
Figure 37 - Scattergram, Flow vs Chlorides Group III Data



CANADIAN RIVER NR LOGAN,NM
TERGRAM-PIEZOMETERS,REVUELTO CR AND CANAD. R BELOW REV CR 84/09/23. 16.52.12. PAGE 73
NONAME (CREATION DATE = 84/09/23.)
SUBFILE S11 S12 S14 S15 S16

SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR005 FIELD CONDUCTANCE

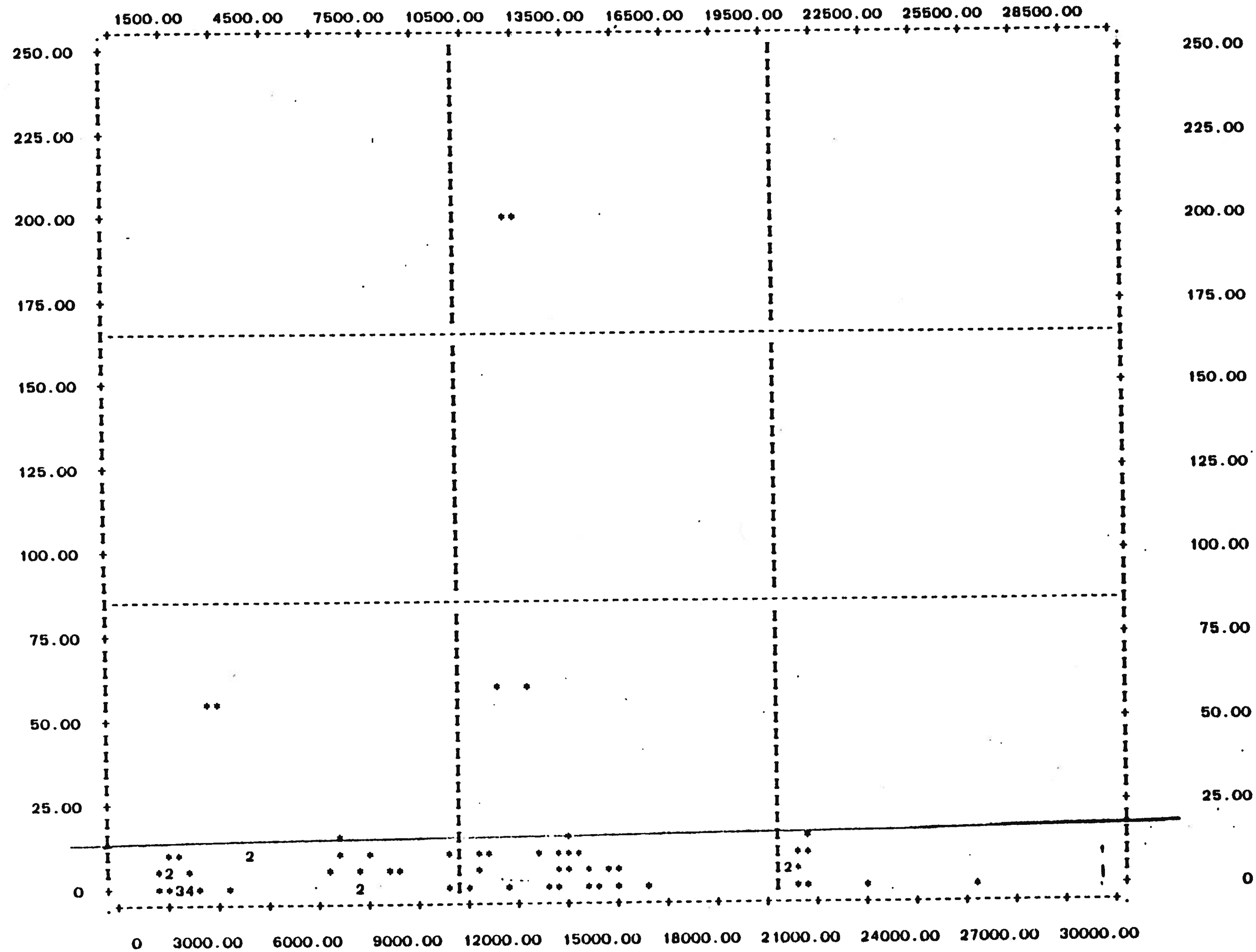
Figure 38 – Scattergram, Flow vs Field Conductance
Group III Data



CANADIAN R. .R NR LOGAN,NM .4/09/23. 16.52.12. PAGE 76
SCATTERGRAM-PIEZOMETERS,REVUELTO CR AND CANAD. R BELOW REV CR
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S11 S12 S14 S15 S16

SCATTERGRAM OF (DOWN) VAR002 FLOW
(ACROSS) VAR006 TDS

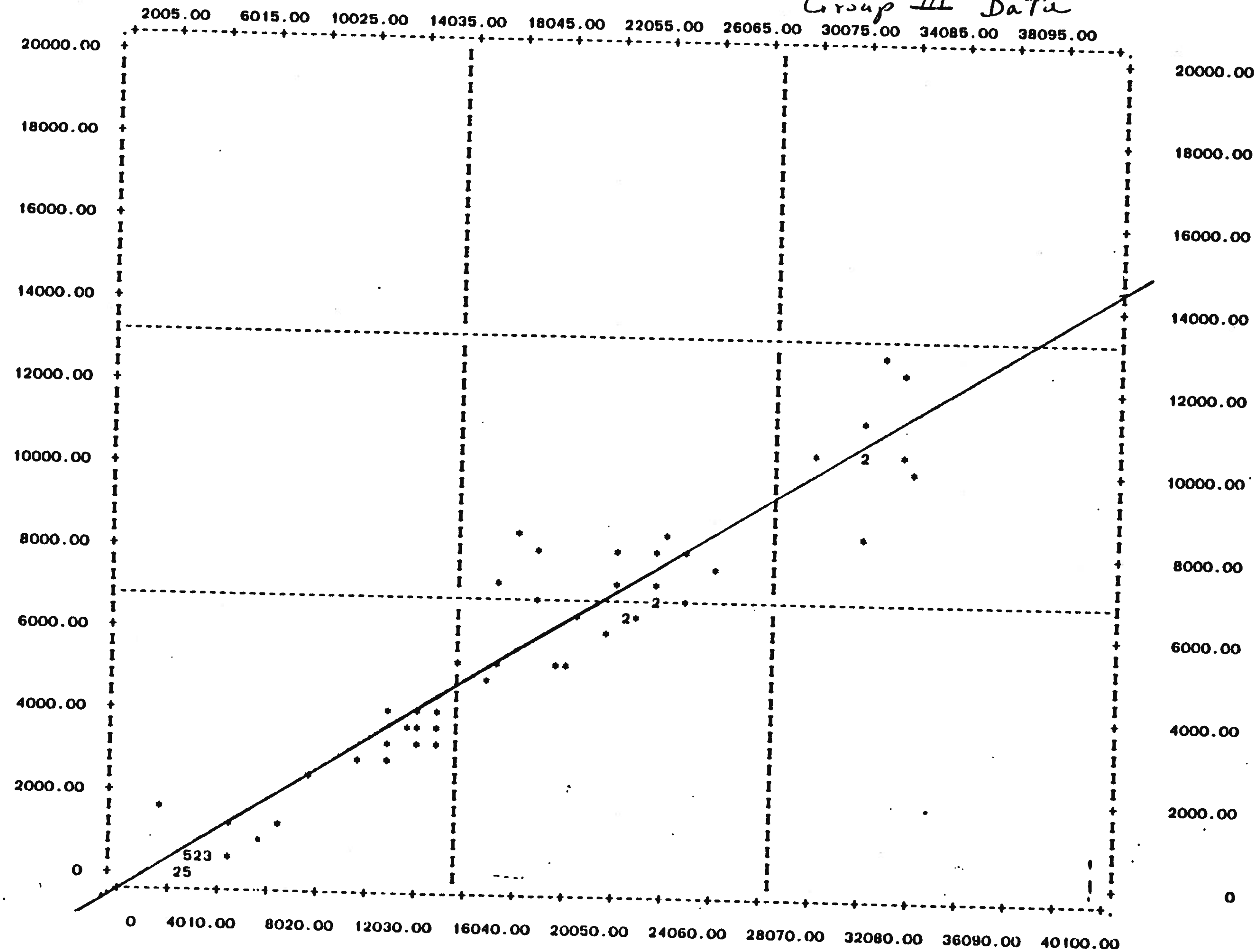
Figure 39 - Scattergram, Flow vs TDS Group III Data



CANADIAN RIVER NR LOGAN,NM
SCATTERGRAM-PIEZOMETERS,REVUELTO CR AND CANAD. R BELOW REV CR
FILE NONAME (CREATION DATE = 84/09/23.)
FILE S11 S12 S14 S15 S16

SCATTERGRAM OF (DOWN) VAR003 CHLORIDES
(ACROSS) VAR005 FIELD CONDUCTANCE

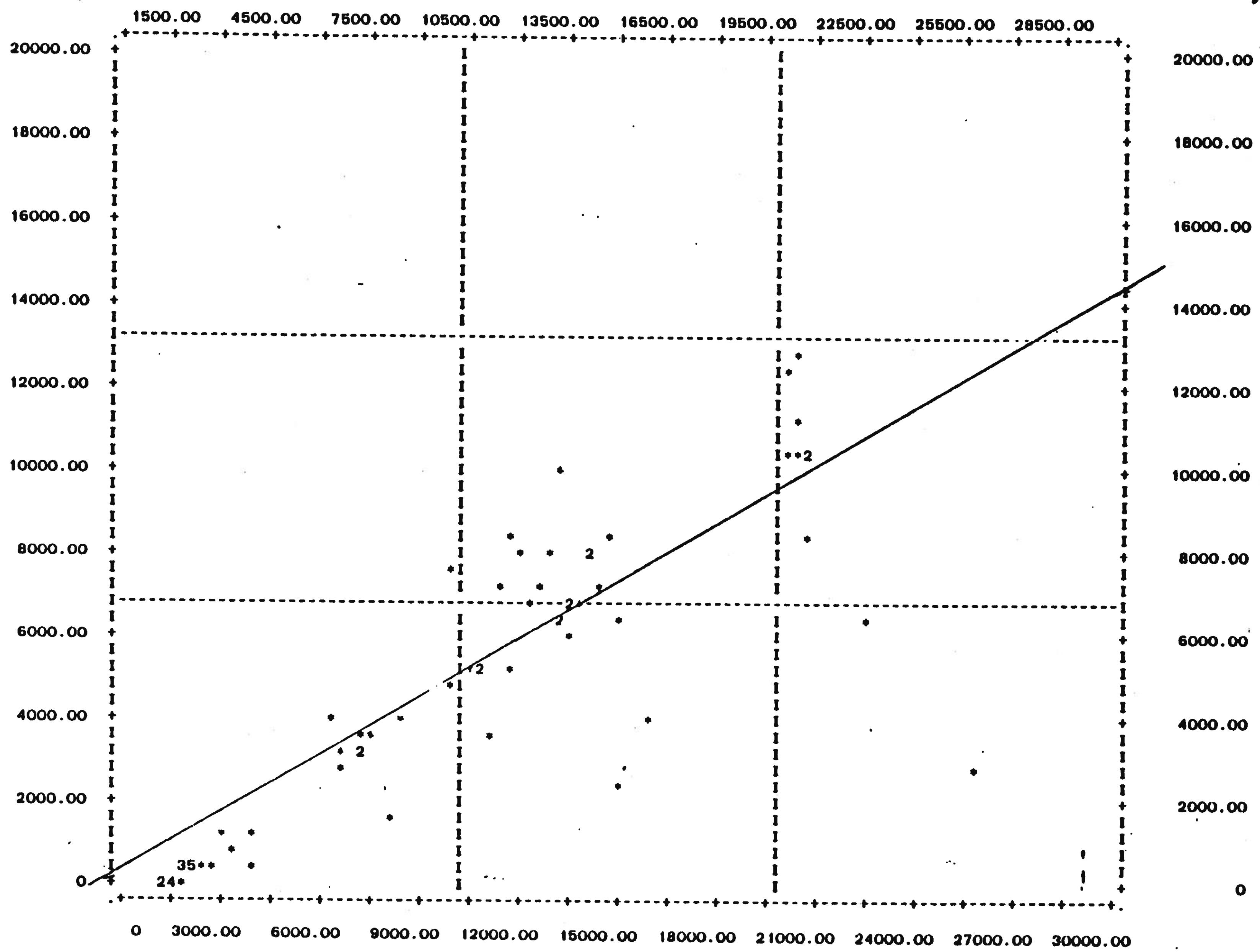
Figure 40 - Scattergram, Chlorides vs Field Conductance
Group III Data



CA[illegible]N RIVER NR LOGAN,NM
SC[illegible]RGRAM-PIEZOMETERS,REVUELTO CR AND CANAD. R BELOW REV CR
FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S11 S12 S14 S15 S16

SCATTERGRAM OF (DOWN) VAR003 CHLORIDES
(ACROSS) VAR006 TDS

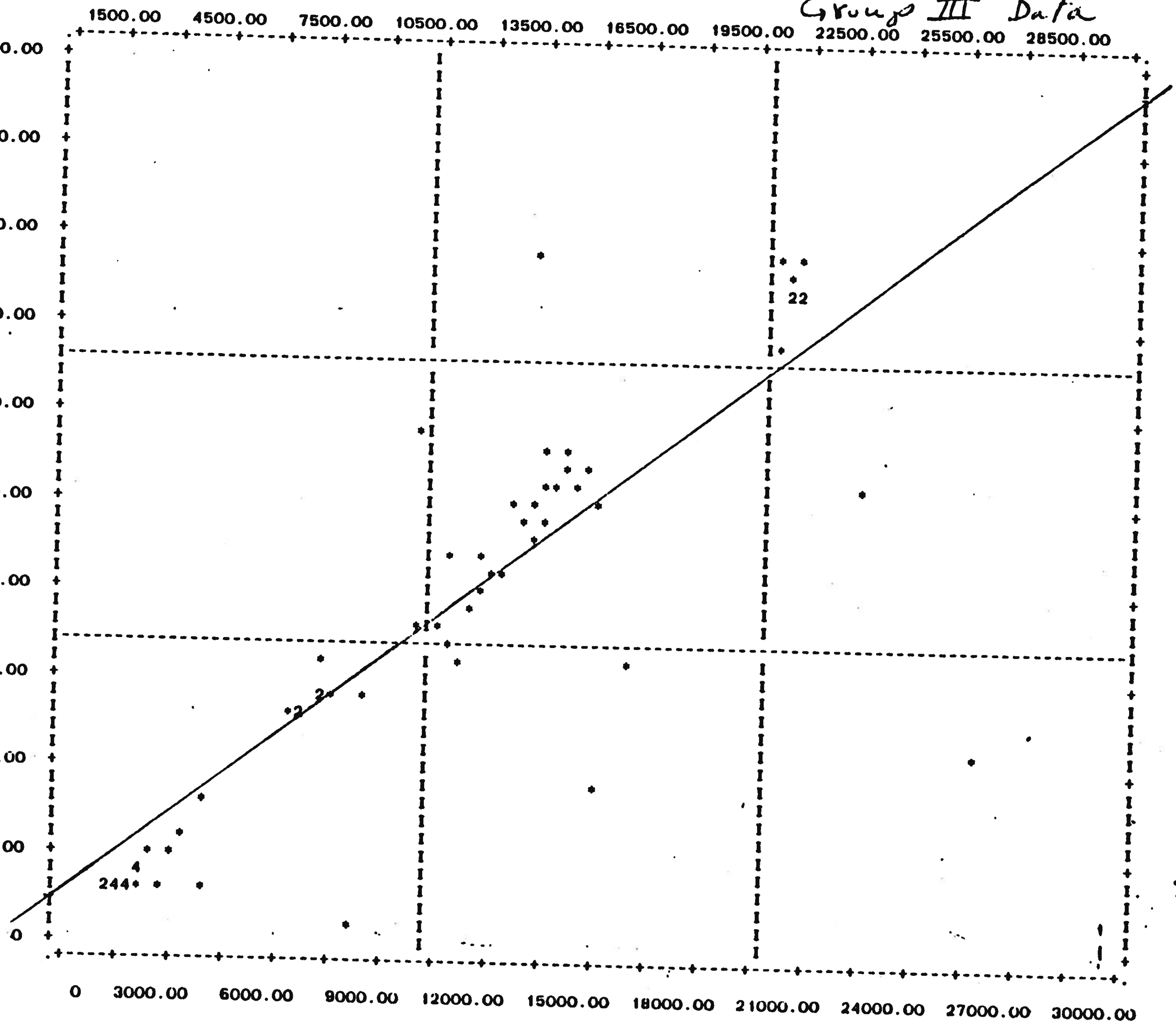
Figure 41 - Scattergram, Chlorides VS TDS Group III Data



FILE NONAME (CREATION DATE = 84/09/23.)
SUBFILE S11 S12 S14 S15 S16

SCATTERGRAM OF (DOWN) VAR005 FIELD CONDUCTANCE
(ACROSS) VAR006 TDS

Figure 42 - Scattergram, Field Conductance VS TDS
Group III Data



Outputs from Ute Reservoir model, Whipple (1987)

Note: this worksheet has not been fully proofed, and the possibility exists that additional data manipulations may be performed.

Ute Reservoir
Firm Yield Simulation
Reservoir Operation Study
Monthly Summary

CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1939	JAN	2.3	0.06	0.2	1.4	0.0	0.1	0.0	40.7	3.9	3760.3
	FEB	0.1	0.18	0.7	1.2	0.0	0.1	0.0	38.9	3.8	3759.7
	MAR	0.1	0.41	1.5	1.4	0.0	0.1	0.0	36.0	3.7	3758.7
	APR	0.3	0.43	1.6	1.7	0.0	0.1	0.0	33.0	3.6	3757.6
	MAY	20.3	0.47	1.8	1.7	0.0	0.1	0.0	49.8	4.2	3763.1
	JUNE	7.5	0.72	3.0	2.0	0.0	0.1	0.0	52.3	4.3	3763.8
	JULY	30.4	0.51	2.5	2.5	0.0	0.1	0.0	77.7	5.3	3770.1
	AUG	26.8	0.51	2.9	2.3	0.0	0.2	0.0	99.3	5.9	3774.4
	SEPT	0.4	0.52	3.0	1.9	0.0	0.2	0.0	94.8	5.8	3773.5
	OCT	0.0	0.42	2.4	1.7	0.0	0.2	0.0	90.7	5.7	3772.7
	NOV	0.0	0.17	1.0	1.4	0.0	0.2	0.0	88.4	5.6	3772.3
	DEC	0.0	0.07	0.4	1.4	0.0	0.2	0.0	86.6	5.5	3771.9
		88.2	4.47	21.0	20.6	0.0	1.7	0.0			
1940	JAN	0.1	0.03	0.2	1.4	0.0	0.2	0.0	85.1	5.5	3771.6
	FEB	0.2	0.18	1.0	1.2	0.0	0.1	0.0	83.1	5.4	3771.2
	MAR	0.3	0.41	2.2	1.4	0.0	0.2	0.0	79.8	5.3	3770.5
	APR	0.0	0.53	2.8	1.7	0.0	0.1	0.0	75.4	5.2	3769.5
	MAY	2.8	0.49	2.5	1.7	0.0	0.2	0.0	74.0	5.1	3769.2
	JUNE	3.8	0.68	3.5	2.0	0.0	0.1	0.0	72.3	5.1	3768.9
	JULY	0.7	0.67	3.4	2.5	0.0	0.1	0.0	67.1	4.9	3767.7
	AUG	8.9	0.49	2.4	2.3	0.0	0.1	0.0	71.3	5.0	3768.6
	SEPT	0.0	0.56	2.7	1.9	0.0	0.1	0.0	66.6	4.9	3767.5
	OCT	0.0	0.51	2.5	1.7	0.0	0.1	0.0	62.5	4.7	3766.5
	NOV	0.1	−0.01	−0.1	1.4	0.0	0.1	0.0	61.2	4.7	3766.2
	DEC	0.4	0.09	0.4	1.4	0.0	0.1	0.0	59.8	4.6	3765.9
		17.3	4.63	23.5	20.6	0.0	1.5	0.0			
1941	JAN	0.1	0.05	0.2	1.4	0.0	0.1	0.0	58.3	4.5	3765.5
	FEB	0.0	0.19	0.8	1.2	0.0	0.1	0.0	56.3	4.5	3764.9
	MAR	2.6	0.15	0.7	1.4	0.0	0.1	0.0	56.7	4.5	3765.1
	APR	13.8	0.27	1.3	1.7	0.0	0.1	0.0	67.5	4.9	3767.8
	MAY	224.5	−0.18	−1.2	1.7	0.0	0.2	109.4	182.1	7.9	3787.0
	JUNE	279.7	0.25	2.0	2.0	0.0	0.2	275.7	182.1	7.9	3787.0
	JULY	138.6	0.08	0.7	2.5	0.0	0.2	135.4	182.1	7.9	3787.0
	AUG	64.2	0.49	3.9	2.3	0.0	0.2	58.0	182.1	7.9	3787.0
	SEPT	477.6	−0.08	−0.6	1.9	0.0	0.2	476.3	182.1	7.9	3787.0
	OCT	297.9	−0.18	−1.4	1.7	0.0	0.2	297.6	182.1	7.9	3787.0
	NOV	39.4	0.20	1.6	1.4	0.0	0.2	36.5	182.1	7.9	3787.0
	DEC	29.3	0.17	1.3	1.4	0.0	0.2	26.6	182.1	7.9	3787.0
		1567.7	1.41	9.3	20.6	0.0	2.0	1415.5			
1942	JAN	11.5	0.19	1.5	1.4	0.0	0.2	8.6	182.1	7.9	3787.0
	FEB	8.8	0.23	1.8	1.2	0.0	0.2	5.8	182.1	7.9	3787.0
	MAR	5.9	0.42	3.4	1.4	0.0	0.2	1.1	182.1	7.9	3787.0
	APR	412.4	0.09	0.7	1.7	0.0	0.2	410.0	182.1	7.9	3787.0
	MAY	163.9	0.62	4.9	1.7	0.0	0.2	157.3	182.1	7.9	3787.0
	JUNE	6.4	0.47	3.8	2.0	0.0	0.2	0.6	182.1	7.9	3787.0
	JULY	27.9	0.57	4.6	2.5	0.0	0.2	20.9	182.1	7.9	3787.0
	AUG	42.6	0.27	2.1	2.3	0.0	0.2	38.2	182.1	7.9	3787.0
	SEPT	271.0	0.29	2.3	1.9	0.0	0.2	266.8	182.1	7.9	3787.0
	OCT	41.0	0.20	1.6	1.7	0.0	0.2	37.8	182.1	7.9	3787.0
	NOV	25.1	0.33	2.6	1.4	0.0	0.2	21.0	182.1	7.9	3787.0
	DEC	3.3	0.12	1.0	1.4	0.0	0.2	0.9	182.1	7.9	3787.0
		1019.8	3.80	30.3	20.6	0.0	2.4	969.0			

Ute Reservoir
Firm Yield Simulation
Reservoir Operation Study
Monthly Summary

CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1943	JAN	23.9	0.19	1.5	1.4	0.0	0.2	21.0	182.1	7.9	3787.0
	FEB	1.1	0.23	2.0	1.2	0.0	0.2	0.0	179.9	7.9	3786.7
	MAR	0.5	0.44	3.5	1.4	0.0	0.2	0.0	175.6	7.8	3786.1
	APR	0.0	0.55	4.2	1.7	0.0	0.2	0.0	169.6	7.7	3785.3
	MAY	1.4	0.42	3.2	1.7	0.0	0.2	0.0	166.2	7.6	3784.9
	JUNE	3.3	0.60	4.5	2.0	0.0	0.2	0.0	162.9	7.5	3784.4
	JULY	10.0	0.45	3.4	2.5	0.0	0.2	0.0	167.1	7.6	3785.0
	AUG	11.3	0.44	3.4	2.3	0.0	0.2	0.0	172.7	7.7	3785.8
	SEPT	0.3	0.49	3.8	1.9	0.0	0.2	0.0	167.3	7.6	3785.0
	OCT	0.1	0.43	3.2	1.7	0.0	0.2	0.0	162.5	7.5	3784.4
	NOV	0.0	0.19	1.4	1.4	0.0	0.2	0.0	159.7	7.5	3784.0
	DEC	0.5	0.08	0.6	1.4	0.0	0.2	0.0	158.1	7.4	3783.8
		52.4	4.51	34.7	20.6	0.0	2.4	21.0			
1944	JAN	2.2	0.15	1.1	1.4	0.0	0.2	0.0	157.8	7.4	3783.7
	FEB	0.4	0.22	1.6	1.2	0.0	0.2	0.0	155.4	7.4	3783.4
	MAR	0.4	0.38	2.8	1.4	0.0	0.2	0.0	151.7	7.3	3782.8
	APR	0.2	0.28	2.0	1.7	0.0	0.2	0.0	148.2	7.2	3782.3
	MAY	29.7	0.14	1.0	1.7	0.0	0.2	0.0	175.1	7.8	3786.1
	JUNE	32.7	0.25	2.0	2.0	0.0	0.2	21.8	182.1	7.9	3787.0
	JULY	13.9	0.41	3.3	2.5	0.0	0.2	8.1	182.1	7.9	3787.0
	AUG	31.7	0.45	3.6	2.3	0.0	0.2	25.8	182.1	7.9	3787.0
	SEPT	30.0	0.41	3.3	1.9	0.0	0.2	24.8	182.1	7.9	3787.0
	OCT	2.5	0.32	2.5	1.7	0.0	0.2	0.0	180.4	7.9	3786.8
	NOV	1.4	0.19	1.5	1.4	0.0	0.2	0.0	178.9	7.9	3786.6
	DEC	3.0	0.04	0.3	1.4	0.0	0.2	0.0	180.1	7.9	3786.7
		148.1	3.24	25.0	20.6	0.0	2.4	80.5			
1945	JAN	2.7	0.14	1.1	1.4	0.0	0.2	0.0	180.3	7.9	3786.8
	FEB	1.6	0.26	2.0	1.2	0.0	0.2	0.0	178.7	7.9	3786.5
	MAR	0.5	0.46	3.6	1.4	0.0	0.2	0.0	174.2	7.8	3786.0
	APR	1.7	0.42	3.2	1.7	0.0	0.2	0.0	171.0	7.7	3785.5
	MAY	1.3	0.62	4.7	1.7	0.0	0.2	0.0	165.8	7.6	3784.8
	JUNE	1.1	0.69	5.2	2.0	0.0	0.2	0.0	159.8	7.5	3784.0
	JULY	4.6	0.34	2.5	2.5	0.0	0.2	0.0	159.3	7.5	3783.9
	AUG	18.8	0.13	1.0	2.3	0.0	0.2	0.0	174.9	7.8	3786.1
	SEPT	0.8	0.38	2.9	1.9	0.0	0.2	0.0	170.8	7.7	3785.5
	OCT	1.7	0.32	2.4	1.7	0.0	0.2	0.0	168.4	7.7	3785.2
	NOV	0.3	0.31	2.4	1.4	0.0	0.2	0.0	164.9	7.6	3784.7
	DEC	0.4	0.19	1.5	1.4	0.0	0.2	0.0	162.5	7.5	3784.4
		35.5	4.26	32.5	20.6	0.0	2.4	0.0			
1946	JAN	0.7	0.19	1.4	1.4	0.0	0.2	0.0	160.4	7.5	3784.1
	FEB	0.4	0.25	1.9	1.2	0.0	0.2	0.0	157.7	7.4	3783.7
	MAR	0.3	0.44	3.2	1.4	0.0	0.2	0.0	153.4	7.3	3783.1
	APR	0.0	0.48	3.5	1.7	0.0	0.2	0.0	148.2	7.2	3782.3
	MAY	35.7	0.53	4.0	1.7	0.0	0.2	0.0	178.2	7.9	3786.5
	JUNE	3.2	0.74	5.8	2.0	0.0	0.2	0.0	173.6	7.8	3785.9
	JULY	1.3	0.64	5.0	2.5	0.0	0.2	0.0	167.5	7.6	3785.1
	AUG	10.8	0.30	2.3	2.3	0.0	0.2	0.0	173.7	7.8	3785.9
	SEPT	43.5	0.22	1.8	1.9	0.0	0.2	31.5	182.1	7.9	3787.0
	OCT	45.2	0.24	1.9	1.7	0.0	0.2	41.5	182.1	7.9	3787.0
	NOV	2.5	0.09	0.7	1.4	0.0	0.2	0.4	182.1	7.9	3787.0
	DEC	0.8	0.19	1.5	1.4	0.0	0.2	0.0	180.0	7.9	3786.7
		144.4	4.31	33.0	20.6	0.0	2.4	73.4			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1947	JAN	1.6	0.17	1.3	1.4	0.0	0.2	0.0	178.9	7.9	3786.6
	FEB	1.2	0.26	2.0	1.2	0.0	0.2	0.0	176.9	7.8	3786.3
	MAR	1.0	0.39	3.0	1.4	0.0	0.2	0.0	173.5	7.8	3785.9
	APR	0.0	0.44	3.4	1.7	0.0	0.2	0.0	168.4	7.7	3785.2
	MAY	33.7	0.30	2.4	1.7	0.0	0.2	16.0	182.1	7.9	3787.0
	JUNE	4.5	0.66	5.2	2.0	0.0	0.2	0.0	179.4	7.9	3786.6
	JULY	24.8	0.61	4.9	2.5	0.0	0.2	14.7	182.1	7.9	3787.0
	AUG	8.2	0.50	4.0	2.3	0.0	0.2	1.9	182.1	7.9	3787.0
	SEPT	0.1	0.61	4.8	1.9	0.0	0.2	0.0	175.5	7.8	3786.1
	OCT	0.0	0.43	3.3	1.7	0.0	0.2	0.0	170.5	7.7	3785.5
	NOV	0.1	0.08	0.6	1.4	0.0	0.2	0.0	168.6	7.7	3785.2
	DEC	0.2	0.07	0.6	1.4	0.0	0.2	0.0	166.9	7.6	3785.0
		75.4	4.52	35.5	20.6	0.0	2.4	32.6			
1948	JAN	0.2	0.14	1.0	1.4	0.0	0.2	0.0	164.6	7.6	3784.7
	FEB	3.8	0.17	1.3	1.2	0.0	0.2	0.0	165.9	7.6	3784.8
	MAR	3.5	0.44	3.3	1.4	0.0	0.2	0.0	164.7	7.6	3784.7
	APR	0.4	0.58	4.3	1.7	0.0	0.2	0.0	159.1	7.5	3783.9
	MAY	1.6	0.25	1.9	1.7	0.0	0.2	0.0	157.1	7.4	3783.6
	JUNE	78.3	0.34	2.6	2.0	0.0	0.2	48.7	182.1	7.9	3787.0
	JULY	6.1	0.59	4.7	2.5	0.0	0.2	0.0	181.0	7.9	3786.9
	AUG	16.0	0.18	1.4	2.3	0.0	0.2	11.2	182.1	7.9	3787.0
	SEPT	0.0	0.52	4.1	1.9	0.0	0.2	0.0	176.1	7.8	3786.2
	OCT	0.1	0.35	2.8	1.7	0.0	0.2	0.0	171.7	7.7	3785.6
	NOV	0.4	0.15	1.2	1.4	0.0	0.2	0.0	169.5	7.7	3785.3
	DEC	0.0	0.19	1.5	1.4	0.0	0.2	0.0	166.7	7.6	3784.9
		110.4	3.90	30.1	20.6	0.0	2.4	59.9			
1949	JAN	0.5	0.11	0.9	1.4	0.0	0.2	0.0	164.8	7.6	3784.7
	FEB	2.1	0.20	1.5	1.2	0.0	0.2	0.0	164.2	7.6	3784.6
	MAR	1.0	0.40	3.0	1.4	0.0	0.2	0.0	160.9	7.5	3784.1
	APR	6.8	0.21	1.6	1.7	0.0	0.2	0.0	164.4	7.6	3784.6
	MAY	11.3	0.30	2.3	1.7	0.0	0.2	0.0	171.7	7.7	3785.6
	JUNE	28.5	0.13	1.0	2.0	0.0	0.2	15.1	182.1	7.9	3787.0
	JULY	24.6	0.38	3.0	2.5	0.0	0.2	19.1	182.1	7.9	3787.0
	AUG	19.8	0.50	4.0	2.3	0.0	0.2	13.5	182.1	7.9	3787.0
	SEPT	5.9	0.27	2.1	1.9	0.0	0.2	1.9	182.1	7.9	3787.0
	OCT	0.2	0.37	2.9	1.7	0.0	0.2	0.0	177.6	7.9	3786.4
	NOV	0.0	0.28	2.2	1.4	0.0	0.2	0.0	174.0	7.8	3785.9
	DEC	0.5	0.16	1.3	1.4	0.0	0.2	0.0	171.9	7.7	3785.6
		101.2	3.31	25.8	20.6	0.0	2.4	49.6			
1950	JAN	0.3	0.19	1.5	1.4	0.0	0.2	0.0	169.3	7.7	3785.3
	FEB	0.2	0.26	2.0	1.2	0.0	0.2	0.0	166.3	7.6	3784.9
	MAR	0.1	0.44	3.3	1.4	0.0	0.2	0.0	161.6	7.5	3784.2
	APR	0.9	0.53	3.9	1.7	0.0	0.2	0.0	156.9	7.4	3783.6
	MAY	0.0	0.63	4.6	1.7	0.0	0.2	0.0	150.6	7.3	3782.7
	JUNE	7.2	0.61	4.4	2.0	0.0	0.2	0.0	151.3	7.3	3782.8
	JULY	82.6	0.05	0.4	2.5	0.0	0.2	48.9	182.1	7.9	3787.0
	AUG	15.4	0.44	3.5	2.3	0.0	0.2	9.6	182.1	7.9	3787.0
	SEPT	14.1	0.23	1.8	1.9	0.0	0.2	10.3	182.1	7.9	3787.0
	OCT	0.6	0.42	3.3	1.7	0.0	0.2	0.0	177.7	7.9	3786.4
	NOV	0.0	0.25	2.0	1.4	0.0	0.2	0.0	174.3	7.8	3786.0
	DEC	0.1	0.17	1.3	1.4	0.0	0.2	0.0	171.7	7.7	3785.6
		121.5	4.22	32.0	20.6	0.0	2.4	68.8			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1951	JAN	0.2	0.15	1.2	1.4	0.0	0.2	0.0	169.4	7.7	3785.3
	FEB	0.4	0.22	1.7	1.2	0.0	0.2	0.0	166.9	7.6	3785.0
	MAR	0.8	0.38	2.9	1.4	0.0	0.2	0.0	163.4	7.5	3784.5
	APR	0.1	0.47	3.6	1.7	0.0	0.2	0.0	158.2	7.4	3783.8
	MAY	29.2	0.36	2.8	1.7	0.0	0.2	0.8	182.1	7.9	3787.0
	JUNE	8.1	0.59	4.7	2.0	0.0	0.2	1.5	182.1	7.9	3787.0
	JULY	24.3	0.55	4.4	2.5	0.0	0.2	17.4	182.1	7.9	3787.0
	AUG	1.4	0.61	4.8	2.3	0.0	0.2	0.0	176.4	7.8	3786.3
	SEPT	0.8	0.59	4.6	1.9	0.0	0.2	0.0	170.8	7.7	3785.5
	OCT	0.5	0.37	2.9	1.7	0.0	0.2	0.0	166.7	7.6	3784.9
	NOV	0.4	0.25	1.9	1.4	0.0	0.2	0.0	163.8	7.6	3784.6
	DEC	0.2	0.18	1.4	1.4	0.0	0.2	0.0	161.3	7.5	3784.2
		66.4	4.72	36.9	20.6	0.0	2.4	19.7			
1952	JAN	0.1	0.16	1.2	1.4	0.0	0.2	0.0	158.8	7.4	3783.9
	FEB	0.0	0.25	1.8	1.2	0.0	0.2	0.0	155.7	7.4	3783.4
	MAR	0.5	0.38	2.8	1.4	0.0	0.2	0.0	152.1	7.3	3782.9
	APR	0.5	0.32	2.3	1.7	0.0	0.2	0.0	148.6	7.2	3782.4
	MAY	0.3	0.49	3.5	1.7	0.0	0.2	0.0	143.7	7.1	3781.7
	JUNE	0.4	0.71	5.0	2.0	0.0	0.2	0.0	137.0	6.9	3780.7
	JULY	8.1	0.48	3.3	2.5	0.0	0.2	0.0	139.3	7.0	3781.0
	AUG	22.2	0.37	2.7	2.3	0.0	0.2	0.0	156.5	7.4	3783.5
	SEPT	1.1	0.46	3.4	1.9	0.0	0.2	0.0	152.4	7.3	3782.9
	OCT	0.1	0.40	2.9	1.7	0.0	0.2	0.0	147.9	7.2	3782.3
	NOV	0.2	0.20	1.4	1.4	0.0	0.2	0.0	145.2	7.1	3781.9
	DEC	0.2	0.17	1.2	1.4	0.0	0.2	0.0	142.8	7.1	3781.5
		33.7	4.39	31.5	20.6	0.0	2.4	0.0			
1953	JAN	0.2	0.19	1.4	1.4	0.0	0.2	0.0	140.2	7.0	3781.1
	FEB	0.1	0.23	1.6	1.2	0.0	0.2	0.0	137.5	7.0	3780.7
	MAR	0.1	0.40	2.8	1.4	0.0	0.2	0.0	133.3	6.9	3780.1
	APR	0.0	0.53	3.6	1.7	0.0	0.2	0.0	128.1	6.7	3779.3
	MAY	0.2	0.48	3.2	1.7	0.0	0.2	0.0	123.4	6.6	3778.5
	JUNE	0.0	0.82	5.4	2.0	0.0	0.2	0.0	116.0	6.4	3777.3
	JULY	10.6	0.52	3.4	2.5	0.0	0.2	0.0	120.7	6.5	3778.1
	AUG	32.5	0.14	1.0	2.3	0.0	0.2	0.0	149.9	7.2	3782.6
	SEPT	1.5	0.59	4.2	1.9	0.0	0.2	0.0	145.3	7.1	3781.9
	OCT	0.0	0.38	2.7	1.7	0.0	0.2	0.0	140.9	7.0	3781.3
	NOV	0.9	0.22	1.5	1.4	0.0	0.2	0.0	138.9	7.0	3781.0
	DEC	0.3	0.13	0.9	1.4	0.0	0.2	0.0	136.8	6.9	3781.6
		46.4	4.63	31.7	20.6	0.0	2.4	0.0			
1954	JAN	0.1	0.17	1.2	1.4	0.0	0.2	0.0	134.4	6.9	3780.3
	FEB	0.0	0.25	1.7	1.2	0.0	0.2	0.0	131.5	6.8	3779.8
	MAR	0.0	0.43	2.9	1.4	0.0	0.2	0.0	127.2	6.7	3779.1
	APR	0.0	0.54	3.6	1.7	0.0	0.2	0.0	121.9	6.6	3778.3
	MAY	6.3	0.39	2.6	1.7	0.0	0.2	0.0	123.9	6.6	3778.6
	JUNE	3.3	0.77	5.0	2.0	0.0	0.2	0.0	120.1	6.5	3778.0
	JULY	1.7	0.59	3.8	2.5	0.0	0.2	0.0	115.5	6.4	3777.2
	AUG	6.5	0.47	3.0	2.3	0.0	0.2	0.0	116.6	6.4	3777.4
	SEPT	2.2	0.50	3.2	1.9	0.0	0.2	0.0	113.8	6.3	3776.9
	OCT	42.1	0.22	1.5	1.7	0.0	0.2	0.0	152.6	7.3	3783.0
	NOV	0.2	0.22	1.6	1.4	0.0	0.2	0.0	149.8	7.2	3782.6
	DEC	0.1	0.19	1.4	1.4	0.0	0.2	0.0	147.2	7.2	3782.2
		62.5	4.74	31.5	20.6	0.0	2.4	0.0			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1955	JAN	0.2	0.18	1.3	1.4	0.0	0.2	0.0	144.7	7.1	3781.8
	FEB	0.1	0.25	1.8	1.2	0.0	0.2	0.0	141.8	7.1	3781.4
	MAR	0.0	0.44	3.1	1.4	0.0	0.2	0.0	137.4	6.9	3780.7
	APR	1.5	0.45	3.1	1.7	0.0	0.2	0.0	134.1	6.9	3780.2
	MAY	30.5	0.28	2.0	1.7	0.0	0.2	0.0	160.8	7.5	3784.1
	JUNE	0.1	0.64	4.8	2.0	0.0	0.2	0.0	154.2	7.3	3783.2
	JULY	17.5	0.36	2.7	2.5	0.0	0.2	0.0	166.5	7.6	3784.9
	AUG	11.9	0.52	4.0	2.3	0.0	0.2	0.0	172.1	7.7	3785.7
	SEPT	7.8	0.33	2.5	1.9	0.0	0.2	0.0	175.5	7.8	3786.1
	OCT	0.1	0.44	3.4	1.7	0.0	0.2	0.0	170.5	7.7	3785.5
	NOV	0.0	0.25	1.9	1.4	0.0	0.2	0.0	167.2	7.6	3785.0
	DEC	0.1	0.19	1.5	1.4	0.0	0.2	0.0	164.4	7.6	3784.6
		69.8	4.33	32.1	20.6	0.0	2.4	0.0			
1956	JAN	0.2	0.19	1.5	1.4	0.0	0.2	0.0	161.7	7.5	3784.3
	FEB	0.3	0.16	1.2	1.2	0.0	0.2	0.0	159.6	7.5	3784.0
	MAR	0.0	0.44	3.2	1.4	0.0	0.2	0.0	155.0	7.4	3783.3
	APR	0.0	0.56	4.1	1.7	0.0	0.2	0.0	149.2	7.2	3782.5
	MAY	4.1	0.55	4.0	1.7	0.0	0.2	0.0	147.6	7.2	3782.2
	JUNE	7.0	0.56	4.0	2.0	0.0	0.2	0.0	148.6	7.2	3782.4
	JULY	20.1	0.31	2.3	2.5	0.0	0.2	0.0	163.9	7.6	3784.6
	AUG	3.8	0.60	4.5	2.3	0.0	0.2	0.0	160.9	7.5	3784.1
	SEPT	0.0	0.63	4.7	1.9	0.0	0.2	0.0	154.3	7.3	3783.2
	OCT	0.0	0.44	3.2	1.7	0.0	0.2	0.0	149.4	7.2	3782.5
	NOV	0.0	0.22	1.5	1.4	0.0	0.2	0.0	146.4	7.2	3782.1
	DEC	0.0	0.19	1.4	1.4	0.0	0.2	0.0	143.6	7.1	3781.7
		35.5	4.85	35.6	20.6	0.0	2.4	0.0			
1957	JAN	1.0	0.17	1.2	1.4	0.0	0.2	0.0	141.1	7.0	3781.3
	FEB	1.0	0.24	1.7	1.2	0.0	0.2	0.0	138.4	7.0	3780.9
	MAR	1.0	0.33	2.3	1.4	0.0	0.2	0.0	134.7	6.9	3780.3
	APR	2.0	0.36	2.5	1.7	0.0	0.2	0.0	132.5	6.8	3780.0
	MAY	5.4	0.38	2.6	1.7	0.0	0.2	0.0	133.7	6.9	3780.1
	JUNE	3.2	0.66	4.5	2.0	0.0	0.2	0.0	130.4	6.8	3779.6
	JULY	20.1	0.36	2.5	2.5	0.0	0.2	0.0	145.5	7.1	3781.9
	AUG	33.0	0.33	2.5	2.3	0.0	0.2	0.0	173.7	7.8	3785.9
	SEPT	5.9	0.50	3.9	1.9	0.0	0.2	0.0	173.7	7.8	3785.9
	OCT	5.5	0.15	1.1	1.7	0.0	0.2	0.0	176.4	7.8	3786.3
	NOV	0.4	0.20	1.5	1.4	0.0	0.2	0.0	173.9	7.8	3785.9
	DEC	0.3	0.19	1.5	1.4	0.0	0.2	0.0	171.3	7.7	3785.6
		78.8	3.87	27.8	20.6	0.0	2.4	0.0			
1958	JAN	0.4	0.12	0.9	1.4	0.0	0.2	0.0	169.4	7.7	3785.3
	FEB	0.2	0.23	1.8	1.2	0.0	0.2	0.0	166.6	7.6	3784.9
	MAR	2.2	0.29	2.2	1.4	0.0	0.2	0.0	165.2	7.6	3784.7
	APR	2.0	0.40	3.0	1.7	0.0	0.2	0.0	162.5	7.5	3784.4
	MAY	50.8	0.14	1.1	1.7	0.0	0.2	28.4	182.1	7.9	3787.0
	JUNE	44.1	0.40	3.2	2.0	0.0	0.2	38.9	182.1	7.9	3787.0
	JULY	21.6	0.13	1.1	2.5	0.0	0.2	18.0	182.1	7.9	3787.0
	AUG	36.0	0.29	2.3	2.3	0.0	0.2	31.3	182.1	7.9	3787.0
	SEPT	25.2	0.06	0.5	1.9	0.0	0.2	22.8	182.1	7.9	3787.0
	OCT	0.6	0.33	2.6	1.7	0.0	0.2	0.0	178.4	7.9	3786.5
	NOV	0.4	0.22	1.7	1.4	0.0	0.2	0.0	175.6	7.8	3786.2
	DEC	0.4	0.16	1.3	1.4	0.0	0.2	0.0	173.3	7.8	3785.8
		183.9	2.77	21.7	20.6	0.0	2.4	139.4			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1959	JAN	0.9	0.17	1.3	1.4	0.0	0.2	0.0	171.5	7.7	3785.6
	FEB	0.5	0.25	1.9	1.2	0.0	0.2	0.0	169.0	7.7	3785.3
	MAR	0.2	0.42	3.2	1.4	0.0	0.2	0.0	164.6	7.6	3784.7
	APR	0.6	0.40	3.0	1.7	0.0	0.2	0.0	160.5	7.5	3784.1
	MAY	1.1	0.46	3.4	1.7	0.0	0.2	0.0	156.5	7.4	3783.5
	JUNE	1.5	0.41	3.0	2.0	0.0	0.2	0.0	152.9	7.3	3783.0
	JULY	4.1	0.23	1.7	2.5	0.0	0.2	0.0	152.9	7.3	3783.0
	AUG	38.1	0.17	1.3	2.3	0.0	0.2	5.3	182.1	7.9	3787.0
	SEPT	0.8	0.53	4.2	1.9	0.0	0.2	0.0	176.8	7.8	3786.3
	OCT	1.5	0.21	1.6	1.7	0.0	0.2	0.0	175.1	7.8	3786.1
	NOV	0.5	0.24	1.8	1.4	0.0	0.2	0.0	172.3	7.7	3785.7
	DEC	5.4	−0.15	−1.2	1.4	0.0	0.2	0.0	177.5	7.9	3786.4
		55.2	3.34	25.2	20.6	0.0	2.4	5.3			
1960	JAN	1.9	0.13	1.0	1.4	0.0	0.2	0.0	177.0	7.8	3786.3
	FEB	0.9	0.20	1.6	1.2	0.0	0.2	0.0	175.2	7.8	3786.1
	MAR	0.7	0.38	2.9	1.4	0.0	0.2	0.0	171.5	7.7	3785.6
	APR	0.3	0.51	3.9	1.7	0.0	0.2	0.0	166.2	7.6	3784.9
	MAY	0.3	0.50	3.8	1.7	0.0	0.2	0.0	161.0	7.5	3784.2
	JUNE	26.5	0.25	2.0	2.0	0.0	0.2	1.5	182.1	7.9	3787.0
	JULY	74.2	−0.31	−2.5	2.5	0.0	0.2	74.2	182.1	7.9	3787.0
	AUG	23.0	0.40	3.1	2.3	0.0	0.2	17.5	182.1	7.9	3787.0
	SEPT	2.7	0.39	3.1	1.9	0.0	0.2	0.0	179.8	7.9	3786.7
	OCT	23.7	0.00	0.0	1.7	0.0	0.2	19.7	182.1	7.9	3787.0
	NOV	1.5	0.25	2.0	1.4	0.0	0.2	0.0	180.2	7.9	3786.8
	DEC	5.2	0.05	0.4	1.4	0.0	0.2	1.5	182.1	7.9	3787.0
		160.9	2.75	21.3	20.6	0.0	2.4	114.4			
1961	JAN	3.5	0.18	1.5	1.4	0.0	0.2	0.7	182.1	7.9	3787.0
	FEB	15.6	0.24	1.9	1.2	0.0	0.2	12.5	182.1	7.9	3787.0
	MAR	11.5	0.24	1.9	1.4	0.0	0.2	8.1	182.1	7.9	3787.0
	APR	12.5	0.45	3.6	1.7	0.0	0.2	7.3	182.1	7.9	3787.0
	MAY	4.9	0.64	5.1	1.7	0.0	0.2	0.0	180.2	7.9	3786.8
	JUNE	1.4	0.49	3.8	2.0	0.0	0.2	0.0	175.7	7.8	3786.2
	JULY	15.3	0.52	4.1	2.5	0.0	0.2	2.3	182.1	7.9	3787.0
	AUG	10.4	0.25	2.0	2.3	0.0	0.2	6.1	182.1	7.9	3787.0
	SEPT	22.0	0.41	3.2	1.9	0.0	0.2	16.9	182.1	7.9	3787.0
	OCT	2.5	0.40	3.1	1.7	0.0	0.2	0.0	179.7	7.9	3786.7
	NOV	2.0	0.12	1.0	1.4	0.0	0.2	0.0	179.4	7.9	3786.6
	DEC	1.0	0.15	1.2	1.4	0.0	0.2	0.0	177.8	7.9	3786.4
		102.6	4.09	32.4	20.6	0.0	2.4	53.9			
1962	JAN	1.2	0.16	1.2	1.4	0.0	0.2	0.0	176.3	7.8	3786.2
	FEB	3.5	0.25	2.0	1.2	0.0	0.2	0.0	176.7	7.8	3786.3
	MAR	2.0	0.41	3.2	1.4	0.0	0.2	0.0	174.1	7.8	3786.0
	APR	1.2	0.48	3.7	1.7	0.0	0.2	0.0	169.9	7.7	3785.4
	MAY	1.8	0.76	5.8	1.7	0.0	0.2	0.0	164.3	7.6	3784.6
	JUNE	4.1	0.45	3.4	2.0	0.0	0.2	0.0	163.0	7.5	3784.4
	JULY	21.6	0.27	2.1	2.5	0.0	0.2	0.0	180.0	7.9	3786.7
	AUG	4.8	0.68	5.4	2.3	0.0	0.2	0.0	177.2	7.8	3786.4
	SEPT	2.8	0.38	3.0	1.9	0.0	0.2	0.0	175.1	7.8	3786.1
	OCT	0.6	0.42	3.2	1.7	0.0	0.2	0.0	170.7	7.7	3785.5
	NOV	0.4	0.22	1.7	1.4	0.0	0.2	0.0	168.1	7.7	3785.1
	DEC	0.3	0.13	1.0	1.4	0.0	0.2	0.0	166.0	7.6	3784.9
		44.3	4.61	35.7	20.6	0.0	2.4	0.0			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1963	JAN	0.2	0.15	1.1	1.4	0.0	0.2	0.0	163.7	7.6	3784.5
	FEB	0.4	0.13	1.0	1.2	0.0	0.2	0.0	161.9	7.5	3784.3
	MAR	0.4	0.44	3.3	1.4	0.0	0.2	0.0	157.6	7.4	3783.7
	APR	1.9	0.67	5.0	1.7	0.0	0.2	0.0	152.8	7.3	3783.0
	MAY	5.4	0.49	3.6	1.7	0.0	0.2	0.0	153.0	7.3	3783.0
	JUNE	3.2	0.63	4.6	2.0	0.0	0.2	0.0	149.6	7.2	3782.5
	JULY	2.0	0.62	4.5	2.5	0.0	0.2	0.0	144.6	7.1	3781.8
	AUG	11.7	0.27	2.0	2.3	0.0	0.2	0.0	152.1	7.3	3782.9
	SEPT	3.2	0.44	3.2	1.9	0.0	0.2	0.0	150.2	7.3	3782.6
	OCT	0.1	0.40	2.9	1.7	0.0	0.2	0.0	145.7	7.1	3782.0
	NOV	0.1	0.30	2.1	1.4	0.0	0.2	0.0	142.3	7.1	3781.5
	DEC	−0.1	0.18	1.3	1.4	0.0	0.2	0.0	139.6	7.0	3781.1
		28.5	4.72	34.6	20.6	0.0	2.4	0.0			
1964	JAN	0.3	0.19	1.3	1.4	0.0	0.2	0.0	137.2	6.9	3780.7
	FEB	0.7	0.14	1.0	1.2	0.0	0.2	0.0	135.8	6.9	3780.5
	MAR	0.7	0.42	2.9	1.4	0.0	0.2	0.0	132.2	6.8	3779.9
	APR	0.4	0.54	3.6	1.7	0.0	0.2	0.0	127.2	6.7	3779.1
	MAY	1.3	0.48	3.2	1.7	0.0	0.2	0.0	123.6	6.6	3778.6
	JUNE	0.0	0.76	5.0	2.0	0.0	0.2	0.0	116.6	6.4	3777.4
	JULY	0.1	0.67	4.3	2.5	0.0	0.2	0.0	110.0	6.2	3776.3
	AUG	2.2	0.54	3.4	2.3	0.0	0.2	0.0	106.5	6.1	3775.7
	SEPT	9.0	0.33	2.0	1.9	0.0	0.2	0.0	111.6	6.3	3776.5
	OCT	−0.3	0.42	2.6	1.7	0.0	0.2	0.0	106.9	6.2	3775.7
	NOV	−0.1	0.16	1.0	1.4	0.0	0.2	0.0	104.4	6.1	3775.3
	DEC	0.4	0.16	0.9	1.4	0.0	0.2	0.0	102.5	6.0	3774.9
		14.7	4.81	31.2	20.6	0.0	2.4	0.0			
1965	JAN	0.1	0.17	1.0	1.4	0.0	0.2	0.0	100.1	6.0	3774.5
	FEB	0.1	0.20	1.2	1.2	0.0	0.1	0.0	97.8	59.0	3774.1
	MAR	1.1	0.29	1.7	1.4	0.0	0.2	0.0	95.8	5.8	3773.7
	APR	−0.1	0.61	3.5	1.7	0.0	0.2	0.0	90.6	5.7	3772.7
	MAY	5.2	0.59	3.3	1.7	0.0	0.2	0.0	90.7	5.7	3772.7
	JUNE	36.0	0.25	1.5	2.0	0.0	0.2	0.0	123.1	6.6	3778.5
	JULY	16.0	0.49	3.3	2.5	0.0	0.2	0.0	133.3	6.8	3780.1
	AUG	27.9	0.42	3.0	2.3	0.0	0.2	0.0	155.9	7.4	3783.4
	SEPT	9.7	0.36	2.7	1.9	0.0	0.2	0.0	161.0	7.5	3784.2
	OCT	6.3	0.34	2.6	1.7	0.0	0.2	0.0	163.0	7.5	3784.4
	NOV	0.1	0.27	2.1	1.4	0.0	0.2	0.0	159.7	7.5	3784.0
	DEC	0.0	0.15	1.1	1.4	0.0	0.2	0.0	157.2	7.4	3783.6
		102.4	4.14	27.0	20.6	0.0	2.3	0.0			
1966	JAN	0.4	0.17	1.3	1.4	0.0	0.2	0.0	154.9	7.4	3783.3
	FEB	1.1	0.17	1.3	1.2	0.0	0.2	0.0	153.5	7.3	3783.1
	MAR	0.8	0.49	3.6	1.4	0.0	0.2	0.0	149.3	7.2	3782.5
	APR	1.0	0.56	4.1	1.7	0.0	0.2	0.0	144.6	7.1	3781.8
	MAY	1.1	0.69	4.9	1.7	0.0	0.2	0.0	139.1	7.0	3781.0
	JUNE	9.9	0.55	3.9	2.0	0.0	0.2	0.0	143.1	7.1	3781.6
	JULY	6.9	0.63	4.5	2.5	0.0	0.2	0.0	143.0	7.1	3781.6
	AUG	20.7	0.25	1.8	2.3	0.0	0.2	0.0	159.5	7.5	3784.0
	SEPT	−0.1	0.40	3.0	1.9	0.0	0.2	0.0	154.5	7.3	3783.2
	OCT	−0.4	0.48	3.5	1.7	0.0	0.2	0.0	149.0	7.2	3782.4
	NOV	0.1	0.30	2.2	1.4	0.0	0.2	0.0	145.5	7.1	3781.9
	DEC	−0.2	0.20	1.4	1.4	0.0	0.2	0.0	142.5	7.1	3781.5
		41.3	4.89	35.5	20.6	0.0	2.4	0.0			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1967	JAN	0.1	0.19	1.4	1.4	0.0	0.2	0.0	139.8	7.0	3781.1
	FEB	0.4	0.26	1.8	1.2	0.0	0.2	0.0	137.2	6.9	3780.7
	MAR	0.9	0.52	3.6	1.4	0.0	0.2	0.0	133.1	6.8	3780.1
	APR	0.9	0.73	4.9	1.7	0.0	0.2	0.0	127.4	6.7	3779.2
	MAY	7.5	0.72	4.8	1.7	0.0	0.2	0.0	128.4	6.7	3779.3
	JUNE	13.0	0.73	5.0	2.0	0.0	0.2	0.0	134.4	6.9	3780.3
	JULY	32.5	0.44	3.2	2.5	0.0	0.2	0.0	161.2	7.5	3784.2
	AUG	6.8	0.50	3.8	2.3	0.0	0.2	0.0	161.9	7.5	3784.3
	SEPT	6.0	0.36	2.7	1.9	0.0	0.2	0.0	163.4	7.5	3784.5
	OCT	0.1	0.50	3.7	1.7	0.0	0.2	0.0	158.1	7.4	3783.8
	NOV	−0.3	0.26	1.9	1.4	0.0	0.2	0.0	154.5	7.3	3783.2
	DEC	0.4	0.16	1.1	1.4	0.0	0.2	0.0	152.3	7.3	3782.9
		68.3	5.37	37.9	20.6	0.0	2.4	0.0			
1968	JAN	0.2	0.12	0.9	1.4	0.0	0.2	0.0	150.2	7.3	3782.6
	FEB	0.5	0.21	1.5	1.2	0.0	0.2	0.0	148.1	7.2	3782.3
	MAR	1.2	0.38	2.8	1.4	0.0	0.2	0.0	145.1	7.1	3781.9
	APR	1.9	0.60	4.2	1.7	0.0	0.2	0.0	141.0	7.0	3781.3
	MAY	0.5	0.52	3.6	1.7	0.0	0.2	0.0	136.2	6.9	3780.5
	JUNE	0.9	0.64	4.4	2.0	0.0	0.2	0.0	130.7	6.8	3779.7
	JULY	3.8	0.40	2.7	2.5	0.0	0.2	0.0	129.3	6.8	3779.5
	AUG	7.9	0.45	3.1	2.3	0.0	0.2	0.0	131.8	6.8	3779.9
	SEPT	0.1	0.40	2.7	1.9	0.0	0.2	0.0	127.3	6.7	3779.2
	OCT	1.0	0.44	3.0	1.7	0.0	0.2	0.0	123.7	6.6	3778.6
	NOV	−0.2	0.34	2.2	1.4	0.0	0.2	0.0	119.9	6.5	3777.9
	DEC	0.0	0.17	1.1	1.4	0.0	0.2	0.0	117.4	6.4	3777.5
		17.8	4.67	32.2	20.6	0.0	2.4	0.0			
1969	JAN	0.3	0.26	1.7	1.4	0.0	0.2	0.0	114.7	6.4	3777.1
	FEB	0.9	0.20	1.3	1.2	0.0	0.2	0.0	113.0	6.3	3776.8
	MAR	0.4	0.38	2.4	1.4	0.0	0.2	0.0	109.6	6.2	3776.2
	APR	0.7	0.37	2.3	1.7	0.0	0.2	0.0	106.3	6.1	3775.6
	MAY	11.5	0.28	1.7	1.7	0.0	0.2	0.0	114.4	6.4	3777.0
	JUNE	41.6	0.24	1.6	2.0	0.0	0.2	0.0	152.4	7.3	3783.0
	JULY	13.0	0.16	1.2	2.5	0.0	0.2	0.0	161.8	7.5	3784.3
	AUG	8.3	0.14	1.1	2.3	0.0	0.2	0.0	166.8	7.6	3785.0
	SEPT	46.4	0.05	0.4	1.9	0.0	0.2	28.8	182.1	7.9	3787.0
	OCT	1.5	0.16	1.3	1.7	0.0	0.2	0.0	180.6	7.9	3786.8
	NOV	2.3	0.27	2.1	1.4	0.0	0.2	0.0	179.4	7.9	3786.6
	DEC	0.4	0.07	0.6	1.4	0.0	0.2	0.0	177.8	7.9	3786.4
		127.3	2.58	17.7	20.6	0.0	2.4	28.8			
1970	JAN	1.1	0.15	1.2	1.4	0.0	0.2	0.0	176.4	7.8	3786.2
	FEB	0.7	0.24	1.9	1.2	0.0	0.2	0.0	173.9	7.8	3785.9
	MAR	0.5	0.19	1.5	1.4	0.0	0.2	0.0	171.6	7.7	3785.6
	APR	4.2	0.23	1.7	1.7	0.0	0.2	0.0	172.4	7.7	3785.7
	MAY	1.1	0.57	4.4	1.7	0.0	0.2	0.0	167.4	7.6	3785.0
	JUNE	0.1	0.52	3.9	2.0	0.0	0.2	0.0	161.6	7.5	3784.2
	JULY	5.1	0.28	2.1	2.5	0.0	0.2	0.0	162.1	7.5	3784.3
	AUG	3.3	0.33	2.5	2.3	0.0	0.2	0.0	160.5	7.5	3784.1
	SEPT	1.2	0.13	1.0	1.9	0.0	0.2	0.0	158.8	7.4	3783.9
	OCT	−0.5	0.15	1.1	1.7	0.0	0.2	0.0	155.5	7.4	3783.4
	NOV	0.1	0.31	2.3	1.4	0.0	0.2	0.0	152.0	7.3	3782.9
	DEC	0.1	0.20	1.5	1.4	0.0	0.2	0.0	149.2	7.2	3782.5
		17.0	3.30	25.1	20.6	0.0	2.4	0.0			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1971	JAN	−0.3	0.19	1.3	1.4	0.0	0.2	0.0	146.2	7.2	3782.0
	FEB	0.4	0.18	1.3	1.2	0.0	0.2	0.0	144.1	7.1	3781.7
	MAR	0.8	0.29	2.1	1.4	0.0	0.2	0.0	141.4	7.0	3781.3
	APR	1.2	0.41	2.9	1.7	0.0	0.2	0.0	138.0	7.0	3780.8
	MAY	7.7	0.43	3.0	1.7	0.0	0.2	0.0	141.0	7.0	3781.3
	JUNE	4.3	0.40	2.8	2.0	0.0	0.2	0.0	140.5	7.0	3781.2
	JULY	8.1	0.11	0.8	2.5	0.0	0.2	0.0	145.4	7.1	3781.9
	AUG	16.0	0.30	2.2	2.3	0.0	0.2	0.0	156.9	7.4	3783.6
	SEPT	−0.5	0.25	1.8	1.9	0.0	0.2	0.0	152.7	7.3	3783.0
	OCT	0.0	0.17	1.2	1.7	0.0	0.2	0.0	149.7	7.2	3782.6
	NOV	1.3	0.11	0.8	1.4	0.0	0.2	0.0	148.8	7.2	3782.4
	DEC	0.4	0.18	1.3	1.4	0.0	0.2	0.0	146.5	7.2	3782.1
		39.4	3.02	21.5	20.6	0.0	2.4	0.0			
1972	JAN	0.4	0.19	1.4	1.4	0.0	0.2	0.0	144.2	7.1	3781.7
	FEB	0.2	0.34	2.4	1.2	0.0	0.2	0.0	140.7	7.0	3781.2
	MAR	0.3	0.37	2.6	1.4	0.0	0.2	0.0	137.0	6.9	3780.7
	APR	0.5	0.56	3.9	1.7	0.0	0.2	0.0	132.0	6.8	3779.9
	MAY	0.9	0.57	3.8	1.7	0.0	0.2	0.0	127.4	6.7	3779.2
	JUNE	0.9	0.45	3.0	2.0	0.0	0.2	0.0	123.3	6.6	3778.5
	JULY	32.0	0.08	0.6	2.5	0.0	0.2	0.0	152.2	7.3	3782.9
	AUG	16.8	0.12	0.9	2.3	0.0	0.2	0.0	165.8	7.6	3784.8
	SEPT	20.3	−0.04	−0.3	1.9	0.0	0.2	2.4	182.1	7.9	3787.0
	OCT	0.8	0.15	1.2	1.7	0.0	0.2	0.0	180.0	7.9	3786.7
	NOV	0.7	0.04	0.3	1.4	0.0	0.2	0.0	179.0	7.9	3786.6
	DEC	0.6	0.12	0.9	1.4	0.0	0.2	0.0	177.2	7.8	3786.4
		74.4	2.95	20.7	20.6	0.0	2.4	2.4			
1973	JAN	0.3	0.15	1.2	1.4	0.0	0.2	0.0	174.9	7.8	3786.1
	FEB	0.4	0.07	0.6	1.2	0.0	0.2	0.0	173.6	7.8	3785.9
	MAR	0.8	0.17	1.3	1.4	0.0	0.2	0.0	171.6	7.7	3785.6
	APR	6.6	0.13	1.0	1.7	0.0	0.2	0.0	175.4	7.8	3786.1
	MAY	0.6	0.34	2.6	1.7	0.0	0.2	0.0	171.7	7.7	3785.6
	JUNE	0.5	0.31	2.4	2.0	0.0	0.2	0.0	167.8	7.6	3785.1
	JULY	5.1	0.27	2.1	2.5	0.0	0.2	0.0	168.3	7.7	3785.2
	AUG	0.4	0.33	2.5	2.3	0.0	0.2	0.0	163.9	7.6	3784.6
	SEPT	0.6	0.37	2.8	1.9	0.0	0.2	0.0	159.9	7.5	3784.0
	OCT	0.2	0.24	1.8	1.7	0.0	0.2	0.0	156.6	7.4	3783.5
	NOV	−1.5	0.28	2.1	1.4	0.0	0.2	0.0	151.5	7.3	3782.8
	DEC	−0.5	0.14	1.0	1.4	0.0	0.2	0.0	148.6	7.2	3782.4
		13.5	2.80	21.4	20.6	0.0	2.4	0.0			
1974	JAN	1.4	0.15	1.1	1.4	0.0	0.2	0.0	147.5	7.2	3782.2
	FEB	0.3	0.25	1.8	1.2	0.0	0.2	0.0	144.8	7.1	3781.8
	MAR	0.2	0.33	2.3	1.4	0.0	0.2	0.0	141.3	7.0	3781.3
	APR	0.7	0.62	4.3	1.7	0.0	0.2	0.0	136.0	6.9	3780.5
	MAY	0.6	0.70	4.8	1.7	0.0	0.2	0.0	130.0	6.8	3779.6
	JUNE	−0.6	0.50	3.3	2.0	0.0	0.2	0.0	124.1	6.6	3778.6
	JULY	0.0	0.53	3.4	2.5	0.0	0.2	0.0	118.1	6.5	3777.7
	AUG	1.7	0.23	1.5	2.3	0.0	0.2	0.0	116.1	6.4	3777.3
	SEPT	1.9	0.13	0.8	1.9	0.0	0.2	0.0	115.3	6.4	3777.2
	OCT	3.2	−0.07	−0.4	1.7	0.0	0.2	0.0	117.2	6.4	3777.5
	NOV	−0.3	0.24	1.5	1.4	0.0	0.2	0.0	114.0	6.4	3777.0
	DEC	0.3	0.15	1.0	1.4	0.0	0.2	0.0	111.9	6.3	3776.6
		9.4	3.76	25.4	20.6	0.0	2.4	0.0			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1975	JAN	0.7	0.16	1.0	1.4	0.0	0.2	0.0	110.2	6.2	3776.3
	FEB	0.9	0.22	1.4	1.2	0.0	0.2	0.0	108.6	6.2	3776.0
	MAR	1.3	0.56	3.4	1.4	0.0	0.2	0.0	105.0	6.1	3775.4
	APR	0.6	0.54	3.3	1.7	0.0	0.2	0.0	100.6	6.0	3774.6
	MAY	1.1	0.65	3.8	1.7	0.0	0.2	0.0	96.1	5.8	3773.8
	JUNE	4.3	0.46	2.7	2.0	0.0	0.2	0.0	95.7	5.8	3773.7
	JULY	5.5	0.37	2.2	2.5	0.0	0.2	0.0	96.6	5.9	3773.8
	AUG	1.2	0.40	2.3	2.3	0.0	0.2	0.0	93.1	5.8	3773.2
	SEPT	0.5	0.41	2.4	1.9	0.0	0.2	0.0	89.4	5.6	3772.5
	OCT	−0.3	0.53	2.9	1.7	0.0	0.2	0.0	84.5	5.5	3771.5
	NOV	0.2	0.35	1.9	1.4	0.0	0.2	0.0	81.4	5.4	3770.8
	DEC	0.4	0.26	1.4	1.4	0.0	0.2	0.0	79.0	5.3	3770.3
		16.4	4.91	28.7	20.6	0.0	2.4	0.0			
1976	JAN	0.0	0.18	1.0	1.4	0.0	0.2	0.0	76.7	5.2	3769.8
	FEB	1.5	0.53	2.7	1.2	0.0	0.1	0.0	74.2	5.1	3769.3
	MAR	0.4	0.69	3.5	1.4	0.0	0.2	0.0	69.7	5.0	3768.3
	APR	2.0	0.76	3.7	1.7	0.0	0.1	0.0	66.2	4.8	3767.4
	MAY	1.0	0.63	3.0	1.7	0.0	0.1	0.0	62.5	4.7	3766.5
	JUNE	1.7	0.54	2.5	2.0	0.0	0.1	0.0	59.7	4.6	3765.8
	JULY	8.1	0.67	3.1	2.5	0.0	0.1	0.0	62.2	4.7	3766.5
	AUG	0.2	0.49	2.2	2.3	0.0	0.1	0.0	57.8	4.5	3765.3
	SEPT	4.6	0.34	1.5	1.9	0.0	0.1	0.0	59.0	4.6	3765.7
	OCT	−0.3	0.44	2.0	1.7	0.0	0.1	0.0	55.0	4.4	3764.6
	NOV	0.1	0.30	1.3	1.4	0.0	0.1	0.0	52.4	4.3	3763.9
	DEC	0.1	0.22	1.0	1.4	0.0	0.1	0.0	50.1	4.2	3763.2
		19.4	5.79	27.5	20.6	0.0	1.4	0.0			
1977	JAN	0.4	0.16	0.7	1.4	0.0	0.1	0.0	48.4	4.1	3762.7
	FEB	1.2	0.39	1.6	1.2	0.0	0.1	0.0	46.8	4.1	3762.2
	MAR	1.1	0.74	3.0	1.4	0.0	0.1	0.0	43.6	4.0	3761.2
	APR	6.7	0.44	1.8	1.7	0.0	0.1	0.0	46.7	4.1	3762.2
	MAY	10.5	0.55	2.3	1.7	0.0	0.1	0.0	53.2	4.3	3764.1
	JUNE	1.1	0.53	2.3	2.0	0.0	0.1	0.0	50.1	4.2	3763.2
	JULY	4.1	0.53	2.2	2.5	0.0	0.1	0.0	49.5	4.2	3763.0
	AUG	18.5	0.27	1.2	2.3	0.0	0.1	0.0	64.5	4.8	3767.0
	SEPT	2.3	0.53	2.5	1.9	0.0	0.1	0.0	62.4	4.7	3766.5
	OCT	−0.2	0.38	1.8	1.7	0.0	0.1	0.0	58.7	4.6	3765.6
	NOV	−0.1	0.34	1.5	1.4	0.0	0.1	0.0	55.7	4.4	3764.8
	DEC	−0.4	0.19	0.8	1.4	0.0	0.1	0.0	53.0	4.3	3764.0
		45.2	5.05	21.7	20.6	0.0	1.2	0.0			
1978	JAN	0.3	0.15	0.6	1.4	0.0	0.1	0.0	51.3	4.3	3763.5
	FEB	0.5	0.17	0.7	1.2	0.0	0.1	0.0	49.8	4.2	3763.1
	MAR	1.0	0.40	1.7	1.4	0.0	0.1	0.0	47.7	4.1	3762.5
	APR	0.0	0.51	2.1	1.7	0.0	0.1	0.0	44.0	4.0	3761.4
	MAY	0.5	0.31	1.2	1.7	0.0	0.1	0.0	41.6	3.9	3760.6
	JUNE	8.3	0.50	2.0	2.0	0.0	0.1	0.0	45.9	4.0	3762.0
	JULY	1.5	0.76	3.0	2.5	0.0	0.1	0.0	41.9	3.9	3760.7
	AUG	0.3	0.61	2.3	2.3	0.0	0.1	0.0	37.6	3.7	3759.2
	SEPT	−0.8	0.30	1.1	1.9	0.0	0.1	0.0	33.8	3.6	3757.9
	OCT	−0.7	0.33	1.2	1.7	0.0	0.1	0.0	30.2	3.5	3756.5
	NOV	6.0	−0.03	−0.1	1.4	0.0	0.1	0.0	34.9	3.7	3758.3
	DEC	−0.1	0.16	0.6	1.4	0.0	0.1	0.0	32.8	3.6	3757.5
		16.8	4.17	16.4	20.6	0.0	1.2	0.0			

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CAL YEAR	MONTH	INFLOW (1000 AF)	EVAP RATE (FT)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SHORTAGE (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	EOM VOLUME (1000 AF)	EOM AREA (1000 AF)	EOM ELEV. (FT)
1979	JAN	0.5	0.14	0.5	1.4	0.0	0.1	0.0	31.4	3.5	3757.0
	FEB	0.6	0.13	0.5	1.2	0.0	0.1	0.0	30.4	3.5	3756.6
	MAR	0.9	0.41	1.4	1.4	0.0	0.1	0.0	28.4	3.4	3755.8
	APR	0.3	0.15	0.5	1.7	0.0	0.1	0.0	26.5	3.3	3755.0
	MAY	6.5	0.24	0.8	1.7	0.0	0.1	0.0	30.5	3.5	3756.7
	JUNE	2.4	0.39	1.3	2.0	0.0	0.1	0.0	29.6	3.5	3756.3
	JULY	6.3	0.38	1.3	2.5	0.0	0.1	0.0	32.0	3.5	3757.2
	AUG	13.0	0.56	2.1	2.3	0.0	0.1	0.0	40.7	3.9	3760.3
	SEPT	1.8	0.36	1.4	1.9	0.0	0.1	0.0	39.2	3.8	3759.8
	OCT	−0.9	0.22	0.8	1.7	0.0	0.1	0.0	35.8	3.7	3758.6
	NOV	0.8	0.25	0.9	1.4	0.0	0.1	0.0	34.3	3.6	3758.1
	DEC	0.8	0.33	1.2	1.4	0.0	0.1	0.0	32.5	3.6	3757.4
		33.0	3.56	12.7	20.6	0.0	1.2	0.0			
1980	JAN	0.5	0.29	1.0	1.4	0.0	0.1	0.0	30.6	3.5	3756.7
	FEB	1.3	0.22	0.8	1.2	0.0	0.1	0.0	30.0	3.5	3756.4
	MAR	0.8	0.40	1.4	1.4	0.0	0.1	0.0	28.0	3.4	3755.6
	APR	2.1	0.41	1.4	1.7	0.0	0.1	0.0	27.0	3.4	3755.3
	MAY	5.9	0.31	1.0	1.7	0.0	0.1	0.0	30.2	3.5	3756.5
	JUNE	0.9	0.62	2.1	2.0	0.0	0.1	0.0	27.0	3.3	3755.2
	JULY	0.1	0.64	2.1	2.5	0.0	0.1	0.0	22.5	3.2	3753.3
	AUG	3.5	0.32	1.0	2.3	0.0	0.1	0.0	22.7	3.2	3753.4
	SEPT	4.1	0.14	0.4	1.9	0.0	0.1	0.0	24.5	3.2	3754.2
	OCT	0.1	0.41	1.3	1.7	0.0	0.1	0.0	21.6	3.1	3752.9
	NOV	0.2	0.18	0.5	1.4	0.0	0.1	0.0	19.9	3.0	3752.0
	DEC	0.4	0.23	0.7	1.4	0.0	0.1	0.0	18.2	2.9	3751.2
		19.9	4.17	13.7	20.6	0.0	1.2	0.0			
1981	JAN	0.7	0.28	0.8	1.4	0.0	0.1	0.0	16.7	2.9	3750.4
	FEB	0.5	0.23	0.7	1.2	0.0	0.1	0.0	15.4	2.8	3748.7
	MAR	0.9	0.38	1.0	1.4	0.0	0.1	0.0	13.8	2.7	3749.6
	APR	0.2	0.44	1.2	1.7	0.0	0.1	0.0	11.2	2.5	3747.0
	MAY	2.1	0.53	1.3	1.7	0.0	0.1	0.0	10.3	2.5	3746.3
	JUNE	0.3	0.52	1.2	2.0	0.0	0.1	0.0	7.4	2.2	3744.0
	JULY	2.8	0.55	1.2	2.5	0.0	0.1	0.0	6.5	2.1	3743.1
	AUG	65.8	0.03	0.1	2.3	0.0	0.1	0.0	69.9	5.0	3768.3
	SEPT	8.3	0.31	1.6	1.9	0.0	0.1	0.0	74.7	5.2	3769.4
	OCT	−0.2	0.22	1.1	1.7	0.0	0.2	0.0	71.8	5.0	3768.7
	NOV	0.3	0.24	1.2	1.4	0.0	0.1	0.0	69.4	5.0	3768.2
	DEC	0.2	0.19	0.9	1.4	0.0	0.1	0.0	67.3	4.9	3767.7
		81.9	3.92	12.3	20.6	0.0	1.3	0.0			
1982	JAN	0.4	0.18	0.9	1.4	0.0	0.1	0.0	65.4	4.8	3767.3
	FEB	0.7	0.24	1.1	1.2	0.0	0.1	0.0	63.8	4.8	3766.9
	MAR	0.8	0.42	2.0	1.4	0.0	0.1	0.0	61.3	4.7	3766.2
	APR	0.6	0.48	2.2	1.7	0.0	0.1	0.0	57.9	4.5	3765.4
	MAY	6.0	0.43	2.0	1.7	0.0	0.1	0.0	60.2	4.6	3766.0
	JUNE	25.9	0.33	1.7	2.0	0.0	0.1	0.0	82.5	5.4	3771.1
	JULY	40.5	0.30	1.8	2.5	0.0	0.2	0.0	118.7	6.5	3777.7
	AUG	25.8	0.50	3.4	2.3	0.0	0.2	0.0	138.8	7.0	3780.9
	SEPT	4.7	0.40	2.8	1.9	0.0	0.2	0.0	138.9	7.0	3780.9
	OCT	10.1	0.21	1.5	1.7	0.0	0.2	0.0	145.8	7.1	3782.0
	NOV	0.6	0.19	1.3	1.4	0.0	0.2	0.0	143.7	7.1	3781.7
	DEC	1.5	0.10	0.7	1.4	0.0	0.2	0.0	143.0	7.1	3781.6
		117.6	3.78	21.4	20.6	0.0	1.8	0.0			

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1983	JAN	2.0	0.13	1.0	1.4	0.0	0.2	0.0	142.7	7.1	3781.5
	FEB	2.7	0.12	0.9	1.2	0.0	0.2	0.0	143.3	7.1	3781.6
	MAR	1.9	0.36	2.6	1.4	0.0	0.2	0.0	141.2	7.0	3781.3
	APR	0.8	0.38	2.7	1.7	0.0	0.2	0.0	137.6	7.0	3780.8
	MAY	1.3	0.46	3.2	1.7	0.0	0.2	0.0	134.0	6.9	3780.2
	JUNE	4.8	0.36	2.5	2.0	0.0	0.2	0.0	134.3	6.9	3780.2
	JULY	0.0	0.62	4.2	2.5	0.0	0.2	0.0	127.6	6.7	3779.2
	AUG	−0.1	0.54	3.6	2.3	0.0	0.2	0.0	121.7	6.6	3778.2
	SEPT	0.5	0.52	3.4	1.9	0.0	0.2	0.0	116.9	6.4	3777.4
	OCT	0.7	0.22	1.4	1.7	0.0	0.2	0.0	114.5	6.4	3777.0
	NOV	−0.8	0.17	1.1	1.4	0.0	0.2	0.0	111.2	6.3	3776.5
	DEC	0.4	0.11	0.7	1.4	0.0	0.2	0.0	109.4	6.2	3776.2
		14.2	3.99	27.3	20.6	0.0	2.4	0.0			
1984	JAN	0.7	0.17	1.0	1.4	0.0	0.2	0.0	107.6	6.2	3775.9
	FEB	0.4	0.25	1.5	1.2	0.0	0.2	0.0	105.3	6.1	3775.5
	MAR	0.6	0.33	2.0	1.4	0.0	0.2	0.0	102.5	6.0	3774.9
	APR	0.6	0.41	2.4	1.7	0.0	0.2	0.0	99.0	5.9	3774.3
	MAY	0.2	0.36	2.1	1.7	0.0	0.2	0.0	95.4	5.8	3773.6
	JUNE	2.1	0.34	2.0	2.0	0.0	0.2	0.0	93.5	5.8	3773.3
	JULY	1.0	0.54	3.1	2.5	0.0	0.2	0.0	89.0	5.6	3772.4
	AUG	9.0	0.23	1.3	2.3	0.0	0.2	0.0	94.3	5.8	3773.4
	SEPT	0.3	0.41	2.3	1.9	0.0	0.2	0.0	90.3	5.7	3772.6
	OCT	1.0	0.05	0.3	1.7	0.0	0.2	0.0	89.4	5.6	3772.5
	NOV	1.9	0.16	0.9	1.4	0.0	0.2	0.0	89.0	5.6	3772.4
	DEC	0.5	0.06	0.3	1.4	0.0	0.2	0.0	87.8	5.6	3772.1
		18.3	3.31	19.2	20.6	0.0	2.4	0.0			
1985	JAN	1.5	0.17	1.0	1.4	0.0	0.2	0.0	86.8	5.6	3772.0
	FEB	0.4	0.12	0.7	1.2	0.0	0.1	0.0	85.3	5.5	3771.7
	MAR	2.3	0.20	1.1	1.4	0.0	0.2	0.0	85.1	5.5	3771.6
	APR	1.1	0.36	2.0	1.7	0.0	0.2	0.0	82.5	5.4	3771.1
	MAY	6.7	0.30	1.6	1.7	0.0	0.2	0.0	85.9	5.5	3771.8
	JUNE	1.2	0.45	2.4	2.0	0.0	0.2	0.0	82.7	5.4	3771.1
	JULY	3.3	0.50	2.7	2.5	0.0	0.2	0.0	80.7	5.4	3770.7
	AUG	0.1	0.32	1.7	2.3	0.0	0.2	0.0	76.9	5.2	3769.9
	SEPT	1.5	0.26	1.4	1.9	0.0	0.1	0.0	75.1	5.2	3769.5
	OCT	23.0	−0.03	−0.2	1.7	0.0	0.2	0.0	96.6	5.9	3773.9
	NOV	1.4	0.18	1.0	1.4	0.0	0.2	0.0	95.6	5.8	3773.7
	DEC	0.6	0.19	1.1	1.4	0.0	0.2	0.0	93.7	5.8	3773.3
		43.1	3.02	16.5	20.6	0.0	2.2	0.0			

Ute Reservoir Firm Yield Simulation

Annual summary Reservoir Operation Study

SIM YEAR	CAL YEAR	INFLOW (1000 AF)	RES EVAP (1000 AF)	DEMAND (1000 AF)	SEEPAGE (1000 AF)	SPILLS (1000 AF)	TOTAL DISCHARGE (1000 AF)
1	1939	88.3	21.1	20.6	1.7	0.0	1.7
2	1940	17.3	23.5	20.6	1.8	0.0	1.8
3	1941	1567.7	9.3	20.6	2.2	1415.5	1417.7
4	1942	1019.9	30.3	20.6	2.4	969.0	971.4
5	1943	52.3	34.7	20.6	2.4	21.0	23.4
6	1944	148.1	25.0	20.6	2.4	80.5	82.9
7	1945	33.5	32.6	20.6	2.4	0.0	2.4
8	1946	144.5	33.0	20.6	2.4	73.4	75.8
9	1947	75.5	35.4	20.6	2.4	32.6	35.0
10	1948	110.4	30.1	20.6	2.4	60.0	62.4
11	1949	101.2	25.8	20.6	2.4	49.6	52.0
12	1950	121.3	32.1	20.6	2.4	68.8	71.2
13	1951	66.4	36.6	20.6	2.4	19.7	22.1
14	1952	33.8	31.7	20.6	2.2	0.0	2.2
15	1953	46.3	31.6	20.6	2.2	0.0	2.2
16	1954	62.5	31.6	20.6	2.1	0.0	2.1
17	1955	69.8	32.0	20.6	2.3	0.0	2.3
18	1956	35.4	35.5	20.6	2.3	0.0	2.3
19	1957	76.0	27.8	20.6	2.3	0.0	2.3
20	1958	184.0	21.8	20.6	2.4	139.5	141.9
21	1959	55.3	25.3	20.6	2.4	5.3	7.7
22	1960	160.8	21.3	20.6	2.4	114.3	116.7
23	1961	102.6	32.4	20.6	2.4	53.9	56.3
24	1962	44.4	35.6	20.6	2.4	0.0	2.4
25	1963	28.6	34.4	20.6	2.3	0.0	2.3
26	1964	14.6	31.2	20.6	2.1	0.0	2.1
27	1965	102.3	27.0	20.6	2.1	0.0	2.1
28	1966	41.2	35.3	20.6	2.2	0.0	2.2
29	1967	68.3	37.9	20.6	2.2	0.0	2.2
30	1968	17.8	32.1	20.6	2.2	0.0	2.2
31	1969	127.4	17.6	20.6	2.2	28.8	31.0
32	1970	17.1	25.1	20.6	2.3	0.0	2.3
33	1971	39.4	21.5	20.6	2.2	0.0	2.2
34	1972	74.4	20.6	20.6	2.3	2.4	4.7
35	1973	13.3	21.3	20.6	2.3	0.0	2.3
36	1974	9.3	25.4	20.6	2.1	0.0	2.1
37	1975	16.4	28.7	20.6	1.9	0.0	1.9
38	1976	19.3	27.6	20.6	1.7	0.0	1.7
39	1977	45.2	21.7	20.6	1.6	0.0	1.6
40	1978	16.8	16.4	20.6	1.5	0.0	1.5
41	1979	32.9	12.7	20.6	1.4	0.0	1.4
42	1980	20.0	13.7	20.6	1.3	0.0	1.3
43	1981	82.2	12.4	20.6	1.4	0.0	1.4
44	1982	117.7	21.4	20.6	1.9	0.0	1.9
45	1983	14.1	27.0	20.6	2.1	0.0	2.1
46	1984	18.3	19.4	20.6	1.9	0.0	1.9
47	1985	43.0	16.5	20.6	1.9	0.0	1.9
	avg	114.8	26.4	20.6	2.1	66.7	68.8
	min	9.3	9.3	20.6	1.3	0.0	1.3
1963–82		45.2	24.2	20.6	2.0	1.6	3.5
1973–80		21.7	20.9	20.6	1.7	0.0	1.7
%INFLOW			23.0%	17.9%	1.9%	58.1%	

START = 40000 AF CONTENT END = 93700 AF

Index to data tabulations from HDR (1987)

Canadian River, Logan NM:	Monthly discharge in acre-feet
Canadian River, Amarillo TX:	Monthly discharge in acre-feet
Lake Meredith TX:	Monthly precipitation in inches
Lake Meredith TX:	Monthly water surface evaporation in inches
Lake Meredith TX:	Monthly diversion in acre-feet
Ute Reservoir NM:	End-of-month storage in acre-feet
Lake Meredith TX:	End-of-month storage in acre-feet

CANADIAN RIVER. LOGAN. NM
MONTHLY DISCHARGE IN ACRE-FEET

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
40	123	208	315	0	2840	3820	653	8850	30	0	54	409	17302
41	95	28	2570	13770	224500	279700	138600	64200	477600	297900	39440	29320	1567723
42	11530	8790	5870	412400	163900	6390	27940	42620	271000	41040	25080	3320	1019880
43	23880	1060	518	0	1410	3260	10040	11280	292	95	10	452	52297
44	2180	450	448	212	29670	32720	13890	31720	29950	2550	1360	2970	148120
45	2650	1580	545	1720	1290	1110	4550	18830	825	1740	258	424	35522
46	748	377	298	18	35680	3220	1330	10770	43550	45170	2510	845	144516
47	1630	1220	986	20	33720	4480	24770	8180	95	0	135	236	75472
48	136	3840	3530	367	1560	78330	6120	16030	10	67	375	6	110421
49	454	2130	1040	6840	11310	28490	24560	19800	5890	171	24	524	101233
50	278	151	73	904	14	7170	82570	15350	14050	621	26	129	121336
51	234	379	764	67	29210	8150	24280	1440	791	484	399	206	66404
52	113	12	545	496	349	389	8110	22200	1140	111	163	184	33812
53	171	79	63	12	212	2	10550	32510	1490	210	276	258	45833
54	296	169	116	62	118	30	357	1730	420	42060	210	135	45703
55	214	117	2	1460	30460	135	17550	11870	7830	60	8	103	69809
56	186	252	0	20	4050	6990	20120	3770	0	0	0	0	35388
57	54	125	65	1990	5420	3240	20120	32970	5860	5530	405	260	76039
58	446	232	2230	2040	50810	44110	21560	35980	25170	621	373	383	183955
59	899	516	226	573	1150	1490	4120	38120	807	1550	484	5410	55345
60	1920	924	659	292	258	26540	74200	22960	2670	23720	1520	5180	160843
61	3530	15650	11490	12510	4930	1350	15270	10350	22010	2500	1980	1030	102600
62	1190	3550	1960	1240	1800	4130	21570	4850	2790	558	448	313	44399
63	53	102	38	16	39	37	40	73	228	80	106	115	927
64	92	87	97	167	134	48	61	89	103	165	117	121	1281
65	138	106	130	100	61	258	136	146	11980	20000	2390	178	35623
66	175	151	143	134	130	148	130	5030	348	160	156	186	6891
67	172	158	164	127	112	3950	30340	5150	4590	7100	2940	175	54978
68	165	153	159	149	158	148	152	139	141	152	157	157	1830
69	167	157	155	138	146	34220	12000	7370	49880	8010	175	153	112571
70	186	180	205	207	201	161	2750	5730	705	513	158	178	11174
71	161	150	172	151	188	2490	6990	16110	158	148	133	144	26995
72	143	144	143	123	135	114	15520	13100	29760	1380	160	146	60868
73	151	139	167	4560	149	166	1030	2320	130	130	141	149	9232
74	134	117	143	125	149	124	135	106	126	152	330	141	1782
75	136	133	131	127	128	137	176	121	129	127	108	99	1552
76	152	158	118	129	119	117	150	186	181	144	115	130	1699
77	113	119	124	161	134	121	3230	13160	6350	177	115	121	23925
78	139	134	253	138	166	133	121	108	113	87	95	117	1604
79	109	112	136	127	119	121	3040	4140	1830	119	4730	166	14749
80	2950	10010	204	133	136	121	109	110	107	114	116	124	14234
81	152	125	134	3690	613	109	238	44260	12510	156	126	145	62258
82	141	134	140	124	130	16030	37370	31850	17880	17730	17050	5170	143749
83	3830	3030	699	2570	152	3190	256	104	81	98	71	76	14157
84	100	109	123	119	109	110	122	127	100	116	191	120	1446

CANADIAN RIVER, AMARILLO, TX
MONTHLY DISCHARGE IN ACRE-FEET

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
40	954	1800	115	109	33820	8100	3320	23940	11070	48	11330	2270	96876
41	990	635	1810	12380	418400	314600	300100	162800	477000	348200	48350	28190	2113455
42	13420	10630	10040	356300	177600	35790	43580	43960	271500	65940	21450	7740	1057950
43	31910	1720	478	1270	1050	75	38040	10920	131	268	332	4170	90364
44	9690	4310	1920	2060	49650	58130	29710	34420	48790	3140	930	10210	252960
45	8120	2250	324	324	283	3920	2670	39730	5840	10880	343	433	75117
46	444	471	392	313	28760	8060	1490	17470	69730	120100	5880	2160	255270
47	2780	788	2240	1280	46190	5940	23910	6260	227	327	361	573	90876
48	554	6000	6160	491	6460	110900	9470	46100	739	1650	5030	360	193914
49	926	2830	2270	9510	96320	104000	79460	38930	23320	2280	2700	924	363470
50	1080	468	754	2550	1220	39060	200700	48360	78220	8270	865	998	382545
51	1430	2650	1760	879	72160	13250	34610	4550	1820	867	2340	718	137034
52	772	556	744	3700	1940	1370	16100	33660	3800	616	654	805	64717
53	1010	561	653	596	577	537	30980	48470	1860	8680	1030	1110	96064
54	1010	692	768	2380	49040	1990	38170	16460	1810	64930	1070	657	179477
55	913	779	550	36340	75370	18800	27390	24150	14860	3350	681	767	203950
56	923	902	912	642	33750	6810	25200	3790	430	441	532	667	75004
57	564	645	998	7230	46190	39390	13450	104000	12820	19180	2080	1050	247597
58	2340	2940	9370	8100	62150	48420	169800	64000	68720	2260	1540	2070	441710
59	2010	2110	599	846	5310	17640	24310	74190	3540	4660	725	25440	161380
60	8520	7840	4310	946	625	79800	202400	51280	23520	49160	3210	11030	441201
61	4100	10390	24760	12590	7150	4620	33140	17780	30780	4080	13150	3750	166290
62	3750	3190	2410	2190	1820	14590	32730	28770	7050	1990	1450	2050	102040
63	916	1310	1100	684	5630	32000	13610	19500	13440	662	605	761	90218
64	750	3120	889	491	1450	747	509	2990	27220	732	1160	524	40582
65	429	388	594	332	21330	195200	14650	24170	13170	42370	11250	2420	326303
66	668	2830	2090	559	813	10660	8420	26050	6320	593	656	756	60413
67	1510	858	688	14490	2570	30870	99410	19820	13890	19470	6180	4940	214696
68	5210	2640	1100	662	11630	7570	14450	16070	1270	3830	988	408	65823
69	918	2740	3180	184	33130	76870	38950	29910	105400	23900	4670	2970	322822
70	3400	1320	1790	29710	2440	1340	6340	19960	8980	4380	1870	921	82451
71	1350	1560	750	1650	9620	20950	36950	45220	17150	4340	22140	4070	165750
72	3910	1890	858	648	5430	8790	81440	56270	61630	17010	3010	1900	242786
73	2570	2190	8650	14940	1470	389	14420	11940	884	526	557	833	59369
74	1410	875	5640	287	7170	4260	2520	49770	18960	36500	3650	1940	132982
75	3720	3660	1820	2830	2450	31670	18450	10100	1300	791	440	333	77564
76	627	672	824	2160	6540	3200	3730	13310	53270	3580	958	772	89643
77	1560	1600	220	9180	7790	4350	7440	52670	28750	85	91	106	113842
78	292	357	507	90	20430	42370	1540	2250	17380	7870	988	370	94444
79	730	579	473	310	1680	18960	332	15370	1940	121	5080	950	46525
80	5330	14920	2550	1050	16890	6870	80	5940	2520	35	164	1080	57429
81	537	247	816	219	2780	18840	14340	184900	50980	7740	2670	2070	286139
82	1710	1330	1290	1140	3830	48090	78670	38690	23100	23830	18370	10760	250810
83	7600	9370	6280	4260	2220	7720	19	7	2	511	280	77	38346
84	592	495	847	3190	1550	3930	1550	13730	627	6610	2740	3700	39561

LAKE MEREDITH. TX
MONTHLY PRECIPITATION IN INCHES

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
40	0.52	0.88	0.24	1.10	2.68	1.64	0.88	0.71	0.54	0.29	3.87	0.27	13.62
41	0.40	0.94	2.55	1.29	7.47	5.07	3.36	3.18	4.30	7.64	0.33	0.68	37.21
42	0.06	0.63	0.42	3.74	0.91	2.29	0.80	3.95	1.45	6.18	0.00	1.19	21.62
43	0.08	0.00	0.01	1.06	1.82	1.01	6.64	2.09	0.79	0.72	0.39	3.77	18.38
44	1.67	0.72	0.00	1.83	3.72	4.33	5.06	1.40	2.08	0.84	0.75	1.20	23.60
45	0.77	0.28	0.41	1.58	0.42	1.61	1.62	5.17	4.02	1.31	0.00	0.00	17.19
46	1.05	0.33	0.66	0.55	0.82	2.37	0.12	3.96	3.25	5.73	0.78	1.18	20.80
47	0.32	0.07	0.77	2.07	4.59	3.19	1.54	0.39	0.24	0.12	0.92	1.26	15.48
48	0.63	1.83	0.72	0.73	2.82	4.92	1.52	5.16	1.27	2.58	2.11	0.09	24.38
49	2.02	0.59	0.57	1.99	6.43	2.82	3.90	3.78	1.69	1.03	0.01	0.30	25.13
50	0.00	0.20	0.00	0.64	1.83	3.25	7.32	4.54	5.02	0.00	0.03	0.35	23.18
51	0.38	1.17	0.55	0.43	9.81	4.34	2.01	1.52	2.01	2.37	0.25	0.45	25.29
52	0.53	0.24	0.56	2.46	2.05	1.75	1.36	0.88	0.38	0.00	1.44	0.50	12.15
53	0.64	0.53	0.38	0.62	0.70	0.01	1.81	2.00	0.26	4.56	0.56	0.98	13.05
54	0.25	0.09	0.17	2.31	4.44	1.95	0.55	2.91	0.30	0.73	0.00	0.19	13.89
55	0.53	0.06	0.33	0.38	2.70	1.49	3.35	1.49	3.13	0.13	0.02	0.10	13.71
56	0.09	1.10	0.03	0.23	1.99	2.03	2.82	0.79	0.48	0.38	0.00	0.00	9.94
57	0.33	1.11	2.82	2.69	4.36	0.53	0.13	4.85	0.88	2.57	0.94	0.03	21.24
58	1.05	0.58	2.36	1.74	2.45	4.22	6.16	2.08	1.60	0.15	0.60	0.30	23.29
59	0.16	0.06	0.26	1.18	4.82	2.19	2.85	2.24	2.29	2.10	0.14	4.52	22.81
60	1.30	0.95	1.66	1.66	0.82	9.85	7.59	3.15	4.22	4.82	0.00	0.65	36.67
61	0.12	0.27	2.55	0.24	3.40	3.42	4.10	3.14	1.87	0.91	2.26	0.16	22.44
62	0.47	0.39	0.02	1.48	1.76	10.16	7.51	3.29	2.66	0.85	0.53	0.64	29.76
63	0.06	0.67	0.28	0.47	3.66	3.60	2.04	3.93	0.43	1.54	0.33	0.29	17.30
64	0.00	1.37	0.03	0.00	1.69	1.90	0.94	5.69	3.95	0.08	1.53	0.79	17.97
65	0.01	0.19	0.92	0.39	4.10	8.63	0.37	2.90	0.95	0.84	0.00	0.68	19.98
66	0.32	0.92	0.00	0.40	0.02	4.39	1.97	4.24	1.14	0.60	0.01	0.03	14.04
67	0.01	0.20	0.20	2.58	1.37	3.19	5.33	2.63	0.45	0.41	0.26	0.23	16.86
68	1.05	0.37	0.33	1.54	2.26	4.13	1.03	3.01	0.15	1.44	0.52	0.00	15.83
69	0.01	1.86	0.55	0.36	3.90	4.07	2.36	3.37	2.49	1.64	0.44	0.07	21.12
70	0.00	0.00	0.52	0.58	0.26	0.73	1.60	1.60	0.42	0.58	0.36	0.00	6.65
71	0.00	0.99	0.00	0.66	0.77	2.34	2.49	2.13	4.03	2.06	2.46	0.47	18.40
72	0.00	0.05	0.20	0.00	2.13	3.08	3.13	1.72	0.31	1.36	1.70	0.19	13.87
73	0.24	0.28	4.37	2.26	1.05	0.73	2.60	0.77	2.53	0.91	0.17	0.50	16.41
74	0.10	0.20	2.50	0.00	3.10	2.03	0.91	7.30	0.62	4.69	0.31	0.44	22.20
75	0.15	1.12	0.19	1.05	2.60	3.53	5.03	0.74	2.04	0.00	1.27	0.00	17.72
76	0.00	0.00	1.31	1.54	0.93	1.01	1.33	3.64	7.64	0.48	0.13	0.00	18.01
77	0.15	0.23	0.35	1.86	5.94	1.38	1.62	6.80	1.12	0.36	0.15	0.08	20.04
78	0.28	0.75	0.19	0.63	4.10	2.88	0.92	2.27	2.90	0.32	0.51	0.09	15.84
79	0.38	0.06	0.98	0.57	4.95	3.97	0.93	3.20	1.50	2.43	0.44	0.14	19.55
80	1.12	0.42	2.67	1.04	4.31	3.15	0.67	1.55	0.43	0.26	0.41	0.66	16.69
81	0.15	0.10	1.98	1.10	2.88	3.12	1.41	4.25	2.70	2.03	1.35	0.06	21.13
82	0.03	0.37	0.58	0.38	2.85	6.20	7.48	0.57	1.51	0.56	0.50	1.05	22.08
83	0.67	1.30	0.78	0.24	2.26	1.57	0.57	0.43	0.26	2.11	0.33	0.05	10.57
84	0.19	0.11	1.34	1.31	0.08	2.04	0.80	4.86	0.80	2.54	1.18	0.98	16.23

LAKE MEREDITH

MONTHLY WATER SURFACE EVAPORATION IN INCHES

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1940	0.80	2.97	5.47	5.97	7.67	8.57	11.27	8.88	8.64	7.07	3.77	2.59	73.65
1941	1.70	2.09	3.27	5.45	5.95	6.92	7.05	7.56	6.65	4.15	3.06	2.66	58.53
1942	1.97	2.56	4.65	5.29	7.82	8.42	9.21	7.55	5.95	4.65	4.76	2.69	65.53
1943	2.28	3.14	4.34	5.91	7.81	8.49	8.31	10.78	7.57	6.32	3.47	2.68	71.10
1944	1.57	2.07	4.51	5.23	7.58	9.26	8.66	8.89	6.90	4.65	3.34	1.36	64.03
1945	1.49	2.42	4.49	4.50	8.45	9.50	8.31	7.68	7.98	4.40	4.20	2.49	65.91
1946	2.90	2.99	4.91	6.41	7.71	9.61	9.92	7.92	5.91	5.51	2.70	2.59	69.06
1947	2.87	3.13	4.01	5.50	6.11	8.93	9.68	8.33	8.93	5.88	3.34	2.05	68.75
1948	1.68	2.01	3.78	6.69	6.99	8.11	9.22	8.49	8.08	5.47	3.98	4.40	68.90
1949	2.90	2.50	4.68	4.52	6.40	7.50	8.43	7.81	6.40	5.50	4.02	2.32	62.97
1950	3.31	2.63	5.00	5.74	7.83	8.54	7.13	7.63	5.74	5.71	3.83	3.20	66.29
1951	1.93	2.81	4.48	5.97	5.88	7.60	11.66	12.47	11.12	8.60	4.24	3.22	79.98
1952	3.19	3.85	4.86	5.85	6.86	11.44	11.35	12.80	11.02	9.74	5.36	3.09	89.42
1953	3.53	3.44	6.63	7.86	9.86	11.28	12.72	9.77	11.72	7.33	4.05	1.33	89.55
1954	2.00	5.00	5.63	6.21	5.39	9.50	12.93	12.30	12.84	8.41	6.10	4.83	91.13
1955	0.82	2.40	5.69	7.89	7.12	8.99	11.69	11.09	10.67	8.79	6.19	4.58	85.94
1956	2.83	1.82	6.54	7.45	9.47	10.47	11.37	12.58	13.59	10.07	9.87	4.63	100.66
1957	3.57	2.94	3.34	4.28	4.78	9.14	13.75	9.37	8.47	5.78	2.94	3.88	71.25
1958	1.57	1.67	1.10	4.01	5.23	10.14	10.86	11.82	9.36	6.89	4.34	2.94	69.93
1959	1.03	2.83	5.15	5.68	7.58	8.98	9.58	11.00	10.60	6.28	3.95	2.12	74.75
1960	0.24	0.51	3.19	6.30	7.62	9.06	7.13	9.48	7.74	6.40	5.35	0.95	63.96
1961	0.85	1.15	3.32	5.09	6.89	7.29	8.73	10.09	9.04	7.72	2.79	1.57	64.52
1962	0.81	3.17	3.97	4.23	7.17	6.57	7.59	8.77	5.61	6.53	3.63	2.03	60.08
1963	0.80	1.68	4.75	6.92	6.52	6.12	9.84	7.01	5.32	5.72	3.54	1.96	60.16
1964	1.52	0.73	2.97	5.67	6.77	7.17	9.87	10.05	7.05	6.13	3.77	2.02	63.70
1965	1.58	2.04	2.34	5.19	6.35	4.77	8.38	7.13	7.53	5.65	4.83	2.71	58.49
1966	1.64	2.20	4.03	4.97	7.24	7.72	10.85	9.36	7.06	8.21	5.65	2.69	71.61
67	3.53	3.46	6.69	7.61	9.59	8.23	8.97	8.14	6.15	7.32	2.69	1.84	74.23
68	1.89	1.87	3.62	8.24	7.34	7.94	6.57	8.11	7.46	6.03	2.63	1.36	63.06
69	2.85	3.08	2.21	6.44	7.31	8.36	9.36	9.74	4.92	3.83	2.65	1.84	62.59
70	1.57	3.39	3.12	6.36	11.05	11.18	12.10	10.59	7.81	4.66	4.15	2.73	78.71
71	2.11	3.29	6.17	8.01	10.11	11.64	10.68	7.75	7.04	5.32	3.77	1.52	77.41
72	2.99	3.30	7.22	9.02	7.69	8.61	7.91	8.55	6.69	4.84	1.48	0.66	68.96
73	1.27	2.07	3.93	5.30	7.88	10.54	9.27	9.93	6.04	5.77	3.46	2.27	67.74
74	1.17	3.97	6.07	8.36	10.69	10.30	11.63	7.98	4.75	4.64	3.03	1.34	74.42
75	1.73	1.16	4.33	6.43	8.88	8.66	7.97	8.86	6.59	6.36	3.13	1.98	66.09
76	2.89	4.68	6.00	6.37	7.28	10.31	8.94	9.50	5.45	4.22	1.97	2.02	69.62
77	2.52	3.47	6.98	5.88	6.99	10.16	11.60	8.08	7.01	5.42	3.70	3.15	74.96
78	1.80	2.52	4.85	8.27	6.78	9.36	11.98	9.87	7.13	5.26	1.86	2.04	71.71
79	2.52	2.63	4.55	5.55	7.12	7.82	9.34	8.23	6.88	7.09	3.05	3.36	68.17
80	1.60	2.29	5.10	6.35	6.79	10.46	12.37	11.29	6.82	6.19	2.53	2.06	73.85
81	1.73	3.76	4.71	7.35	7.17	9.74	9.62	7.27	5.31	3.89	2.47	2.02	65.04
82	3.60	3.33	5.54	7.25	6.23	7.32	8.69	8.00	6.61	5.52	3.41	1.79	67.27
83	1.18	0.83	2.82	5.11	7.03	7.53	10.59	9.35	8.52	4.55	2.78	0.91	61.18
84	1.29	3.12	4.24	6.81	8.98	9.37	10.70	7.84	7.24	3.72	3.17	1.43	67.91

CRMWA SYSTEM. LAKE MEREDITH. TX
MONTHLY DIVERSION IN ACRE-FEET

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
66	0	0	50	79	589	110	60	60	300	0	0	0	1248
67	0	20	320	575	561	556	132	950	0	0	0	0	3114
68	0	0	803	930	2740	3554	4240	3734	4326	3562	3862	4192	31943
69	3694	3576	2354	5243	4458	6068	7128	6997	4332	4594	4699	4486	57629
70	3320	3638	2862	4868	5793	6180	7098	7445	5490	4609	3947	4844	60144
71	5047	3991	4923	5256	6601	6046	6709	5282	6502	4923	4003	3753	63036
72	3326	4001	4837	6253	5196	6512	6376	6714	5623	6440	4688	4659	64625
73	3978	3837	4171	4338	4995	6546	6647	6404	5437	5074	4542	4714	60683
74	3967	4406	5432	6844	7397	8169	8957	6428	5088	4441	4308	4538	69975
75	4393	3742	4866	5274	6754	7137	6449	7298	6559	5867	4758	4184	67279
76	3858	4451	4790	4947	6245	7377	6964	8115	5887	4763	4255	3698	65350
77	3717	4225	5063	4910	5317	7161	8391	6909	6663	6171	4439	5132	68097
78	4913	4683	5648	7077	6232	6446	8284	7010	5579	5426	4365	5110	70773
79	5128	4846	5220	6385	6756	6473	8365	7499	6847	7234	5211	5642	75606
80	4979	5059	6035	6374	6655	8235	9804	9004	7210	6120	5523	5655	80653
81	4778	4483	4985	5943	6845	7816	8803	6727	5935	5371	5219	5700	72605
82	5542	4751	5820	5803	4329	5234	7535	8052	7057	5029	5345	5111	69610
83	4184	4522	5440	5481	6578	6793	9139	9632	7555	4816	3880	5002	73021
84	5364	4900	5585	6197	8009	6675	8975	7433	7716	5330	4684	4361	75729
85	4936	5252	4071	6570	7319	6405	8878	8218	7258	5227	4626	5612	74371

UTE RESERVOIR, NM

END-OF-MONTH STORAGE IN ACRE-FEET

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
63	-	-	-	-	7530	10250	11750	23150	25500	24940	24520	24100
64	24100	24520	24520	23970	24520	23420	22620	23970	32380	31200	30700	30700
65	30370	30050	30530	29410	33600	68790	83050	109200	105500	90510	87260	86550
66	86190	86550	85490	84430	83050	90880	95340	110000	107900	105500	104300	103100
67	102300	101500	100300	98400	103100	109200	109600	109200	109200	100300	96100	95720
68	95340	94970	94590	94210	92720	91240	93470	99560	98020	97250	95720	94970
69	94210	94210	93090	92350	102700	109200	109600	110000	106300	99170	100300	100300
70	100700	100300	99950	103100	101900	99950	101300	97630	97630	96100	94970	94210
71	93090	92720	92350	91980	98020	98400	99170	98020	96480	95720	96480	96100
72	95720	94590	93470	91980	90880	90140	106300	109600	100300	99170	99560	99560
73	99170	99170	99170	100700	99950	99170	102300	99170	98400	97630	94970	93840
74	94590	93910	92910	91430	89560	87220	85420	86300	87690	90950	89560	89200
75	89240	89340	88690	87400	86330	89020	93170	92910	91980	89850	88870	88330
76	87620	87290	85350	84850	83770	83670	89560	88010	91350	89490	88480	87720
77	70750	70590	69270	74360	82850	82010	81070	85460	79580	77930	76540	75360
78	75000	74800	74190	72430	71820	78300	77070	75270	73390	71540	77530	76800
79	78700	78740	76110	75790	81380	82280	84180	91010	89640	87800	83000	82420
80	78970	69550	68870	69600	74390	73070	71030	73360	76940	75530	75040	74550
81	74190	73810	73290	68400	68220	66800	67630	89070	83720	82600	81900	81310
82	80900	80630	79850	78600	82940	91600	93560	85570	71030	62720	45800	41860
83	39720	39100	39480	36900	37080	37920	36420	35170	34560	34720	33530	33610
84	32500	32370	32200	31940	31400	32780	32690	41050	40340	42600	43000	43600

LAKE MEREDITH. TX

END-OF-MONTH STORAGE IN ACRE-FEET

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
65	4320	4920	5550	4970	17738	158090	162752	176350	181898	210088	213546	214761
66	216051	219011	218404	216127	211725	214609	216810	231835	231676	227475	224981	223041
67	222809	222111	220714	228902	226999	259114	312761	320750	322750	320654	319797	320273
68	324775	326613	325549	322370	328161	325742	325259	327871	317224	312855	306849	300714
69	296926	294534	294897	288262	305442	354203	369676	376606	462991	468527	464522	459947
70	457974	454378	450433	469704	461225	450897	438076	445619	438305	430872	424713	417507
71	412676	410056	403204	396109	391527	391315	400731	416842	416842	413004	445391	445391
72	441962	437963	430872	420722	420057	430534	472531	502991	542730	539397	538627	536062
73	513046	510049	515551	523867	516555	504331	499388	490072	477964	467212	458478	451014
74	446852	440886	439745	428446	423094	411223	395127	415154	411876	431139	427550	421763
75	419000	418560	414606	408834	400762	416250	434409	426545	411985	399375	392068	386313
76	380927	374884	368005	362908	357764	347914	337937	332739	364003	358355	352478	348107
77	345115	341276	333767	333861	337177	328035	317754	348688	354724	342808	334428	327101
78	321344	319592	313731	303807	312639	341180	327194	316745	320421	317295	312276	305328
79	300866	296267	291274	284351	278970	284523	274154	282294	278800	267149	264016	258056
80	256356	260415	257570	250494	255629	252493	235908	227818	216208	205375	198542	192803
81	187866	182697	179442	172428	166693	171132	172428	299997	334407	333092	329537	323783
82	317993	314710	309012	300706	299644	328326	384756	422471	427646	437673	444557	448882
83	452660	461673	463186	459931	455075	454154	437673	421157	404961	396184	387850	380046
84	374366	368448	363089	357982	348100	347331	332905	340266	325355	324337	320375	319183

Outputs from Lake Meredith model, HDR (1987)

Note: this worksheet has not been fully proofed, and the possibility exists that additional data manipulations may be performed.

Lake Meredith Operations Model, HDR (1987), Appendix E−2
No Ute diversion, no Conchas spills

1964	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	2066	5024	12262	0.130	1594	497072	2912.80
FEB	3774	4947	12210	−0.050	−609	495908	2912.70
MAR	2166	5411	12143	0.250	3036	489030	2912.14
APR	1879	6493	11997	0.470	5639	478187	2911.24
MAY	2571	6957	11825	0.420	4967	468254	2910.43
JUN	2064	7653	11650	0.440	5126	456967	2909.45
JUL	1892	8889	11416	0.740	8448	440963	2908.02
AUG	3680	8271	11200	0.360	4032	431792	2907.20
SEP	21143	7034	11212	0.260	2915	442437	2908.15
OCT	2053	6029	11217	0.500	5608	432303	2907.25
NOV	2362	5179	11083	0.190	2106	426839	2906.76
DEC	1903	5411	10992	0.100	1099	421695	2906.30

1965	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	380	5024	10891	0.130	1416	415102	2905.71
FEB	754	4947	10780	0.150	1617	408766	2905.14
MAR	765	5411	10668	0.120	1280	402320	2904.52
APR	0	6493	10502	0.400	4201	391114	2903.43
MAY	12842	6957	10429	0.190	1981	394510	2903.76
JUN	88206	7653	11198	−0.320	−3582	478098	2911.24
JUL	32989	8889	12033	0.670	8062	493544	2912.51
AUG	47639	8271	12445	0.350	4356	527942	2915.31
SEP	15481	7034	12729	0.550	7001	528760	2915.38
OCT	4927	6029	12684	0.400	5073	521957	2914.84
NOV	4410	5179	12577	0.400	5031	515537	2914.32
DEC	2815	5411	12480	0.170	2122	510204	2913.88

1966	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	2447	5024	12398	0.110	1364	505652	2913.50
FEB	4099	4947	12338	0.110	1357	502838	2913.27
MAR	2341	5411	12250	0.340	4165	495000	2912.63
APR	1032	6493	12097	0.380	4597	484347	2911.75
MAY	1054	6957	11897	0.600	7138	470722	2910.63
JUN	5406	7653	11734	0.280	3285	464613	2910.13
JUL	8204	8889	11600	0.740	8584	454775	2909.26
AUG	41259	8271	11747	0.430	5051	482135	2911.57
SEP	4052	7034	11895	0.490	5829	472739	2910.80
OCT	1144	6029	11711	0.630	7378	459901	2909.72
NOV	1517	5179	11521	0.470	5415	450259	2908.85
DEC	115	5411	11366	0.220	2501	441905	2908.11

1967	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	2372	5024	11239	0.290	3259	435444	2907.53
FEB	1755	4947	11126	0.270	3004	428704	2906.92
MAR	3426	5411	10995	0.540	5937	420244	2906.17
APR	12362	6493	10929	0.420	4590	420989	2906.23
MAY	4379	6957	10844	0.690	7483	410399	2905.29
JUN	32507	7653	10923	0.420	4588	430132	2907.05
JUL	45848	8889	11376	0.300	3413	463121	2910.00
AUG	16632	8271	11679	0.460	5372	465536	2910.20
SEP	13579	7034	11701	0.480	5617	465890	2910.23
OCT	0	6029	11592	0.580	6723	452568	2909.06
NOV	0	5179	11409	0.200	2282	444549	2908.34
DEC	2182	5411	11295	0.130	1468	439298	2907.87

Lake Meredith Operations Model, HDR (1987), Appendix E–2
No Ute diversion, no Conchas spills

1968	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	5600	5024	11243	0.070	787	438537	2907.80
FEB	3473	4947	11207	0.130	1457	435057	2907.49
MAR	2813	5411	11124	0.270	3003	428912	2906.94
APR	3546	6493	10989	0.560	6154	419274	2906.08
MAY	13038	6957	10914	0.420	4584	420238	2906.17
JUN	4632	7653	10862	0.320	3476	413211	2905.54
JUL	8635	8889	10753	0.460	4946	407486	2905.03
AUG	10878	8271	10682	0.420	4486	405086	2904.79
SEP	0	7034	10528	0.610	6422	391116	2903.43
OCT	3183	6029	10329	0.380	3925	383842	2902.71
NOV	0	5179	10190	0.180	1834	376333	2901.98
DEC	0	5411	10054	0.110	1106	369326	2901.29

1969	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	1931	5024	9932	0.240	2384	363366	2900.71
FEB	2517	4947	9840	0.100	984	359473	2911.33
MAR	4383	5411	9776	0.140	1369	356601	2900.05
APR	3615	6493	9682	0.510	4938	348315	2899.17
MAY	24650	6957	9731	0.280	2725	362810	2900.65
JUN	29797	7653	10035	0.360	3613	380854	2902.42
JUL	43526	8889	10468	0.580	6071	408909	2905.15
AUG	35522	8271	10908	0.530	5781	429846	2907.03
SEP	68665	7034	11592	0.200	2318	488590	2912.10
OCT	26619	6029	12226	0.180	2201	506377	2913.56
NOV	2863	5179	12330	0.180	2219	501234	2913.14
DEC	4313	5411	12259	0.150	1839	497693	2912.85

1970	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	1205	5024	12180	0.130	1583	491691	2912.35
FEB	3919	4947	12089	0.280	3385	486683	2911.94
MAR	1759	5411	11991	0.220	2638	479804	2911.38
APR	30103	6493	12076	0.480	5797	497023	2912.79
MAY	8232	6957	12134	0.900	10920	486781	2911.95
JUN	6508	7653	11919	0.870	10396	474653	2910.95
JUL	2070	8889	11703	0.880	10299	456960	2909.45
AUG	18330	8271	11560	0.750	8670	457782	2909.53
SEP	5025	7034	11484	0.620	7120	448090	2908.66
OCT	1029	6029	11320	0.340	3849	438686	2907.82
NOV	1843	5179	11175	0.320	3576	431227	2907.15
DEC	676	5411	11044	0.230	2540	423413	2906.45

1971	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	2659	5024	10935	0.180	1968	418545	2906.02
FEB	3974	4947	10863	0.190	2064	414977	2905.70
MAR	4157	5411	10770	0.510	5492	407705	2905.04
APR	5242	6493	10631	0.610	6485	399451	2904.24
MAY	10808	6957	10508	0.780	8196	394594	2903.77
JUN	12066	7653	10423	0.780	8130	390370	2903.35
JUL	16927	8889	10387	0.680	7063	390838	2903.40
AUG	20344	8271	10454	0.470	4913	397488	2904.05
SEP	9778	7034	10513	0.250	2628	397091	2904.01
OCT	4580	6029	10464	0.270	2825	392306	2903.54
NOV	38137	5179	10711	0.110	1178	423564	2906.46
DEC	5292	5411	10965	0.090	987	421922	2906.32

Lake Meredith Operations Model, HDR (1987), Appendix E−2
No Ute diversion, no Conchas spills

1972	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	3279	5024	10908	0.250	2727	416917	2905.87
FEB	3614	4947	10824	0.270	2923	412133	2905.44
MAR	4876	5411	10720	0.590	6325	404750	2904.76
APR	5009	6493	10560	0.750	7920	394831	2903.79
MAY	10176	6957	10447	0.460	4806	392736	2903.58
JUN	22646	7653	10518	0.460	4838	402378	2904.53
JUL	36948	8889	10815	0.400	4326	425583	2906.65
AUG	34465	8271	11180	0.570	6372	444858	2908.37
SEP	30576	7034	11490	0.530	6090	461746	2909.88
OCT	6067	6029	11602	0.290	3364	457850	2909.53
NOV	4301	5179	11558	−0.020	−230	456636	2909.42
DEC	3211	5411	11520	0.040	461	453410	2909.14

1973	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	4791	5024	11476	0.090	1033	451582	2908.97
FEB	3312	4947	11427	0.150	1714	447672	2908.62
MAR	9831	5411	11431	−0.040	−456	451983	2909.01
APR	19989	6493	11554	0.250	2888	462030	2909.91
MAY	35142	6957	11813	0.570	6733	282901	2911.63
JUN	5100	7653	11879	0.820	9741	470024	2910.57
JUL	17616	8889	11785	0.560	6600	471572	2910.70
AUG	4661	8271	11690	0.760	8885	458503	2909.59
SEP	0	7034	11486	0.290	3331	447575	2908.61
OCT	0	6029	11296	0.410	4631	436362	2907.61
NOV	0	5179	11124	0.270	3004	427635	2906.83
DEC	0	5411	10984	0.150	1648	420040	2906.15

1974	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	0	5024	10863	0.090	978	413507	2905.56
FEB	133	4947	10732	0.310	3327	404843	2904.77
MAR	8193	5411	10646	0.300	3194	403912	2904.68
APR	3862	6493	10538	0.700	7377	393390	2903.65
MAY	9549	6957	10398	0.630	6551	388325	2903.21
JUN	4769	7653	10254	0.730	7485	378057	2902.15
JUL	2865	8889	10007	0.890	8906	362639	2900.64
AUG	27578	8271	10034	0.060	602	380856	2902.42
SEP	6055	7034	10158	0.340	3454	375928	2901.94
OCT	24193	6029	10278	0.000	0	393591	2903.67
NOV	3440	5179	10400	0.230	2392	388954	2903.21
DEC	113	5411	10294	0.080	824	382331	2902.56

1975	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	3601	5024	10202	0.130	1326	379084	2902.25
FEB	3870	4947	10156	0.000	0	377513	2902.09
MAR	5187	5411	10102	0.350	3536	373262	2901.68
APR	4857	6493	10000	0.450	4500	366639	2901.03
MAY	4774	6957	9865	0.520	5130	358847	2900.27
JUN	27729	7653	9935	0.430	4272	374168	2901.77
JUL	27842	8889	10229	0.240	2455	390167	2903.33
AUG	7483	8271	10301	0.680	7005	381873	2902.52
SEP	0	7034	10117	0.380	3844	370502	2901.41
OCT	0	6029	9900	0.530	5247	358744	2900.26
NOV	0	5179	9724	0.160	1556	351536	2899.51
DEC	0	5411	9603	0.170	1634	344026	2898.71

Lake Meredith Operations Model, HDR (1987), Appendix E–2
No Ute diversion, no Conchas spills

1976	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	0	5024	9489	0.240	2277	336266	2897.88
FEB	621	4947	9363	0.390	3651	327839	2896.98
MAR	2316	5411	9241	0.390	3604	320698	2896.22
APR	4321	6493	9136	0.400	3654	314435	2895.55
MAY	6772	6957	9045	0.530	4794	309026	2894.97
JUN	5503	7653	8921	0.780	6959	299495	2893.87
JUL	3491	8889	8745	0.630	5509	288176	2892.56
AUG	7965	8271	8607	0.490	4217	283248	2891.99
SEP	35862	7034	8819	−0.180	−1587	313247	2895.42
OCT	2657	6029	9017	0.310	2795	306651	2894.70
NOV	342	5179	8906	0.150	1336	300056	2893.93
DEC	1418	5411	8800	0.170	1496	294152	2893.25

1977	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	3082	5024	8715	0.200	1743	290056	2892.77
FEB	3421	4947	8644	0.270	2334	285790	2892.28
MAR	3227	5411	8546	0.550	4701	278505	2891.44
APR	8600	6493	8475	0.340	2881	277334	2891.30
MAY	9910	6957	8480	0.090	763	279128	2891.51
JUN	5323	7653	8420	0.730	6147	270258	2890.48
JUL	2985	8889	8230	0.830	6831	257141	2888.87
AUG	26134	8271	8262	0.110	909	273712	2890.88
SEP	11563	7034	8404	0.490	4118	273731	2890.88
OCT	0	6029	8320	0.420	3494	263820	2889.71
NOV	0	5179	8158	0.300	2447	255816	2888.70
DEC	0	5411	8011	0.260	2083	247953	2888.70

1978	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	0	5024	7878	0.130	1024	241542	2886.89
FEB	4226	4947	7798	0.150	1170	239294	2886.61
MAR	3510	5411	7728	0.390	3014	234026	2885.94
APR	3307	6493	7602	0.640	4865	225628	2884.87
MAY	17497	6957	7603	0.220	1673	234149	2885.96
JUN	40442	7653	7943	0.540	4289	262284	2889.52
JUL	3407	8889	8081	0.920	7434	248994	2887.84
AUG	2828	8271	7857	0.630	4950	238240	2886.48
SEP	12916	7034	7784	0.350	2724	241041	2886.83
OCT	6505	6029	7781	0.410	3190	237970	2886.44
NOV	801	5179	7701	0.110	847	232393	2885.74
DEC	51	5411	7585	0.160	1214	225474	2884.85

1979	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	2674	5024	7478	0.180	1346	221437	2884.28
FEB	2590	4947	7392	0.220	1626	217119	2883.68
MAR	3239	5411	7300	0.300	2190	212427	2883.03
APR	3453	6493	7187	0.420	3019	206044	2882.14
MAY	3318	6957	7068	0.180	1272	200815	2881.41
JUN	15164	7653	7065	0.320	2261	205748	2882.10
JUL	1307	8889	6985	0.700	4889	192963	2880.31
AUG	15448	8271	6895	0.420	2896	196935	2880.87
SEP	5739	7034	6887	0.450	3099	192232	2880.21
OCT	0	6029	6756	0.390	2635	183267	2878.86
NOV	0	5179	6619	0.220	1456	176340	2877.80
DEC	2255	5411	6513	0.270	1759	171140	2877.00

Lake Meredith Operations Model, HDR (1987), Appendix E−2
No Ute diversion, no Conchas spills

1980	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	1028	5024	6429	0.040	257	166607	2876.30
FEB	751	4947	6342	0.160	1015	161122	2875.46
MAR	5011	5411	6278	0.200	1256	159197	2875.17
APR	3230	6493	6204	0.440	2730	152939	2874.13
MAY	13820	6957	6195	0.210	1301	158236	2875.02
JUN	10373	7653	6232	0.610	3802	156888	2874.80
JUL	1248	8889	6088	0.970	5906	143082	2872.48
AUG	7460	8271	5902	0.810	4781	137244	2871.50
SEP	0	7034	5749	0.530	3047	126925	2869.74
OCT	0	6029	5538	0.490	2714	117956	2868.07
NOV	0	5179	5356	0.180	964	111595	2866.88
DEC	360	5411	5211	0.120	625	105709	2865.78

1981	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	1040	5024	5083	0.130	661	100860	2864.86
FEB	1659	4947	4957	0.300	1487	95888	2863.80
MAR	3533	5411	4847	0.230	1115	92703	2863.13
APR	0	6493	4681	0.520	2434	83591	2861.20
MAY	3079	6957	4482	0.360	1613	77924	2860.00
JUN	16080	7653	4483	0.550	2466	83710	2861.23
JUL	14575	8889	4593	0.680	3124	86092	2861.73
AUG	92331	8271	5654	0.250	1413	168506	2876.60
SEP	18353	7034	6506	0.220	1431	178109	2878.07
OCT	5962	6029	6577	0.160	1052	176701	2877.85
NOV	2985	5179	6538	0.090	588	173632	2877.38
DEC	1905	5411	6470	0.160	1035	168808	2876.64

1982	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	2923	5024	6391	0.300	1917	164513	2875.98
FEB	4150	4947	6330	0.250	1583	161859	2875.58
MAR	4290	5411	6273	0.410	2572	157897	2874.97
APR	3031	6493	6170	0.570	3517	150655	2873.75
MAY	6178	6957	6075	0.280	1701	147917	2873.29
JUN	46547	7653	6395	0.090	576	185959	2879.27
JUL	71699	8889	7342	0.100	734	247702	2887.67
AUG	18325	8271	7977	0.620	4946	252442	2888.27
SEP	8519	7034	8000	0.430	3440	250119	2887.98
OCT	13158	6029	8010	0.410	3284	253594	2888.42
NOV	0	5179	7973	0.240	1914	246134	2887.47
DEC	5524	5411	7897	0.060	474	245410	2887.38

1983	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	3520	5024	7870	0.040	315	243230	2887.11
FEB	10697	4947	7903	−0.040	−315	248932	2887.83
MAR	8805	5411	7972	0.170	1355	250604	2888.04
APR	4945	6493	7939	0.410	3255	245436	2887.39
MAY	6883	6957	7858	0.400	3143	241858	2886.93
JUN	8962	7653	7797	0.500	3899	238911	2886.56
JUL	2433	8889	7648	0.830	6348	225758	2884.89
AUG	1890	8271	7400	0.740	5476	213565	2883.19
SEP	0	7034	7150	0.690	4933	201275	2881.47
OCT	0	6029	945	0.200	1389	193546	2880.39
NOV	0	5179	6797	0.200	1359	186703	2879.39
DEC	0	5411	6685	0.070	468	180528	2878.44

Lake Meredith Operations Model, HDR (1987), Appendix E–2
No Ute diversion, no Conchas spills

1984	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
JAN	0	5024	6580	0.090	592	174622	2877.53
FEB	0	4947	6469	0.250	1617	167776	2876.48
MAR	1325	5411	6359	0.240	1526	161889	2875.58
APR	6068	6493	6277	0.460	2887	158306	2875.03
MAY	5782	6957	6189	0.740	4580	152287	2874.02
JUN	12238	7653	6138	0.610	3744	152867	2874.12
JUL	2832	8889	6036	0.830	5010	141545	2872.22
AUG	17590	8271	6000	0.250	1500	149111	2873.49
SEP	0	7034	5972	0.540	3225	138601	2871.73
OCT	3948	6029	5845	0.100	584	135692	2871.24
NOV	2689	5179	5782	0.170	983	131979	2870.61
DEC	3951	5411	5728	0.040	229	130053	2870.29

Year	INFLOW	DIVERSIONS	ACRES	EVAP (FT)	EVAP (AF)	EOM (AF)	EOM ELEV.
1964	47553	77298	11600.58	3.81	43961	456787.25	2909.37
1965	211208	77298	11618.00	3.21	38558	465654.50	2910.00
1966	72670	77298	11879.50	4.8	56664	473740.50	2910.85
1967	135042	77298	11259.00	4.78	53736	439739.50	2907.91
1968	55798	77298	10739.58	3.93	42180	407368.17	2904.94
1969	248401	77298	10731.58	3.45	36442	417005.67	2906.51
1970	80699	77298	11722.92	6.02	70773	421882.00	2907.04
1971	133964	77298	10635.33	4.92	51929	389202.64	2642.37
1972	165168	77298	11011.83	4.59	49922	392462.80	2616.61
1973	100442	77298	11495.42	4.28	49752	435656.58	2909.02
1974	90750	77298	10383.50	4.36	45090	388861.08	2903.21
1975	85343	77298	10011.17	4.04	40505	368863.42	2901.24
1976	71268	77298	9007.42	4.3	38705	307774.08	2894.78
1977	74245	77298	8388.75	4.59	38451	271103.67	2890.63
1978	95490	77298	7778.42	4.65	36394	238419.58	2886.50
1979	55187	77298	7012.08	4.07	28448	198038.92	2880.97
1980	43281	77298	5960.33	4.76	28398	141458.33	2872.11
1981	161502	77298	5405.92	3.65	18419	123877.00	2868.54
1982	184344	77298	7069.42	3.76	26658	205350.08	2881.67
1983	48135	77298	6997.00	4.21	31625	222528.83	2884.30
1984	56423	77298	6114.58	4.32	26477	149560.67	2873.53
AVERAGE	105567.29	77298.00	9372.49	4.31	40623.19	329301.68	2869.62

Tab 29: Water quality, Ute Reservoir
Site B (07226560)

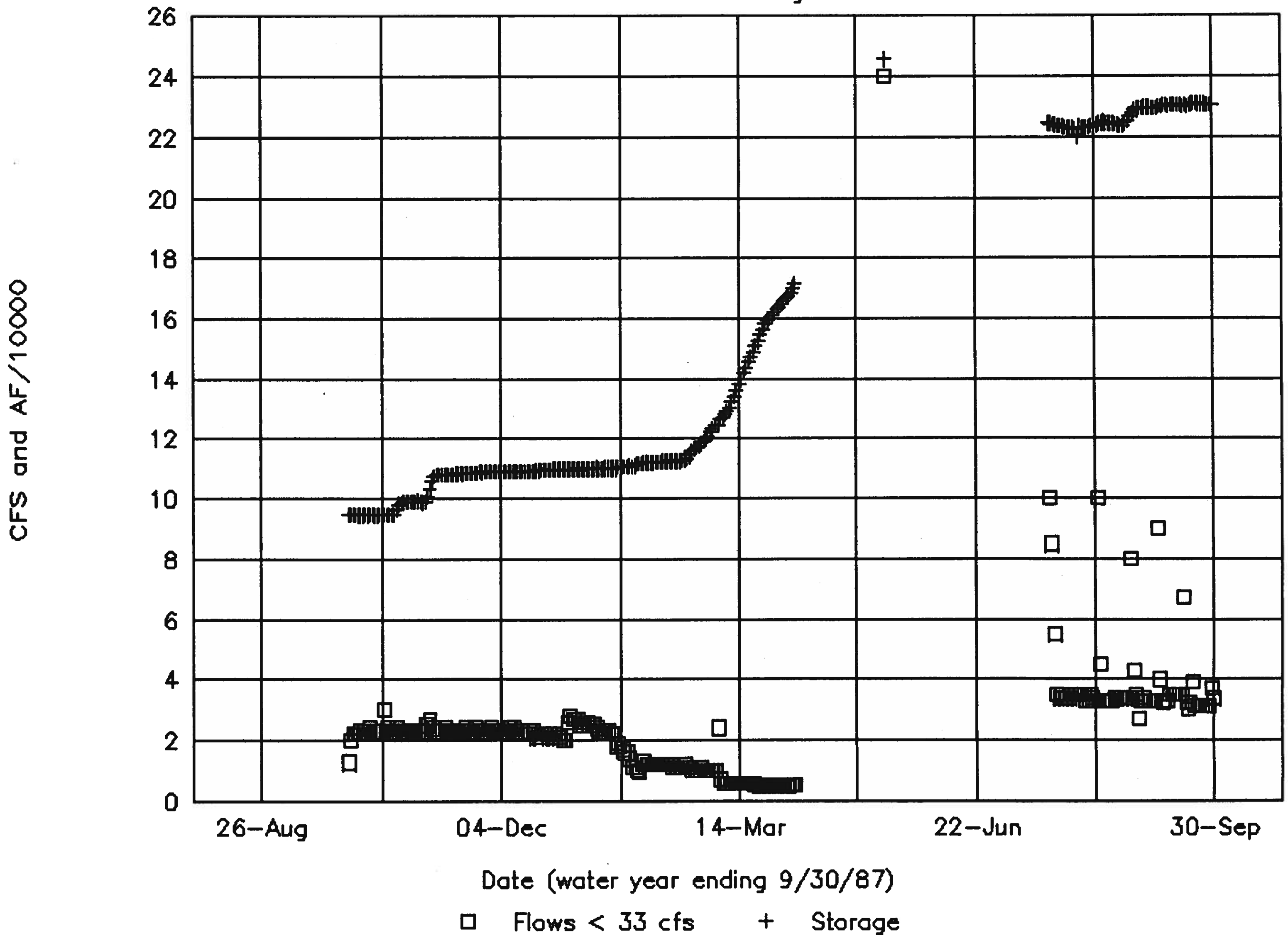
Date	Chloride Dissolved mg/l	Sulfate Dissolved mg/l	Solids Residue @ 180 C mg/l	Solids Sum mg/l	Specific Conductance us/cm	Reservoir Storage Acre–feet
681014	30	150	---	464	767	97630
690104	32	170	---	502	789	94970
690419	33	178	---	499	823	92720
690711	24	126	---	392	620	112100
691103	10	87	---	304	495	101100
700707	21	118	---	379	604	99560
710118	39	130	---	420	671	93470
710408	28	140	---	441	728	92350
710712	19	150	---	426	696	98400
711005	26	150	468	439	712	96100
720111	26	150	478	442	712	95720
720410	29	170	478	489	793	92720
720707	27	160	---	458	748	89780
730102	23	140	---	394	623	99560
730421	24	130	---	388	663	100700
740405	33	180	520	512	835	92420
740906	40	190	572	549	910	85730
750325	40	210	612	585	950	88870
750826	41	230	622	596	850	93200
760324	56	220	653	629	1150	87080
760928	47	250	667	665	1000	90950
770419	42	250	662	673	945	72680
770817	46	230	625	647	923	81690
780426	38	180	550	558	890	72620
780822	45	180	565	556	910	75620
790510	42	230	578	---	940	75270
790815	38	220	549	595	915	84210
800417	37	190	550	494	860	68370
800813	41	180	565	555	800	70020
810514	46	190	---	579	901	67660
820519	28	140	---	431	760	77770
830817	53	180	---	---	920	35820
840816	71	230	---	---	1080	35470
850822	65	230	---	---	1030	51900
860807	60	210	---	---	970	85700
870827	34	220	---	---	850	227900
880908	33	240	---	---	960	233300
890817	36	250	---	---	980	235350
900614	44	260	---	---	930	216540
average	37.1	185.6			838.5	99052
THRU 73	26.1	143.3			696.3	97125
74–82	41.3	204.4			908.7	80260
SINCE 82	49.5	227.5			965.0	140248

TDS PREDICTION AS FUNCTION OF CONDUCTANCE
0.626 WORKS REASONABLY WELL

STORAGE INCREASES DO LOWER SPEC. COND
OVERALL DECLINE IN STORAGE NOT STRONG AND CAN'T EXPLAIN
SALT INCREASE CLEARLY OCCURS

Baseflow and Storage, Canadian River

Ute Reservoir and Logan



Simple accounting model to assess
stream survey data compiled by HGC (1984)

HGC (1984) contains three separate stream surveys which measure various salinity parameters in the Canadian River below Ute Dam (see **TAB 10**). Their text discussion of the surveys (p. 81) suggests that there may be zones where inflow is concentrated; apparently this is based on spikes (high concentrations) in specific conductance or other parameters.

Ignoring these spikes, our inspection of the data suggests that overall there are two salinity patterns:

- salinity (total dissolved solids) increases about 1800 mg/l per mile in the first four miles below Ute Dam (from about 1800 to 9000 mg/l, a gain of 1800 mg/l per mile);

- salinity (total dissolved solids) increases about 1500 mg/l per mile in the next two miles below Ute Dam (from about 9000 to 12000 mg/l).

By mile 7, dilution effects are observed. Note that chloride distributions show patterns very similar to the above, with actual concentration values being roughly half total dissolved solids.

The overall pattern arguable could reflect a nearly constant brine inflow for the entire 6 mile reach. In particular, the relatively rapid salinization of the river below Ute Dam should not be interpreted as demonstrating a localized inflow. To explain and quantify this point, we developed a simple baseflow model for the Canadian River which included the following assumptions:

- seepage from Ute Reservoir is constant at 1.7 cfs and contains 800 mg/l chloride;

- ground water inflow in the Logan area is constant at 0.25 cfs per mile and has a chloride concentration of 12000 mg/l.

Model outputs for the initial reach of the river are:

mile	inflow cfs	total flow cfs	chloride inflow mg/l	net chloride mg/l
0.1	1.7	1.7	800	800
0.2	0.025	1.725	12000	962
0.3	0.025	1.750	12000	1120
0.4	0.025	1.775	12000	1273

Streamflows, chloride concentrations and loads (kg/sec) predicted by the model at specific mile distances are:

mile	total flow cfs	net chloride mg/l	net chloride kg/sec
1	1.925	2109	0.114
2	2.175	3246	0.199
3	2.425	4148	0.284
6	3.150	5956	0.531

A graph on the next page reflect these inputs, and a graph which compares the chloride concentrations predicted by the model with those observed in the HGC stream surveys. (The "actual" values in the graph are a composite of the surveys, and exclude extremely high values and those associated with pools rather than streamflow.)

The values used for the model inputs were selected after several trials, in order to produce the good fit with the data shown in the graph. While estimates of all values are higher than in the Project reports, the differences are not unreasonable for the purposes of this study. Note: the model is intended to illustrate a relationship, and should not be interpreted as an explanation of the real world, especially since it does not pertain to conditions existing since Ute Dam was raised.

What is demonstrated by the graph is that a constant salt input over distance does not result in a linear increase in salinity over distance; and an decreasing rate of salinity increase over distance does not require a decreasing rate of salt input over distance. Rather, if salt input is constant as one goes downstream, and the streamflow becomes more and more saline, the difference between the salt content in the stream and the inflow becomes less. Consequently, the rate at which salinity increases also becomes less.

In addition to the good agreement shown on the plot, the results can be compared to the 16-month monitoring program conducted by USBR (1984).

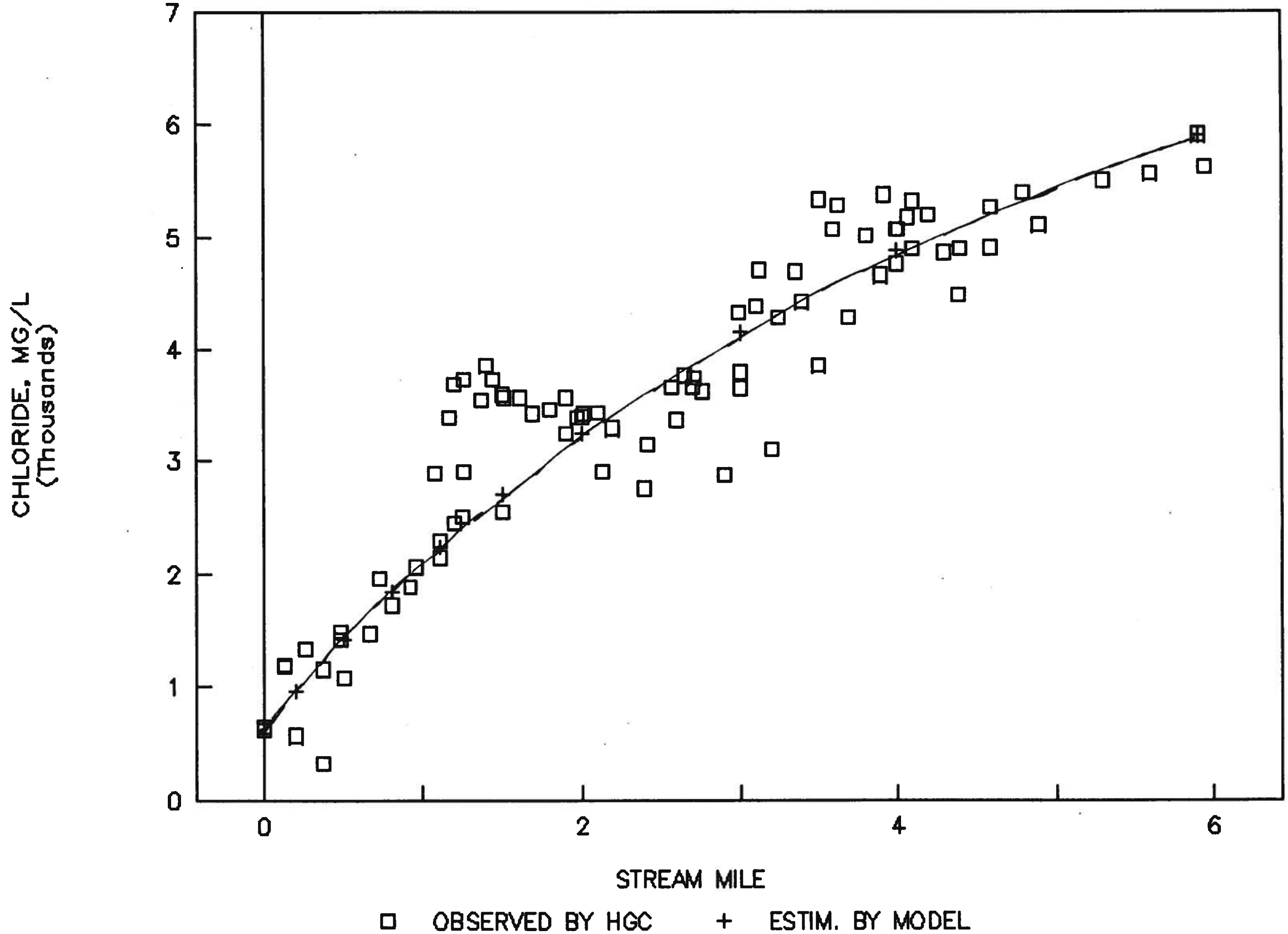
Location	Measured flow	Model flow	Measured chloride	Model chloride
Mile 1.6	2.01 cfs	2.08 cfs	2957 mg/l	2824 mg/l
Mile 5.4	3.03 cfs	3.03 cfs	5780 mg/l	5706 mg/l

Although the above agreement is excellent, it should be noted that both the measured flows and the measured chlorides are biased by two data points when there may have been Ute spills, so that flows were higher than baseflow and chlorides were somewhat diluted.

While the model supports a continuous inflow of brine in the Logan area, the only way to know what actually occurs is to do a stream survey in which both flow and salt data are collected. The CRMWA survey in February 1992 obtained both types of data and is discussed in Section 4.3 of the main notebook. The survey results imply conditions which differ substantially from the model given above.

CANADIAN RIVER, NEAR LOGAN

CHLORIDE INCREASES



Contents of Tab 32

DATA FROM STATELINE GAGE

Date	Mean Daily Discharge Canadian River at Logan CFS	Revuelto Creek near Logan CFS	Q CFS	Cl mg/l	SO4 mg/l	Cl kg/s	SO4 kg/s	COMMENTS
09/25/69	323.0	16.0	310.0	102.0	108.0	0.89	0.95	
10/21/69	3.1	31.0	37.7	1380.0	408.0	1.47	0.44	
11/12/69	3.1	7.8	19.5	1880.0	440.0	1.04	0.24	
01/06/70	4.1	2.0	17.4	2380.0	464.0	1.17	0.23	
02/24/70	3.6	1.7	10.6	2370.0	445.0	0.71	0.13	
03/23/70	3.4	2.3	9.7	2480.0	486.0	0.68	0.13	
04/29/70	3.1	15.0	25.0	1610.0	470.0	1.14	0.33	
05/12/70	2.4	16.0	16.8	1750.0	546.0	0.83	0.26	
06/10/70	2.3	11.0	13.6	1420.0	500.0	0.55	0.19	
07/15/70	1.7	20.0	48.0	188.0	170.0	0.26	0.23	RECEDING
08/06/70	314.0	9.2	334.0	87.0	142.0	0.82	1.34	
09/03/70	3.8	56.0	128.0	1160.0	394.0	4.20	1.43	REV = 116 PREV DAY
10/07/70	5.2	9.6	19.7	1530.0	412.0	0.85	0.23	
11/05/70	2.6	5.4	16.1	1800.0	434.0	0.82	0.20	
12/07/70	3.1	1.7	10.2	2140.0	436.0	0.62	0.13	
01/11/71	2.4	2.5	25.4	2000.0	400.0	1.44	0.29	
02/01/71	2.9	2.6	11.0	2200.0	440.0	0.68	0.14	
03/01/71	2.4	6.7	17.0	1000.0	480.0	0.48	0.23	SLIGHT RECEDING
04/13/71	2.3	15.0	16.0	2100.0	780.0	0.95	0.35	
05/10/71	2.4	17.0	27.0	1000.0	540.0	0.76	0.41	
06/14/71	2.3	29.0	23.0	3800.0	600.0	2.47	0.39	RECEDING
06/24/71	174.0	42.0	133.0	270.0	210.0	1.02	0.79	RISING
07/15/71	3.6	6.3	13.2	1000.0	300.0	0.37	0.11	
08/09/71	332.0	241.0	678.0	51.0	100.0	0.98	1.92	REV = 855 PREV DAY
08/24/71	327.0	49.0	316.0	67.0	170.0	0.60	1.52	
08/31/71	142.0	14.0	218.0	72.0	180.0	0.44	1.11	RECEDING
10/12/71	2.6	13.0	18.0	1800.0	460.0	0.92	0.23	
11/08/71	2.4	4.0	14.0	1700.0	430.0	0.67	0.17	
12/13/71	2.3	5.4	20.0	1800.0	460.0	1.02	0.26	
01/17/72	2.4	2.8	15.0	1900.0	410.0	0.81	0.17	
02/14/72	2.4	2.3	9.9	2100.0	480.0	0.59	0.13	
03/13/72	2.4	0.1	7.8	2200.0	420.0	0.49	0.09	
04/10/72	2.4	0.0	4.3	2100.0	450.0	0.26	0.05	
05/08/72	2.1	10.0	10.0	1700.0	520.0	0.48	0.15	
07/17/72	4.8	438.0	18.0	670.0	300.0	0.34	0.15	REV = 3.8 PREV DAY
08/21/72	3.4	21.0	28.0	1200.0	410.0	0.95	0.32	RISING
09/11/72	853.0	114.0	1000.0	36.0	120.0	1.02	3.40	RECEDING
10/10/72	3.4	14.0	31.0	1600.0	450.0	1.40	0.39	
11/13/72	2.6	7.4	20.0	1800.0	470.0	1.02	0.27	
12/11/72	2.4	6.0	17.0	2300.0	480.0	1.11	0.23	
01/08/73	2.0	2.0	9.2	1800.0	590.0	0.47	0.15	
02/20/73	2.4	3.7	14.0	2200.0	530.0	0.87	0.21	
04/08/73	2.1	17.0	47.0	720.0	320.0	0.96	0.43	RECEDING, 3 DAY LAG
04/30/73	2.3	0.0	15.0	2000.0	560.0	0.85	0.24	RECEDING, 3 DAY LAG
05/21/73	2.4	31.0	58.0	1100.0	530.0	1.81	0.87	
06/11/73	2.6	9.5	6.2	1400.0	570.0	0.25	0.10	RECEDING
11/08/74	73.0	14.0	22.0	1300.0	410.0	0.81	0.26	RISING
12/05/74	2.3	6.0	15.0	2000.0	500.0	0.85	0.21	
01/16/75	2.2	7.0	15.0	2300.0	480.0	0.98	0.20	
02/25/75	2.4	85.0	17.0	2000.0	440.0	0.96	0.21	RISING
03/24/75	1.8	0.0	6.3	2300.0	450.0	0.41	0.08	
04/24/75	2.2	0.0	5.6	2200.0	410.0	0.35	0.06	
05/20/75	2.0	3.7	5.0	1900.0	610.0	0.27	0.09	
06/24/75	2.0	12.0	50.0	130.0	46.0	0.18	0.07	
07/22/75	3.5	1430.0	321.0	220.0	150.0	2.00	1.36	RISING
10/21/75	1.8	0.0	5.2	2200.0	410.0	0.32	0.06	
11/12/75	1.8	0.0	5.5	2500.0	450.0	0.39	0.07	
12/09/75	1.4	0.0	8.5	2500.0	390.0	0.60	0.09	
01/14/76	2.4	0.0	7.2	3000.0	570.0	0.61	0.12	
02/09/76	3.2	0.3	12.0	2500.0	430.0	0.85	0.15	
03/24/76	1.8	0.0	5.1	2600.0	440.0	0.38	0.06	
04/21/76	2.2	0.0	4.9	3100.0	520.0	0.43	0.07	
05/13/76	2.0	0.0	3.0	2500.0	440.0	0.21	0.04	
06/09/76	1.8	18.0	94.0	210.0	140.0	0.56	0.37	Rev = 175 prev day
09/29/76	2.5	46.0	112.0	240.0	76.0	0.76	0.24	Rev = 210 prev day
10/20/76	2.2	0.0	6.3	2500.0	400.0	0.45	0.07	
11/17/76	1.8	0.1	9.7	2900.0	520.0	0.80	0.14	
12/15/76	2.6	0.3	5.9	2700.0	440.0	0.45	0.07	
01/19/77	1.8	0.4	11.0	2900.0	500.0	0.90	0.16	
02/16/77	2.2	0.1	7.6	2800.0	440.0	0.60	0.09	
03/16/77	2.0	0.0	5.9	2700.0	450.0	0.45	0.08	
04/20/77	2.9	261.0	227.0	230.0	130.0	1.48	0.84	Rev = 669 prev day
05/25/77	2.0	0.0	9.8	1100.0	330.0	0.31	0.09	
07/20/77	2.6	0.0	3.4	680.0	340.0	0.07	0.03	
08/18/77	305.0	1770.0	3000.0	66.0	100.0	5.60	8.49	WET WEEK, BUT NOT THIS HIGH
09/28/77	2.2	0.0	7.7	1500.0	340.0	0.33	0.07	
10/26/77	1.8	0.0	5.9	2000.0	400.0	0.33	0.07	
11/23/77	1.8	0.0	5.8	2300.0	400.0	0.38	0.07	
12/14/77	1.8	0.0	7.6	2500.0	460.0	0.54	0.10	
02/01/78	2.2	0.1	12.0	2900.0	440.0	0.98	0.15	
02/22/78	2.4	5.1	12.0	2900.0	470.0	0.98	0.16	
03/29/78	2.9	0.4	10.0	2700.0	45.0	0.76	0.01	
04/27/78	2.6	0.0	2.2	2000.0	390.0	0.12	0.02	

Mean Daily Discharge

DATA FROM STATELINE GAGE

Date	Canadian River at Logan CFS	Revuelto Creek near Logan CFS	Q CFS	Cl mg/l	SO4 mg/l	Cl kg/s	SO4 kg/s	COMMENTS
05/24/78	2.2	0.0	1.6	1800.0	350.0	0.08	0.02	
06/21/78	1.8	0.0	3.8	2100.0	360.0	0.23	0.04	
07/19/78	1.8	0.0	16.1	550.0	85.0	0.25	0.04	3+ DAY LAG
09/26/78	2.2	41.0	38.3	290.0	58.0	0.31	0.06	REV = 0 PREV DAY
11/01/78	1.7	1.1	5.2	3200.0	47.0	0.47	0.01	
11/29/78	1.4	0.0	11.0	1800.0	350.0	0.56	0.11	
12/20/78	2.2	0.0	9.1	3100.0	500.0	0.80	0.13	
01/31/79	2.0	0.5	8.3	2000.0	480.0	0.47	0.11	
02/28/79	2.1	0.1	8.2	2900.0	480.0	0.67	0.11	
04/11/79	2.3	0.2	9.4	2700.0	440.0	0.72	0.12	
05/09/79	1.8	0.0	2.5	3200.0	520.0	0.23	0.04	
06/13/79	2.0	0.2	21.3	900.0	240.0	0.54	0.14	SEV DAY LAG
07/11/79	1.9	0.9	12.5	380.0	170.0	0.13	0.06	RECEDING
08/15/79	6.2	36.0	20.0	1500.0	320.0	0.85	0.18	RISING
09/20/79	1.6	24.0	23.5	1200.0	360.0	0.80	0.24	
10/18/79	2.0	6.5	9.5	2000.0	410.0	0.54	0.11	
11/16/79	3.1	1.1	22.3	1600.0	380.0	1.01	0.24	SEV DAY LAG
12/19/79	2.7	0.0	9.8	2500.0	410.0	0.69	0.11	
01/10/80	86.0	0.0	14.0	2500.0	440.0	0.99	0.17	FIRST DAY OF RELEASE
02/21/80	216.0	1.8	281.0	190.0	140.0	1.51	1.11	LOGAN = 300 PREV DAY
03/19/80	3.7	0.0	6.4	2500.0	420.0	0.45	0.08	
04/17/80	1.9	1.4	8.7	2500.0	430.0	0.62	0.11	
11/20/80	1.7	4.0	18.1	2500.0	370.0	1.28	0.19	RECEDING
12/18/80	2.0	1.0	8.7	2700.0	480.0	0.66	0.12	
01/13/81	2.5	1.3	12.0	2700.0	440.0	0.92	0.15	
02/19/81	2.1	0.6	2.0	3000.0	480.0	0.17	0.03	
03/19/81	2.0	0.0	11.0	1900.0	380.0	0.59	0.12	
05/14/81	2.0	0.0	3.7	2200.0	470.0	0.23	0.05	
06/03/81	1.9	103.0	34.0	650.0	230.0	0.63	0.22	REV MUCH WETTER PREV DAYS
07/15/81	5.2	0.6	114.0	120.0	38.0	0.39	0.12	SEV DAY LAG
09/16/81	261.0	5.0	294.0	150.0	110.0	1.25	0.92	LOGAN = 400 PREV DAY
11/18/81	2.2	1.3	11.0	2800.0	440.0	0.87	0.14	
01/20/82	2.1	0.7	10.0	2900.0	500.0	0.82	0.14	
03/23/82	2.2	0.2	6.4	2800.0	93.0	0.51	0.02	
05/18/82	2.1	0.0	2.2	2700.0	450.0	0.17	0.03	
08/11/82	363.0	9.7	498.0	64.0	100.0	0.90	1.41	LOGAN = 682 PREV DAY
10/05/82	280.0	40.0	326.0	100.0	100.0	0.92	0.92	FOUR DAY LAG REVUELTO
12/08/82	259.0	1.7	206.0	150.0	110.0	0.87	0.64	
08/09/83	1.6	23.0	38.0	1700.0	470.0	1.83	0.51	REV = 95 PREV DAY
10/18/83	1.8	21.0	18.0	970.0	440.0	0.49	0.22	RISING
03/13/84	2.1	0.1	6.6	2700.0	460.0	0.50	0.09	
04/24/84	1.7	10.0	12.0	2200.0	390.0	0.75	0.13	
07/18/84	1.8	100.0	133.0	220.0	110.0	0.83	0.41	REV = 250 PREV DAY
08/29/84	1.6	9.8	40.0	760.0	240.0	0.86	0.27	SEV DAY LAG
11/14/84	1.6	4.3	14.0	2000.0	500.0	0.79	0.20	
01/29/85	1.8	3.9	16.0	2200.0	280.0	1.00	0.13	
03/05/85	1.4	0.8	9.0	2600.0	590.0	0.66	0.15	
09/11/85	3.4	23.0	10.0	1100.0	410.0	0.31	0.12	RISING
12/12/85	1.9	0.3	1.5	2600.0	400.0	0.11	0.02	
03/12/86	2.2	1.5	8.6	2700.0	530.0	0.66	0.13	
11/12/86	2.3	10.0	212.0	10.0	320.0	0.06	1.92	
averages	34.3	40.9	78.6	1728.7	375.3	0.77	0.37	
			3.5 =GAIN					
81-86	44.9	13.8	75.9	1629.4	338.3	0.67	0.34	
74-80	13.2	62.0	76.0	1962.1	363.9	0.69	0.30	

Explanation of model printouts

See text for discussion of the model which generated these printouts.

DATA BASE

The data base is provided in TAB 32. It consists of 135 data sets, each with same-day data for flow at Logan, flow at Revuelto, flow at State Line, chloride at State Line and sulfate at State Line.

STRATIFICATION OF DATA

It was hypothesized that chloride loading would vary depending on whether the stream system was experiencing runoff flow or base flow. Flow conditions in the system divided by reach. Reach 1 is the Logan area, i.e. Ute Dam to Revuelto Creek. Reach 2 is downstream, Revuelto to State Line.

For Logan, there are 15 dates on which flow was 73 cfs or larger; on all other dates the flow was a few cfs (maximum 6.2 cfs). It was assumed that Ute Reservoir was spilling on the 15 high-flow dates; all other dates where classified as baseflow.

For downtream, runoff was considered to be occurring in Revuelto Creek (and, possibly, other streams) if the flow at the Revuelto gage exceeded 40 cfs in summer months (May-September) or 10 cfs in winter months. Runoff from other tributaries (termed "local runoff" on the printouts) was considered to occur on dates when: flow at the State Line was tens of cfs higher than the sum of flows at Logan and Revuelto; or the quality of water at the State Line was unusually fresh, indicating a pulse of fresh runoff. Periods of no Revuelto or local runoff were characterized as "summer Dunes baseflow" or "winter Dunes baseflow", depending on the time of year. The term "Dunes" is explained in the text. Note that during times when both Logan and the downstream reach are experiencing baseflow, discharge at the State Line typically is 10 cfs or less and rarely exceeds 20 cfs.

COLUMNS

Note: the following explanations of columns apply to the basic data sets. The columns on the printout summary have a somewhat different content, described subsequently.

Column A contains labels, either related to the calculation sheet as a whole (e.g. a title, or the word "average"); or it contains a date on which flow data were collected by USGS at all three gaging stations of interest: Logan, Revuelto and State Line, and there are stateline chloride and sulfate data.

Column B gives flow at the Logan gage, as measured by USGS, in cfs.

Column C gives flow at the Revuelto gage, as measured by USGS, in cfs.

Column D gives flow at the State Line gage, as measured by USGS, in cfs.

Column E is the gain in flow at the State Line gage, compared to flow upstream at Logan and Revuelto. Values in columns B and C are added together, and the sum is subtracted from Column D to get the value in Column E.

Column F gives the concentration of chloride at the State Line gage, as measured by USGS, in mg/l. Similar printouts (not provided in this tab) provide data from the sulfate model, but the summary of the sulfate model is included.

Column G converts the chloride calculation into a loading, in kilograms per second. Flow (column D) is multiplied by concentration (column F) and then multiplied by 28.3 (liters in a cubic foot) and by 1,000,000 (milligrams in a kilogram).

Column H gives the chloride loading as calculated by the model, in kilograms per second. It is the sum of values from columns J through M.

Column I is the difference between the measured and calculated chloride loadings. Column H is subtracted from Column G. The model is not considered "correct" unless all inputs are physically reasonable and the value of Column I on the summary printout is very close to zero.

Column J gives the calculated loading for chloride contained in Ute Reservoir spills. For dates on which Ute spills are assumed to have occurred, the spill flow rate is assumed to equal the gaged flow at Logan, minus 2 cfs of baseflow. For all other dates, the value in this column is set to zero. As shown on the summary printout, the chloride content of spilled water was estimated at 40 mg/l. [Sulfate concentrations were estimated at 140 mg/l.]

Column K gives the calculated loading for chloride contained in baseflow which originates in the Logan area. For dates on which Ute spills are assumed to have occurred, the baseflow flow rate is assumed to equal 3 cfs, the value typically measured by USBR in the gravel pit reach. For all other dates, the baseflow flow rate is assumed to equal the gaged flow at Logan plus an additional 1 cfs inflow downstream (e.g. in the gravel pit reach). As shown on the summary printout, the chloride content of baseflow was estimated at 5500 mg/l. [Sulfate concentrations were estimated at 750 mg/l.]

Column L gives the calculated loading for chloride contained in flow from Revuelto Creek. For dates on which flows in Revuelto are assumed to have involved significant runoff, the estimated chloride loading is based on the gaged flow and a chloride content of 60 mg/l. [For this situation, sulfate concentrations were estimated at 100 mg/l.] For dates on which flows in Revuelto are assumed to have involved primarily baseflow, the estimated chloride loading is based on the gaged flow and a chloride content of 400 mg/l. [For this situation, sulfate concentrations were estimated at 500 mg/l.]

Column M gives the calculated loading for chloride contained in baseflow which reaches the Canadian River between the Logan and State Line gages. For dates on which Revuelto flows involve runoff, or there is local runoff, the baseflow quantity is assumed to be 5 cfs; at other dates, the baseflow quantity equals the difference between gaged flows at State Line and the sum of gaged flows at Revuelto and Logan, minus 1 cfs which is accounted for as baseflow in the Logan area, but downstream of the Logan gage. In all cases, chloride concentrations were estimated as 850 mg/l raised to the 1.15 power (see discussion in text). [Sulfate concentrations were estimated at 140 mg/l.]

<u>SUMMARY PRINTOUT</u>

Row 1 of the printout contains the number of data sets in the model, 135.

Row 2 of the printout contains the sum of values contained in the given column of the model. For example, the chloride load on the 135 dates totaled 103.7 kilograms per second.

Row 3 gives the average of the values contained in the given column of the model; the value in row 2 is divided by the value in row 1.

Row 4 gives the percent of the load contributed by Ute spills, Logan baseflow, Revuelto flows and Dunes baseflow.

Rows 5 & 6 contain input assumptions as to salt concentration and loading relationships. Actual values used in the most recent model runs are discussed in the text.

A	B	C	D	E	F	G	H	I	J	K	L	M
Ute spill plus Revuelto runoff												
Date	Logan CFS	Revuelto CFS	Stateline CFS	Gain CFS	Cl mg/l	kg/s	model, net	gap	ute spills	logan baseflow	revuelto flows	dunes baseflow
06/24/71	174.0	42.0	133.0	−83.0	270.0	1.02	0.83	−0.19	0.19	0.47	0.07	0.10
08/09/71	332.0	241.0	678.0	105.0	51.0	0.98	1.35	0.37	0.37	0.47	0.41	0.10
08/24/71	327.0	49.0	316.0	−60.0	67.0	0.60	1.01	0.42	0.37	0.47	0.08	0.10
09/11/72	853.0	114.0	1000.0	33.0	36.0	1.02	1.72	0.70	0.96	0.47	0.19	0.10
08/18/77	305.0	1770.0	3000.0	925.0	66.0	5.60	3.91	−1.69	0.34	0.47	3.01	0.10
10/05/82	280.0	40.0	326.0	6.0	100.0	0.92	0.95	0.02	0.31	0.47	0.07	0.10
average	378.5	376.0	908.8	154.3	98.3	1.69	1.63	−0.06	0.43	0.47	0.64	0.10
Ute spill plus summer Dunes baseflow												
Date	Logan CFS	Revuelto CFS	Stateline CFS	Gain CFS	Cl mg/l	kg/s	model, net	gap	ute spills	logan baseflow	revuelto flows	dunes baseflow
09/25/69	323.0	16.0	310.0	−29.0	102.0	0.89	1.11	0.21	0.36	0.47	0.18	0.10
08/06/70	314.0	9.2	334.0	10.8	87.0	0.82	1.02	0.20	0.35	0.47	0.10	0.10
08/31/71	142.0	14.0	218.0	62.0	72.0	0.44	0.88	0.44	0.16	0.47	0.16	0.10
02/21/80	216.0	1.8	281.0	63.2	190.0	1.51	0.83	−0.69	0.24	0.47	0.02	0.10
09/16/81	261.0	5.0	294.0	28.0	150.0	1.25	0.91	−0.34	0.29	0.47	0.06	0.10
08/11/82	363.0	9.7	498.0	125.3	64.0	0.90	1.08	0.18	0.41	0.47	0.11	0.10
average	269.8	9.3	322.5	43.4	110.8	0.97	0.97	0.00	0.30	0.47	0.11	0.10
Ute spill plus winter Dunes baseflow												
Date	Logan CFS	Revuelto CFS	Stateline CFS	Gain CFS	Cl mg/l	kg/s	model, net	gap	ute spills	logan baseflow	revuelto flows	dunes baseflow
11/06/74	73.0	14.0	22.0	−65.0	1300.0	0.81	0.80	−0.01	0.08	0.47	0.16	0.10
01/10/80	86.0	0.0	14.0	−72.0	2500.0	0.99	0.66	−0.33	0.10	0.47	0.00	0.10
12/08/82	259.0	1.7	206.0	−54.7	150.0	0.87	0.87	−0.00	0.29	0.47	0.02	0.10
average	139.3	5.2	80.7	−63.9	1316.7	0.89	0.78	−0.11	0.16	0.47	0.06	0.10
Logan baseflow plus Revuelto runoff												
Date	Logan CFS	Revuelto CFS	Stateline CFS	Gain CFS	Cl mg/l	kg/s	model, net	gap	ute spills	logan baseflow	revuelto flows	dunes baseflow
10/10/72	3.4	14.0	31.0	13.6	1600.0	1.40	0.80	−0.60	0.0	0.68	0.02	0.10
05/21/73	2.4	31.0	58.0	24.6	1100.0	1.81	0.68	−1.13	0.0	0.53	0.05	0.10
02/25/75	2.4	85.0	17.0	−70.4	2000.0	0.96	0.77	−0.19	0.0	0.53	0.14	0.10
07/22/75	3.5	1430.0	321.0	−1112.5	220.0	2.00	3.22	1.23	0.0	0.70	2.43	0.10
09/29/76	2.5	46.0	112.0	63.5	240.0	0.76	0.72	−0.04	0.0	0.54	0.08	0.10
04/20/77	2.9	261.0	227.0	−36.9	230.0	1.48	1.15	−0.33	0.0	0.61	0.44	0.10
09/26/78	2.2	41.0	38.3	−4.9	290.0	0.31	0.66	0.35	0.0	0.50	0.07	0.10
08/15/79	6.2	36.0	20.0	−22.2	1500.0	0.85	1.28	0.43	0.0	1.12	0.06	0.10
09/20/79	1.6	24.0	23.5	−2.1	1200.0	0.80	0.54	−0.26	0.0	0.40	0.04	0.10
08/03/81	1.9	103.0	34.0	−70.9	650.0	0.63	0.72	0.10	0.0	0.45	0.17	0.10
10/21/69	3.1	31.0	37.7	3.6	1380.0	1.47	0.79	−0.69	0.0	0.64	0.05	0.10
09/03/70	3.8	56.0	128.0	68.2	1160.0	4.20	0.94	−3.26	0.0	0.75	0.10	0.10
06/14/71	2.3	29.0	23.0	−8.3	3800.0	2.47	0.66	−1.81	0.0	0.51	0.05	0.10
07/17/72	4.8	438.0	18.0	−424.8	670.0	0.34	1.74	1.40	0.0	0.90	0.74	0.10
08/21/72	3.4	21.0	28.0	3.6	1200.0	0.95	0.82	−0.13	0.0	0.68	0.04	0.10
10/12/71	2.6	13.0	18.0	2.4	1800.0	0.92	0.68	−0.24	0.0	0.56	0.02	0.10
10/18/83	1.8	21.0	18.0	−4.8	970.0	0.49	0.57	0.07	0.0	0.44	0.04	0.10
08/09/83	1.6	23.0	38.0	13.4	1700.0	1.83	0.54	−1.29	0.0	0.40	0.04	0.10
04/24/84	1.7	10.0	12.0	0.3	2200.0	0.75	0.53	−0.21	0.0	0.42	0.02	0.10
09/11/85	3.4	23.0	10.0	−16.4	1100.0	0.31	0.82	0.51	0.0	0.68	0.04	0.10
average	2.9	136.8	60.6	−79.1	1250.5	1.24	0.93	−0.30	0.00	0.60	0.23	0.10

Logan baseflow plus Dunes winter baseflow

A	B	C	D	E	F	G	H	I	J	K	L	M
Date	Logan CFS	Revuelto CFS	Stateline CFS	Gain CFS	Cl mg/l	kg/s	model, net	gap	use spills	logan baseflow	revuelto flows	dunes baseflow
11/12/69	3.1	7.8	19.5	8.6	1880.0	1.04	1.03	−0.01	0.0	0.84	0.09	0.30
01/06/70	4.1	2.0	17.4	11.3	2380.0	1.17	1.30	0.13	0.0	0.79	0.02	0.48
02/24/70	3.6	1.7	10.6	5.3	2370.0	0.71	0.82	0.11	0.0	0.72	0.02	0.08
03/23/70	3.4	2.3	9.7	4.0	2480.0	0.68	0.71	0.03	0.0	0.68	0.03	−0.00
10/07/70	5.2	9.6	19.7	4.9	1530.0	0.85	1.13	0.28	0.0	0.97	0.11	0.06
11/05/70	2.6	5.4	16.1	8.1	1800.0	0.82	0.89	0.07	0.0	0.56	0.06	0.27
12/07/70	3.1	1.7	10.2	5.4	2140.0	0.62	0.75	0.13	0.0	0.64	0.02	0.09
01/11/71	2.4	2.5	25.4	20.5	2000.0	1.44	1.65	0.21	0.0	0.53	0.03	1.09
02/01/71	2.9	2.6	11.0	5.5	2200.0	0.68	0.73	0.05	0.0	0.61	0.03	0.10
03/01/71	2.4	6.7	17.0	7.9	1000.0	0.48	0.86	0.38	0.0	0.53	0.08	0.26
11/08/71	2.4	4.0	14.0	7.6	1700.0	0.67	0.81	0.14	0.0	0.53	0.05	0.24
12/13/71	2.3	5.4	20.0	12.3	1800.0	1.02	1.12	0.10	0.0	0.51	0.06	0.55
01/17/72	2.4	2.8	15.0	9.8	1900.0	0.81	0.94	0.14	0.0	0.53	0.03	0.38
02/14/72	2.4	2.3	9.9	5.2	2100.0	0.59	0.63	0.04	0.0	0.53	0.03	0.06
03/13/72	2.4	0.1	7.8	5.3	2200.0	0.49	0.61	0.13	0.0	0.53	0.00	0.08
11/13/72	2.6	7.4	20.0	10.0	1600.0	1.02	1.04	0.02	0.0	0.56	0.08	0.40
12/11/72	2.4	6.0	17.0	8.6	2300.0	1.11	0.90	−0.21	0.0	0.53	0.07	0.30
01/08/73	2.0	2.0	9.2	5.2	1800.0	0.47	0.57	0.10	0.0	0.47	0.02	0.08
02/20/73	2.4	3.7	14.0	7.9	2200.0	0.87	0.83	−0.04	0.0	0.53	0.04	0.26
12/05/74	2.3	6.0	15.0	6.7	2000.0	0.85	0.76	−0.09	0.0	0.51	0.07	0.18
01/16/75	2.2	7.0	15.0	5.8	2300.0	0.98	0.69	−0.28	0.0	0.50	0.08	0.12
03/24/75	1.8	0.0	6.3	4.5	2300.0	0.41	0.47	0.06	0.0	0.44	0.00	0.03
10/21/75	1.8	0.0	5.2	3.4	2200.0	0.32	0.39	0.07	0.0	0.44	0.00	−0.04
11/12/75	1.8	0.0	5.5	3.7	2500.0	0.39	0.41	0.03	0.0	0.44	0.00	−0.02
12/09/75	1.4	0.0	8.5	7.1	2500.0	0.60	0.58	−0.02	0.0	0.37	0.00	0.20
01/14/76	2.4	0.0	7.2	4.8	3000.0	0.61	0.58	−0.03	0.0	0.53	0.00	0.05
02/09/76	3.2	0.3	12.0	8.5	2500.0	0.85	0.95	0.10	0.0	0.65	0.00	0.30
03/24/76	1.8	0.0	5.1	3.3	2600.0	0.38	0.39	0.01	0.0	0.44	0.00	−0.05
10/20/76	2.2	0.0	6.3	4.1	2500.0	0.45	0.50	0.06	0.0	0.50	0.00	0.01
11/17/76	1.8	0.1	9.7	7.8	2900.0	0.80	0.69	−0.11	0.0	0.44	0.00	0.25
12/15/76	2.6	0.3	5.9	3.0	2700.0	0.45	0.49	0.04	0.0	0.56	0.00	−0.07
01/19/77	1.8	0.4	11.0	8.8	2900.0	0.90	0.76	−0.15	0.0	0.44	0.00	0.32
02/16/77	2.2	0.1	7.6	5.3	2800.0	0.60	0.58	−0.02	0.0	0.50	0.00	0.09
03/16/77	2.0	0.0	5.9	3.9	2700.0	0.45	0.46	0.01	0.0	0.47	0.00	−0.01
10/26/77	1.8	0.0	5.9	4.1	2000.0	0.33	0.44	0.10	0.0	0.44	0.00	0.00
11/23/77	1.8	0.0	5.8	4.0	2300.0	0.38	0.43	0.06	0.0	0.44	0.00	−0.00
12/14/77	1.8	0.0	7.6	5.8	2500.0	0.54	0.55	0.02	0.0	0.44	0.00	0.12
02/01/78	2.2	0.1	12.0	9.7	2900.0	0.98	0.87	−0.11	0.0	0.50	0.00	0.38
02/22/78	2.4	5.1	12.0	4.5	2900.0	0.98	0.62	−0.37	0.0	0.53	0.06	0.03
03/29/78	2.9	0.4	10.0	6.7	2700.0	0.76	0.79	0.03	0.0	0.61	0.00	0.18
11/01/78	1.7	1.1	5.2	2.4	3200.0	0.47	0.33	−0.15	0.0	0.42	0.01	−0.11
11/29/78	1.4	0.0	11.0	9.6	1600.0	0.56	0.74	0.18	0.0	0.37	0.00	0.37
12/20/78	2.2	0.0	9.1	6.9	3100.0	0.80	0.69	−0.11	0.0	0.50	0.00	0.19
01/31/79	2.0	0.5	8.3	5.8	2000.0	0.47	0.59	0.12	0.0	0.47	0.01	0.12
02/28/79	2.1	0.1	8.2	6.0	2900.0	0.67	0.62	−0.06	0.0	0.48	0.00	0.13
11/16/79	3.1	1.1	22.3	18.1	1600.0	1.01	1.58	0.57	0.0	0.64	0.01	0.93
12/19/79	2.7	0.0	9.8	7.1	2500.0	0.69	0.78	0.09	0.0	0.58	0.00	0.20
03/19/80	3.7	0.0	6.4	2.7	2500.0	0.45	0.64	0.19	0.0	0.73	0.00	−0.09
11/20/80	1.7	4.0	18.1	12.4	2500.0	1.28	1.02	−0.26	0.0	0.42	0.05	0.55
12/18/80	2.0	1.0	8.7	5.7	2700.0	0.66	0.59	−0.06	0.0	0.47	0.01	0.11
01/13/81	2.5	1.3	12.0	8.2	2700.0	0.92	0.84	−0.08	0.0	0.54	0.01	0.28
02/19/81	2.1	0.6	2.0	−0.7	3000.0	0.17	0.18	0.01	0.0	0.48	0.01	−0.31
03/19/81	2.0	0.0	11.0	9.0	1900.0	0.59	0.79	0.20	0.0	0.47	0.00	0.33
11/18/81	2.2	1.3	11.0	7.5	2600.0	0.87	0.74	−0.13	0.0	0.50	0.01	0.23
01/20/82	2.1	0.7	10.0	7.2	2900.0	0.82	0.70	−0.12	0.0	0.48	0.01	0.21
03/23/82	2.2	0.2	6.4	4.1	2800.0	0.51	0.50	−0.01	0.0	0.50	0.00	0.00
03/13/84	2.1	0.1	6.6	4.4	2700.0	0.50	0.51	0.00	0.0	0.48	0.00	0.02
11/14/84	1.6	4.3	14.0	8.1	2000.0	0.79	0.72	−0.07	0.0	0.40	0.05	0.27
01/29/85	1.8	3.9	16.0	10.3	2200.0	1.00	0.90	−0.10	0.0	0.44	0.04	0.42
03/05/85	1.4	0.8	9.0	6.8	2600.0	0.66	0.56	−0.10	0.0	0.37	0.01	0.18
12/12/85	1.9	0.3	1.5	−0.7	2600.0	0.11	0.14	0.03	0.0	0.45	0.00	−0.31
03/12/86	2.2	1.5	8.6	4.9	2700.0	0.66	0.57	−0.08	0.0	0.50	0.02	0.06
average	2.3	1.9	10.9	6.7	2370.6	0.70	0.72	0.02	0.00	0.52	0.02	0.18
81−86	2.0	1.3	9.0	5.7	2575.0	0.63	0.60	−0.04	0.00	0.47	0.01	0.11
74−86	2.1	1.0	9.2	6.1	2544.2	0.64	0.63	−0.01	0.00	0.48	0.01	0.14

Logan baseflow plus summer Dunes baseflow

A Date	B Logan CFS	C Revuelto CFS	D Stateline CFS	E Gain CFS	F Cl mg/l	G kg/s	H model, net	I gap	J ute spills	K logan baseflow	L revuelto flows	M dunes baseflow
04/29/70	3.1	15.0	25.0	6.9	1610.0	1.14	1.10	−0.04	0.0	0.64	0.17	0.29
05/12/70	2.4	16.0	16.8	−1.6	1750.0	0.83	0.44	−0.39	0.0	0.53	0.18	−0.27
06/10/70	2.3	11.0	13.6	0.3	1420.0	0.55	0.49	−0.05	0.0	0.51	0.12	−0.15
04/13/71	2.3	15.0	16.0	−1.3	2100.0	0.95	0.43	−0.52	0.0	0.51	0.17	−0.25
05/10/71	2.4	17.0	27.0	7.6	1000.0	0.76	1.06	0.29	0.0	0.53	0.19	0.34
07/15/71	3.6	6.3	13.2	3.3	1000.0	0.37	0.84	0.47	0.0	0.72	0.07	0.05
04/10/72	2.4	0.0	4.3	1.9	2100.0	0.26	0.49	0.23	0.0	0.53	0.00	−0.04
05/08/72	2.1	10.0	10.0	−2.1	1700.0	0.48	0.29	−0.19	0.0	0.48	0.11	−0.31
04/30/73	2.3	0.0	15.0	12.7	2000.0	0.85	1.19	0.34	0.0	0.51	0.00	0.67
06/11/73	2.6	9.5	6.2	−5.9	1400.0	0.25	0.11	−0.13	0.0	0.56	0.11	−0.56
04/24/75	2.2	0.0	5.6	3.4	2200.0	0.35	0.56	0.21	0.0	0.50	0.00	0.06
05/20/75	2.0	3.7	5.0	−0.7	1900.0	0.27	0.30	0.03	0.0	0.47	0.04	−0.21
04/21/76	2.2	0.0	4.9	2.7	3100.0	0.43	0.51	0.08	0.0	0.50	0.00	0.01
05/13/76	2.0	0.0	3.0	1.0	2500.0	0.21	0.37	0.15	0.0	0.47	0.00	−0.10
05/25/77	2.0	0.0	9.8	7.8	1100.0	0.31	0.82	0.51	0.0	0.47	0.00	0.35
07/20/77	2.6	0.0	3.4	0.8	680.0	0.07	0.45	0.38	0.0	0.56	0.00	−0.11
09/28/77	2.2	0.0	7.7	5.5	1500.0	0.33	0.70	0.37	0.0	0.50	0.00	0.20
04/27/78	2.6	0.0	2.2	−0.4	2000.0	0.12	0.37	0.24	0.0	0.56	0.00	−0.19
05/24/78	2.2	0.0	1.6	−0.6	1600.0	0.08	0.29	0.21	0.0	0.50	0.00	−0.21
06/21/78	1.8	0.0	3.8	2.0	2100.0	0.23	0.40	0.18	0.0	0.44	0.00	−0.03
04/11/79	2.3	0.2	9.4	6.9	2700.0	0.72	0.81	0.09	0.0	0.51	0.00	0.29
05/09/79	1.8	0.0	2.5	0.7	3200.0	0.23	0.32	0.09	0.0	0.44	0.00	−0.12
07/11/79	1.9	0.9	12.5	9.7	360.0	0.13	0.94	0.80	0.0	0.45	0.01	0.47
10/18/79	2.0	6.5	9.5	1.0	2000.0	0.54	0.44	−0.10	0.0	0.47	0.07	−0.10
04/17/80	1.9	1.4	8.7	5.4	2500.0	0.62	0.66	0.04	0.0	0.45	0.02	0.19
05/14/81	2.0	0.0	3.7	1.7	2200.0	0.23	0.41	0.18	0.0	0.47	0.00	−0.05
05/18/82	2.1	0.0	2.2	0.1	2700.0	0.17	0.32	0.15	0.0	0.48	0.00	−0.16
04/24/84	1.7	10.0	12.0	0.3	2200.0	0.75	0.39	−0.36	0.0	0.42	0.11	−0.15
average	2.3	4.4	9.1	2.5	1887.1	0.44	0.55	0.12	0.00	0.51	0.05	−0.00
74−88	2.1	1.3	6.0	2.6	2042.2	0.32	0.50	0.18	0.00	0.48	0.01	0.01

Logan baseflow plus local runoff

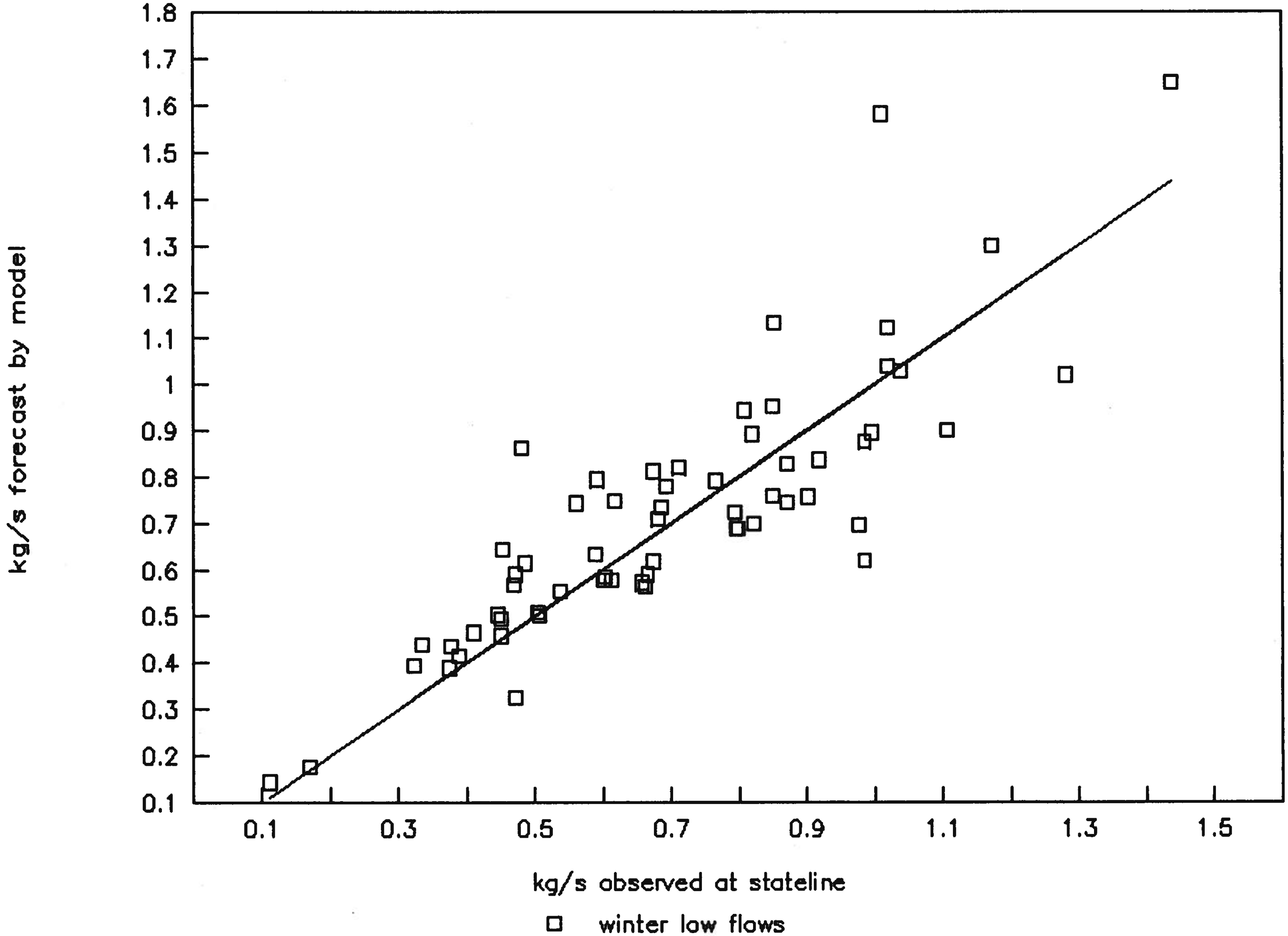
Date	Logan CFS	Revuelto CFS	Stateline CFS	Gain CFS	Cl mg/l	kg/s	model, net	gap	ute spills	logan baseflow	revuelto flows	dunes baseflow
11/12/86	2.3	10.0	212.0	199.7	10.0	0.06	0.72	0.66	0.0	0.51	0.11	0.10
06/24/75	2.0	12.0	50.0	36.0	130.0	0.18	0.70	0.52	0.0	0.47	0.14	0.10
07/15/81	5.2	0.6	114.0	108.2	120.0	0.39	1.07	0.68	0.0	0.97	0.01	0.10
08/29/84	1.6	9.8	40.0	28.6	760.0	0.86	0.61	−0.25	0.0	0.40	0.11	0.10
07/18/84	1.8	100.0	133.0	31.2	220.0	0.83	0.70	−0.13	0.0	0.44	0.17	0.10
07/19/78	1.8	0.0	16.1	14.3	550.0	0.25	0.53	0.28	0.0	0.44	0.00	0.10
06/09/76	1.8	18.0	94.0	74.2	210.0	0.56	0.74	0.18	0.0	0.44	0.20	0.10
07/15/70	1.7	20.0	48.0	26.3	188.0	0.26	0.74	0.49	0.0	0.42	0.23	0.10
04/06/73	2.1	17.0	47.0	27.9	720.0	0.96	0.77	−0.19	0.0	0.48	0.19	0.10
06/13/79	2.0	0.2	21.3	19.2	900.0	0.54	0.56	0.02	0.0	0.47	0.00	0.10
average	2.2	18.8	77.5	56.6	380.8	0.49	0.72	0.23	0.00	0.50	0.12	0.10

A	B	C	D	E	F	G	H	I	J	K	L	M	N
SUMMARY CHLORIDE	Logan CFS	Revuelto CFS	Stateline CFS	Gain CFS	Cl mg/l	kg/s	model, net	gap	ute spills	logan baseflow	revuelto flows	dunes baseflow	
1	135	135	135	135	135	135	135	135	135	135	135	135	
2	4595.8	5492.2	10550.7	462.7	233843.0	103.7	103.7	−0.0	4.8	70.5	13.2	15.2	
3	34.043	40.683	78.153	3.427	1732	0.768	0.768	−0.00	0.04	0.52	0.10	0.11	
4									4.67%	67.99%	12.71%	14.63%	100.00%
5											60.0	1.15	
6									40.0	5500.0	400.0	850.0	
Ute+Revuelto	378.5	376.0	908.8	154.3	98.3	1.69	1.63	−0.06	0.43	0.47	0.64	0.10	
Ute+Dunes sum	269.8	9.3	322.5	43.4	110.8	0.97	0.97	0.00	0.30	0.47	0.11	0.10	
Ute+Dunes wint	139.3	5.2	80.7	−63.9	1316.7	0.89	0.78	−0.11	0.16	0.47	0.08	0.10	
Logan+Revuelto	2.9	136.8	60.6	−79.1	1250.5	1.24	0.93	−0.30	0.00	0.60	0.23	0.10	
Logan+Dunes wir	2.3	1.9	10.9	6.7	2370.6	0.70	0.72	0.02	0.00	0.52	0.02	0.18	
Logan+Dunes su	2.3	4.4	9.1	2.5	1887.1	0.44	0.55	0.12	0.00	0.51	0.05	−0.00	
Ute+localQ	2.2	18.8	77.5	56.6	380.8	0.49	0.72	0.23	0.00	0.50	0.12	0.10	
					One kg/sec =		34792.3	tons/year					

SUMMARY SULFATE		SO4 mg/l	kg/s	model, net	gap	ute spills	logan baseflow	revuelto flows	dunes baseflow	
1			135	135	135	135	135	135	135	
2			48.6	48.7	0.0	18.1	9.6	18.3	2.6	
3			0.360	0.361	0.00	0.13	0.07	0.14	0.02	
4						37.24%	19.74%	37.63%	5.39%	100.00%
5								80.0		
6						150.0	750.0	600.0	150.0	
Ute+Revuelto		133.3	2.84	2.53	−0.31	1.60	0.06	0.85	0.02	
Ute+Dunes sum		130.0	1.14	1.38	0.24	1.14	0.06	0.16	0.02	
Ute+Dunes wint		320.0	0.36	0.76	0.40	0.58	0.06	0.09	0.02	
Logan+Revuelto		351.3	0.43	0.41	−0.01	0.00	0.08	0.31	0.02	
Logan+Dunes wint		432.3	0.13	0.13	−0.01	0.00	0.07	0.03	0.02	
Logan+Dunes sum		450.2	0.12	0.15	0.03	0.00	0.07	0.07	0.01	
Ute+localQ		152.4	0.42	0.26	−0.08	−0.00	0.07	0.17	0.02	

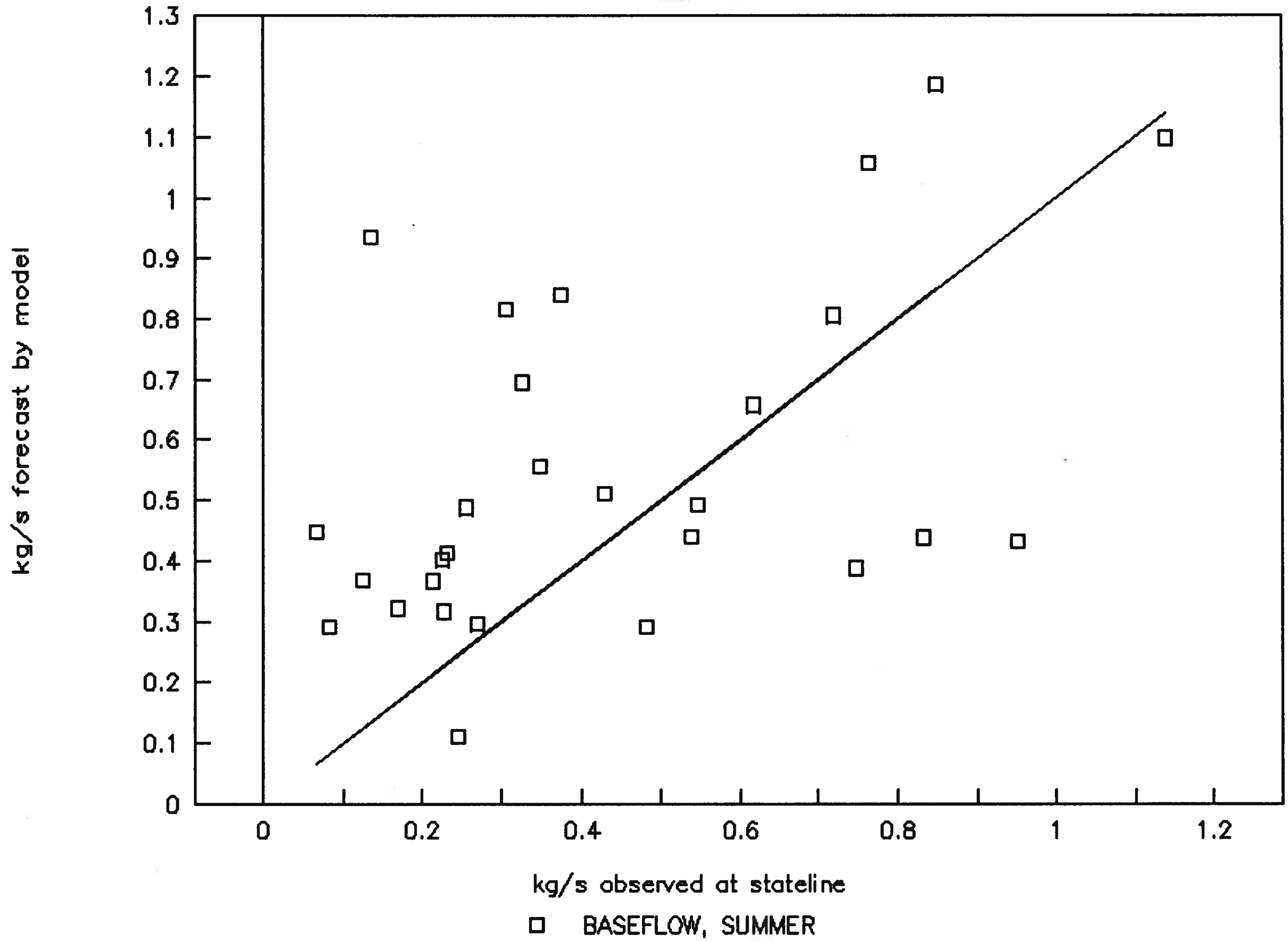
STATELINE GAGE

CHLORIDE MODEL RESULTS



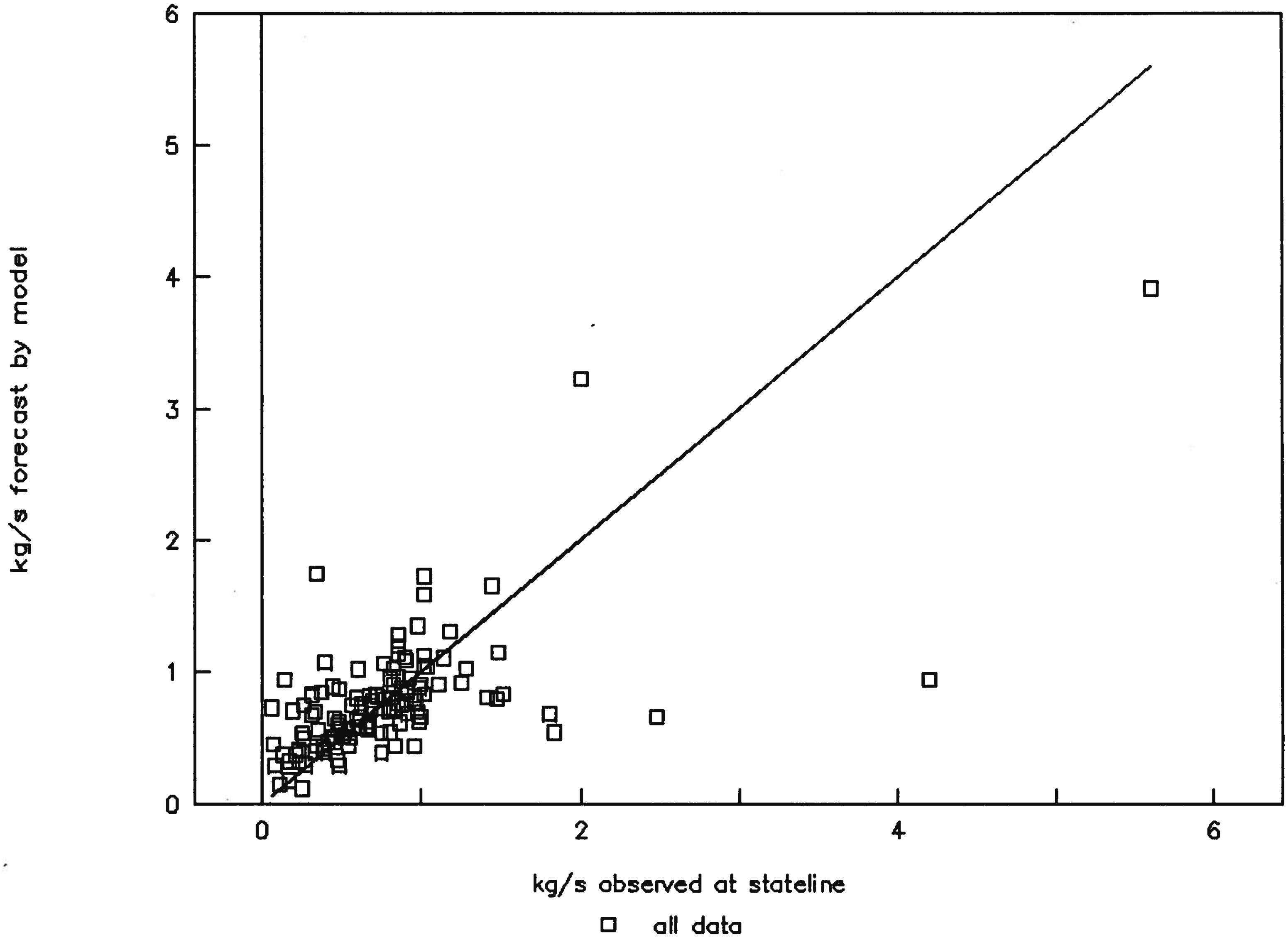
STATELINE GAGE

CHLORIDE MODEL RESULTS



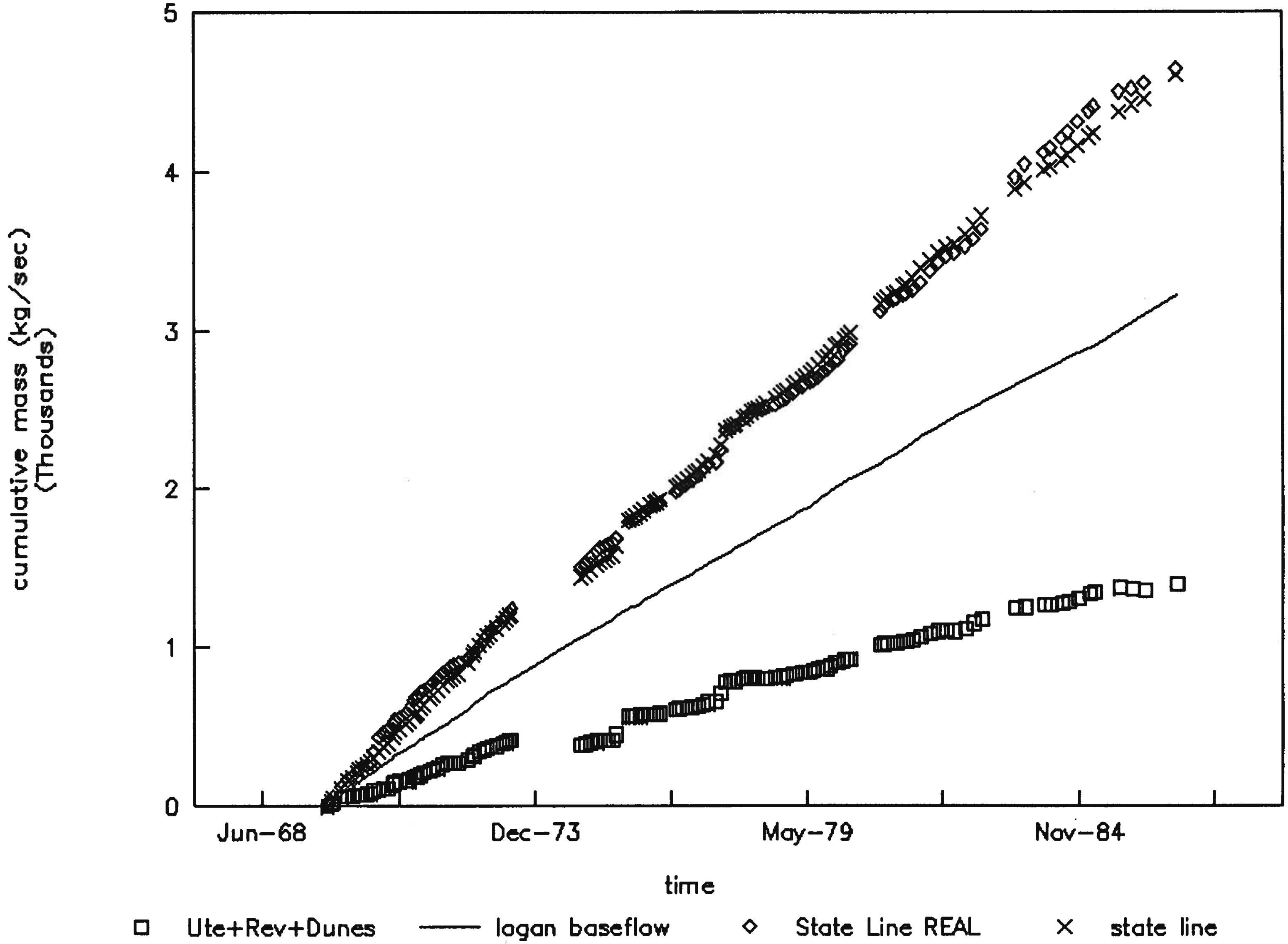
STATELINE GAGE

CHLORIDE MODEL RESULTS



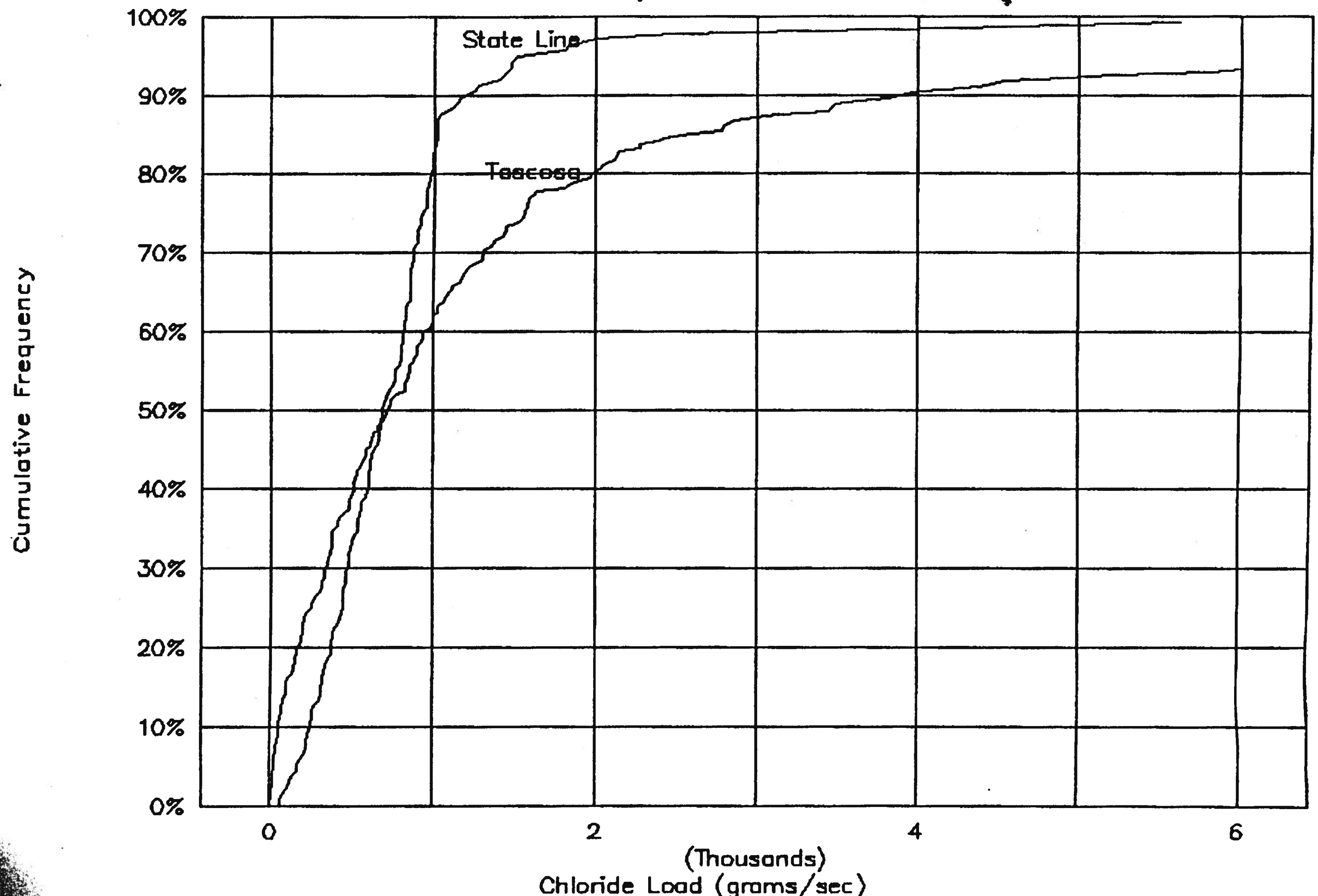
CHLORIDE MODEL

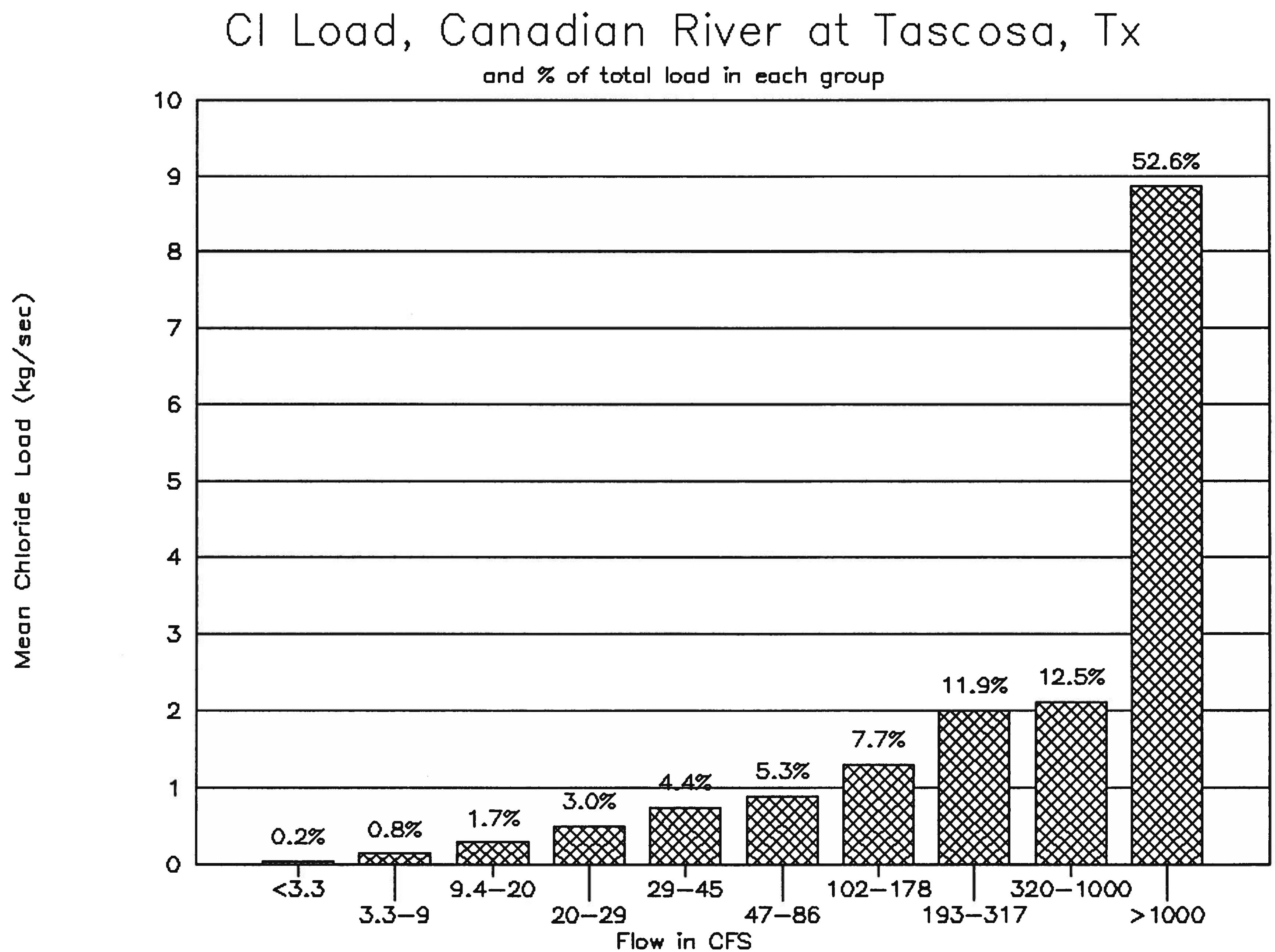
SOURCE VARIATIONS OVER TIME



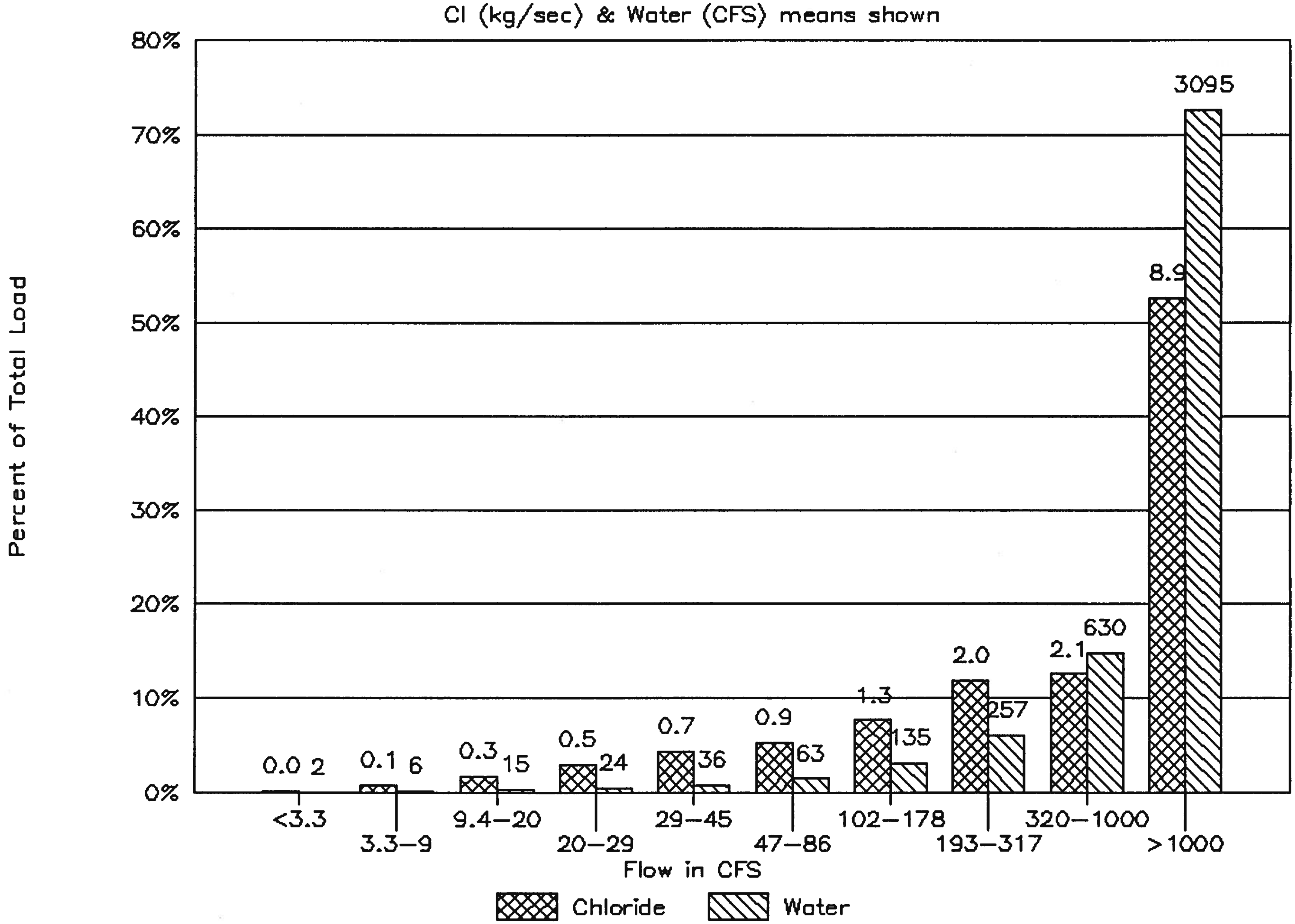
Canadian River Chloride Load

Tascosa, Tx and State Line



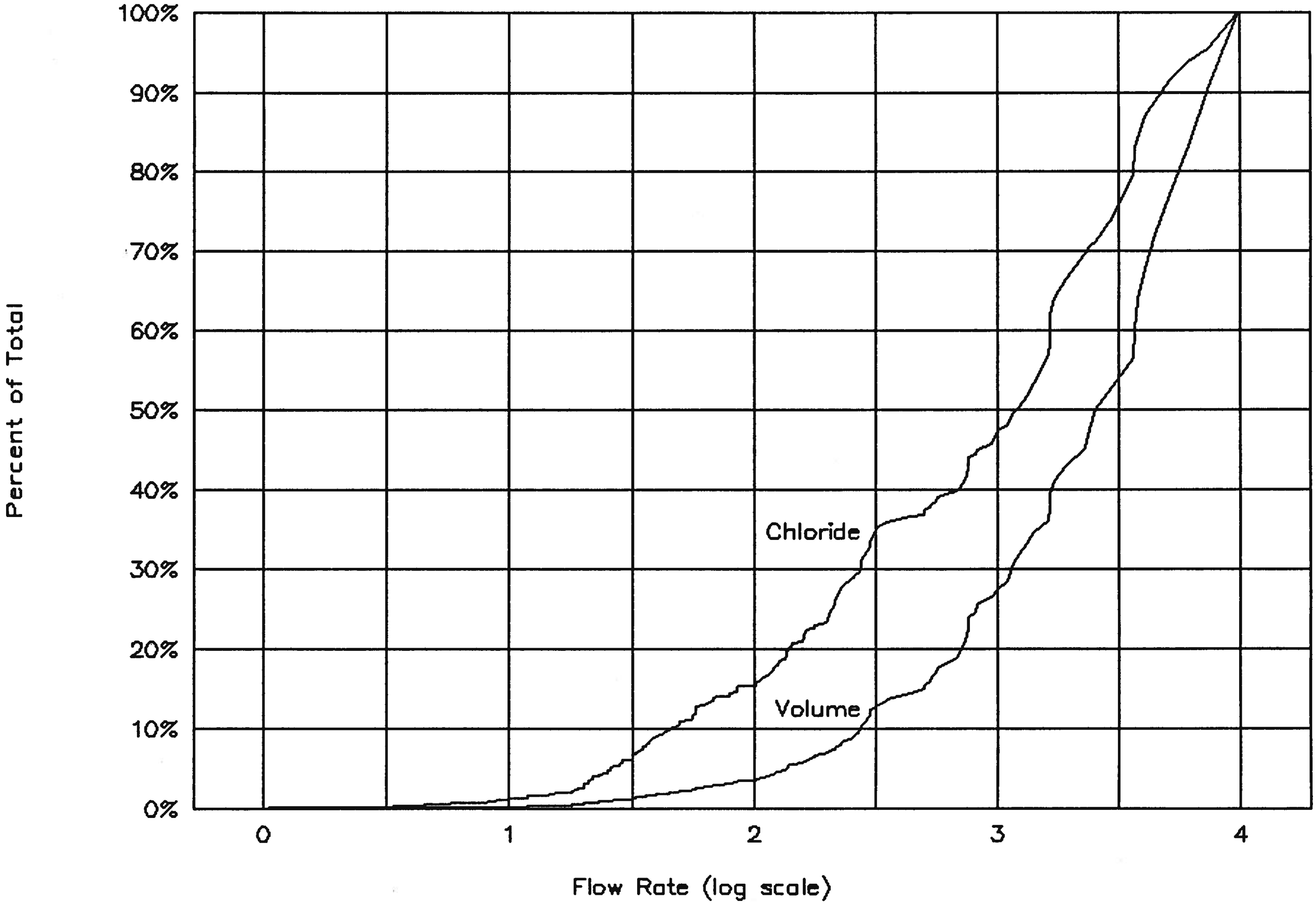

Cl Load, Canadian River at Tascosa, Tx
and % of total load in each group
Mean Chloride Load (kg/sec)
0
1
2
3
4
5
6
7
8
9
10
0.2%
0.8%
1.7%
3.0%
4.4%
5.3%
7.7%
11.9%
12.5%
52.6%
<3.3
3.3–9
9.4–20
20–29
29–45
47–86
102–178
193–317
320–1000
>1000
Flow in CFS

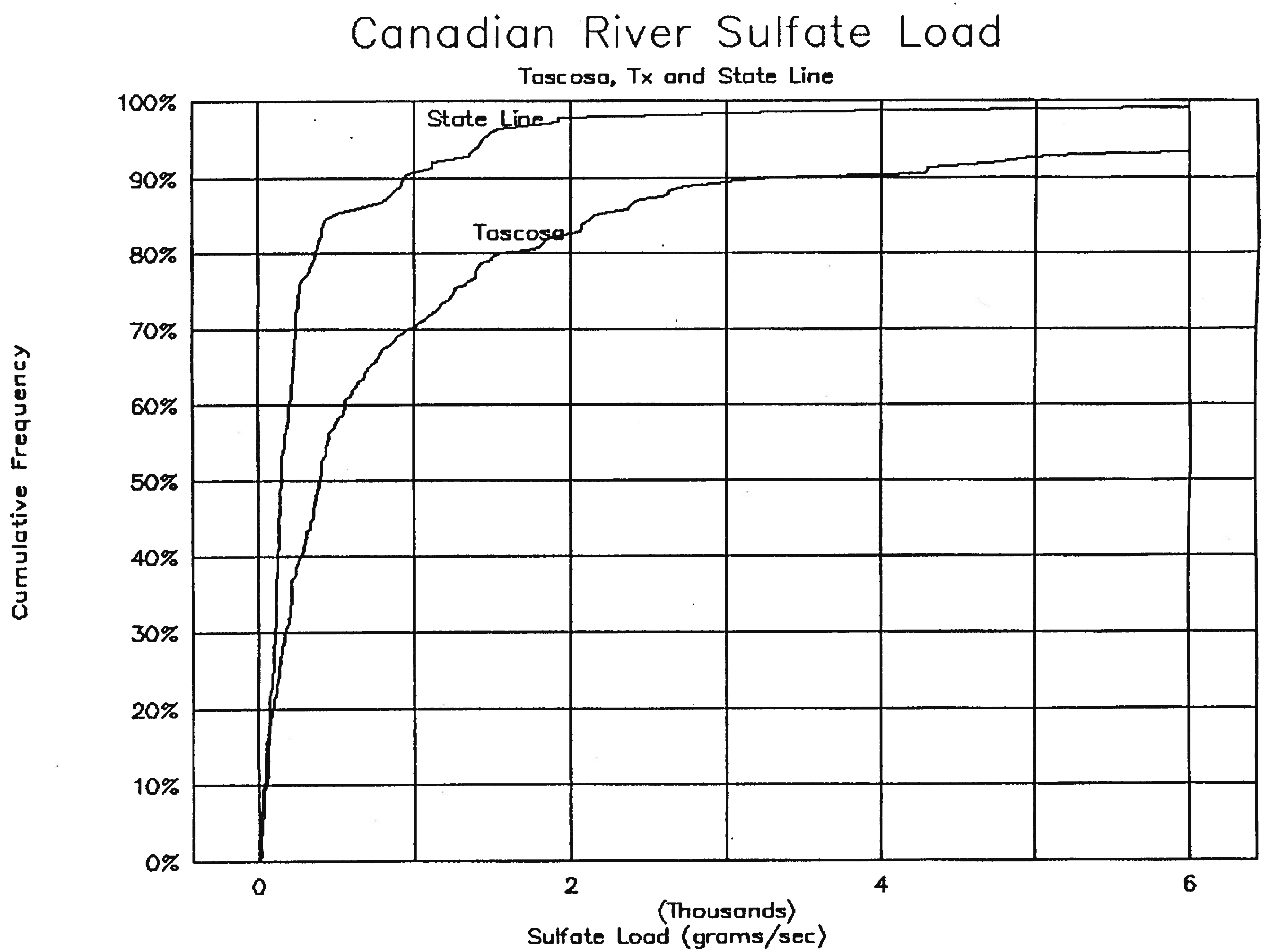
Cl and Water Mass Loads at Tascosa, Tx

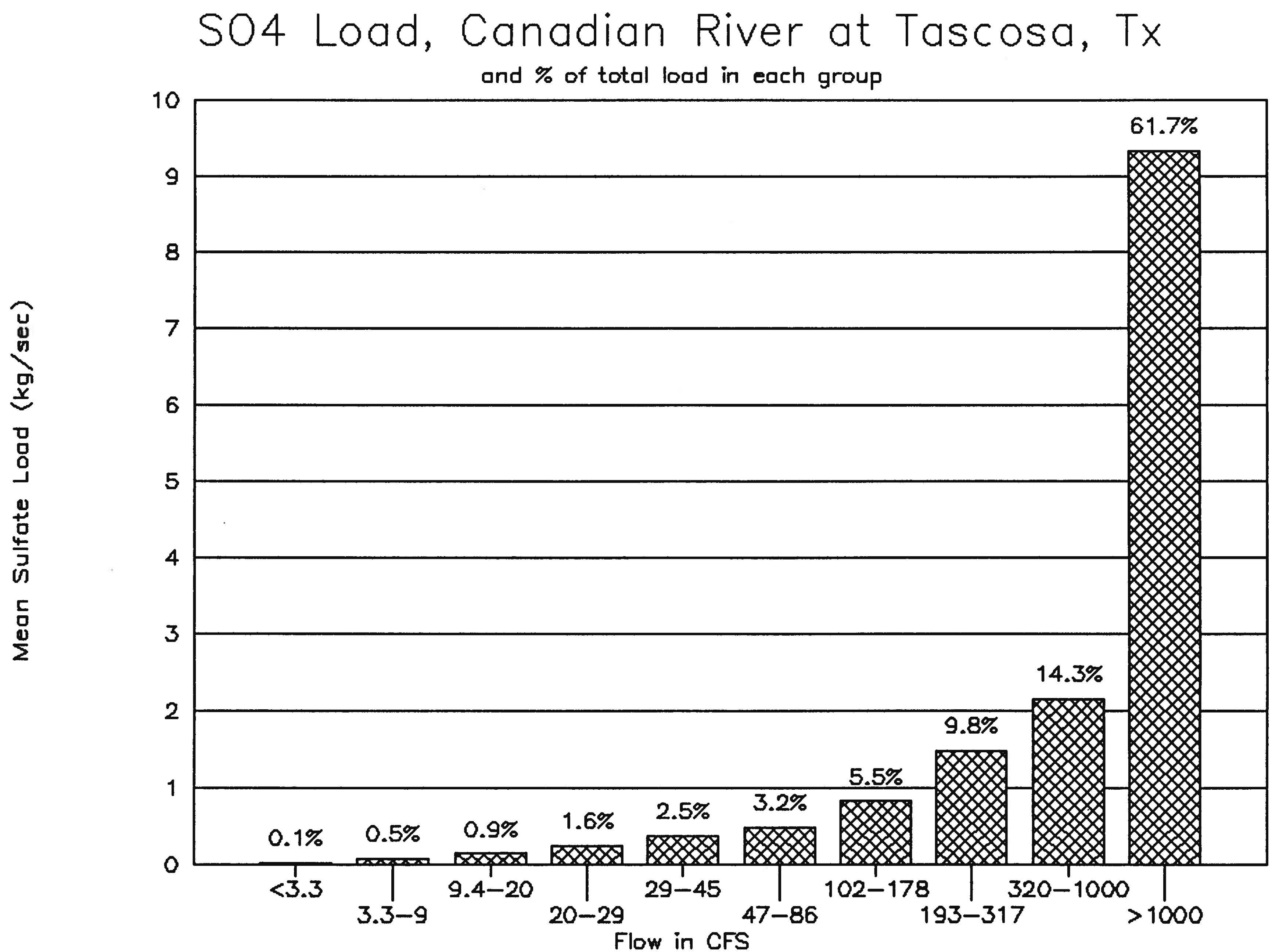


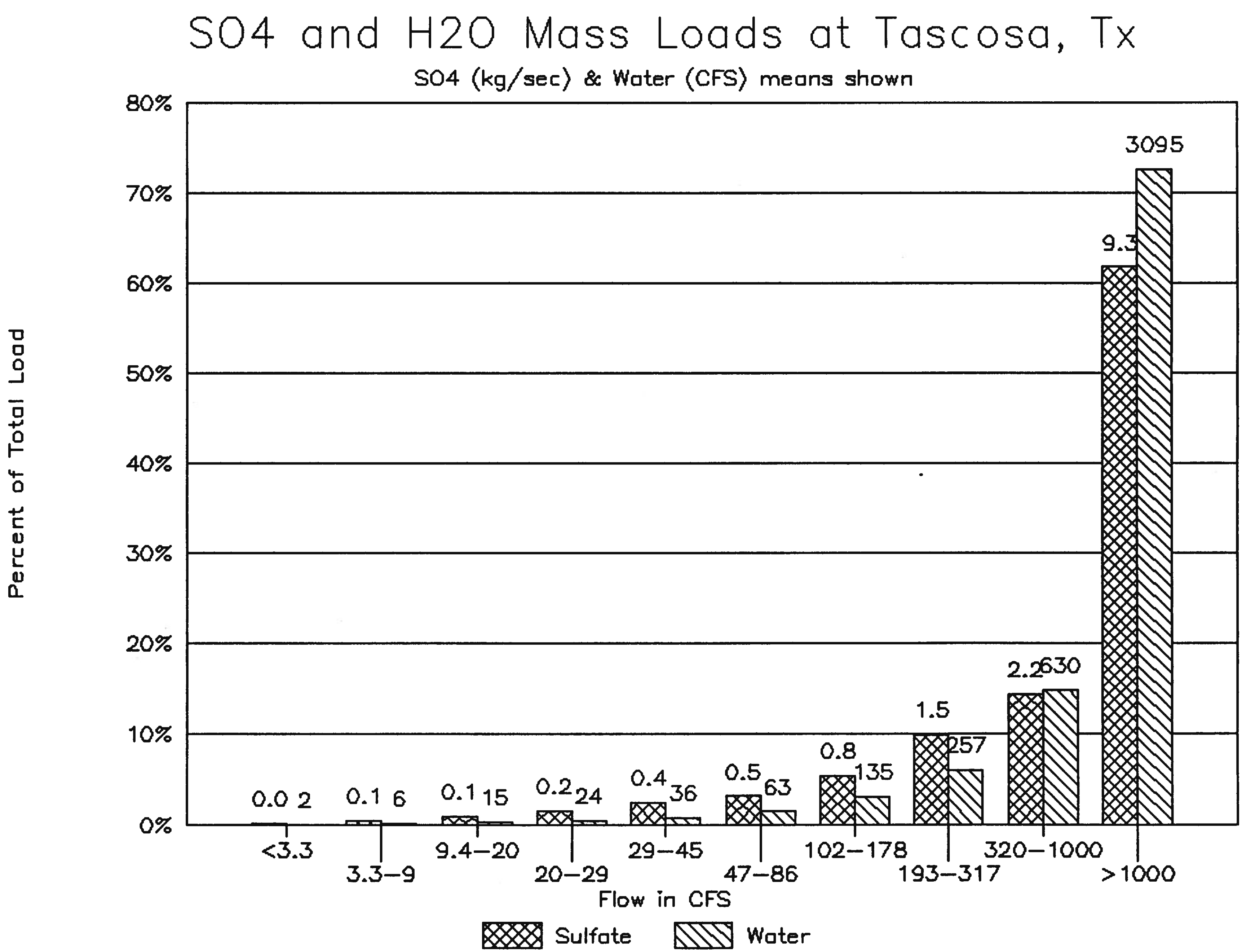
Canadian River at Tascosa, Texas

Chloride Mass and Water Volume




Canadian River Sulfate Load
Tascosa, Tx and State Line
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Cumulative Frequency
State Line
Tascosa
0
2
4
6
(Thousands)
Sulfate Load (grams/sec)

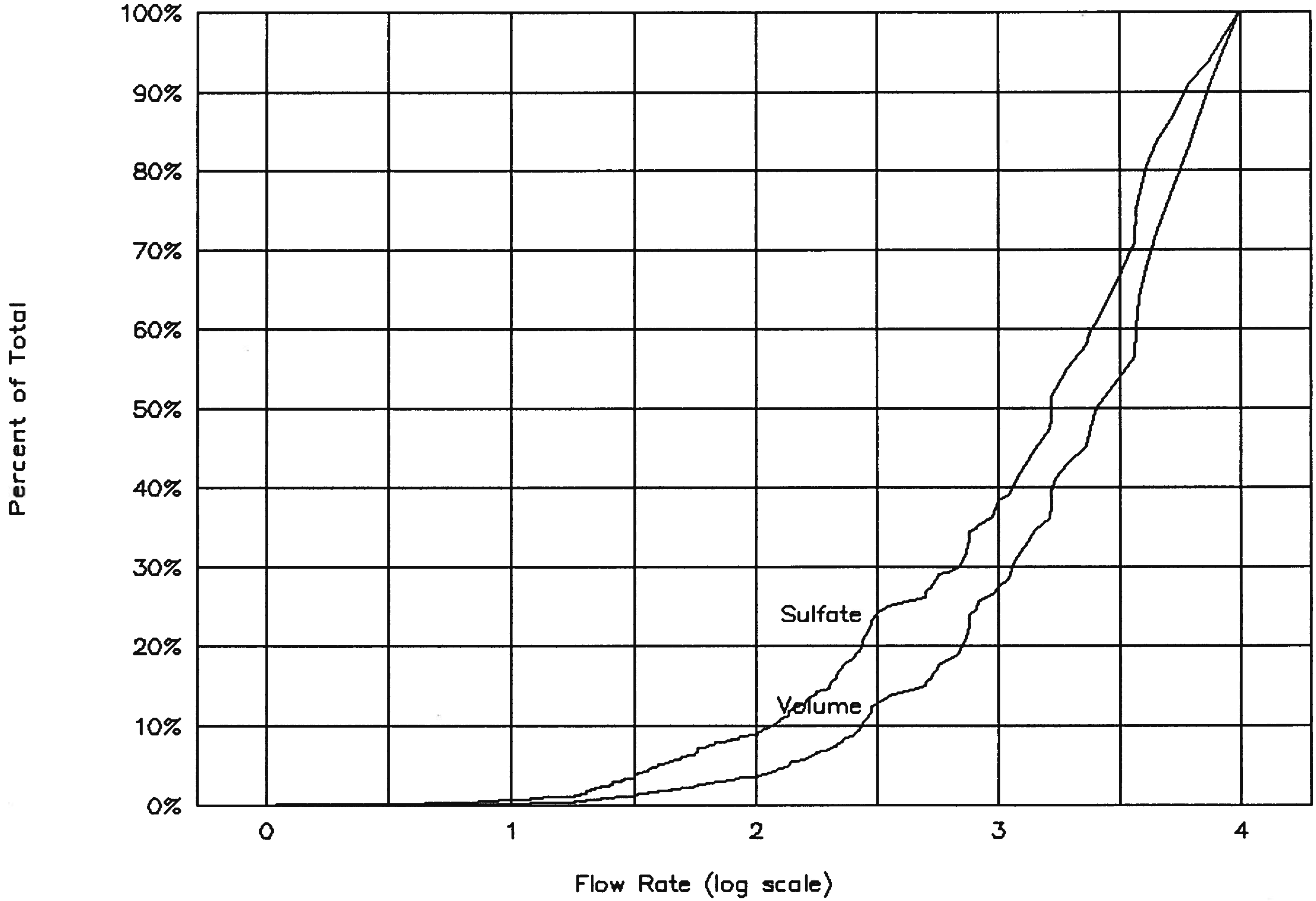

SO4 Load, Canadian River at Tascosa, Tx
and % of total load in each group
Mean Sulfate Load (kg/sec)
0
1
2
3
4
5
6
7
8
9
10
0.1%
0.5%
0.9%
1.6%
2.5%
3.2%
5.5%
9.8%
14.3%
61.7%
<3.3
3.3–9
9.4–20
20–29
29–45
47–86
102–178
193–317
320–1000
>1000
Flow in CFS



SO4 and H2O Mass Loads at Tascosa, Tx
SO4 (kg/sec) & Water (CFS) means shown
Percent of Total Load
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.0 2
0.1 6
0.1 15
0.2 24
0.4 36
0.5 63
0.8 135
1.5 257
2.2 630
9.3 3095
<3.3
3.3–9
9.4–20
20–29
29–45
47–86
102–178
193–317
320–1000
>1000
Flow in CFS
Sulfate
Water

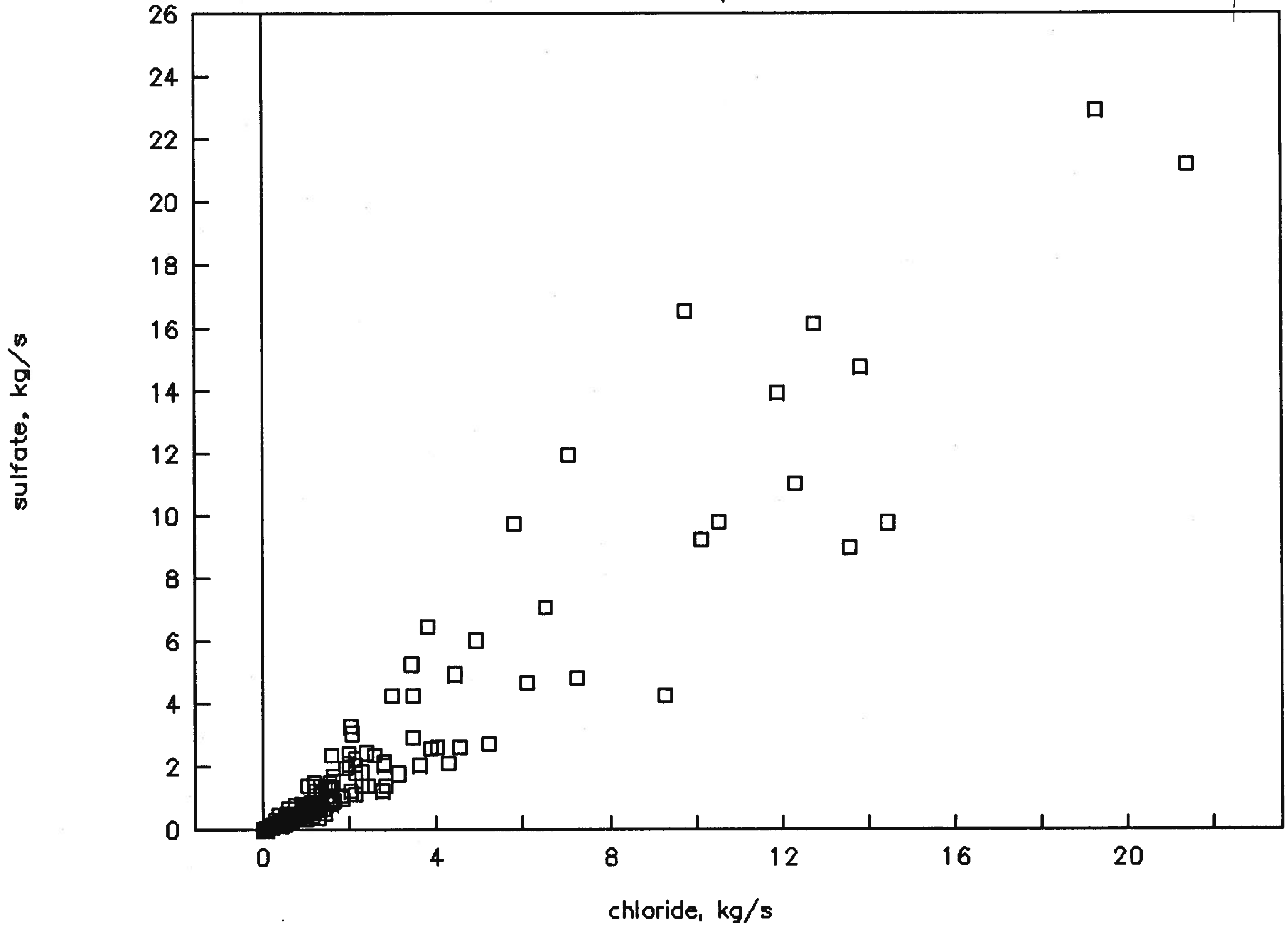
Canadian River at Tascosa, Texas

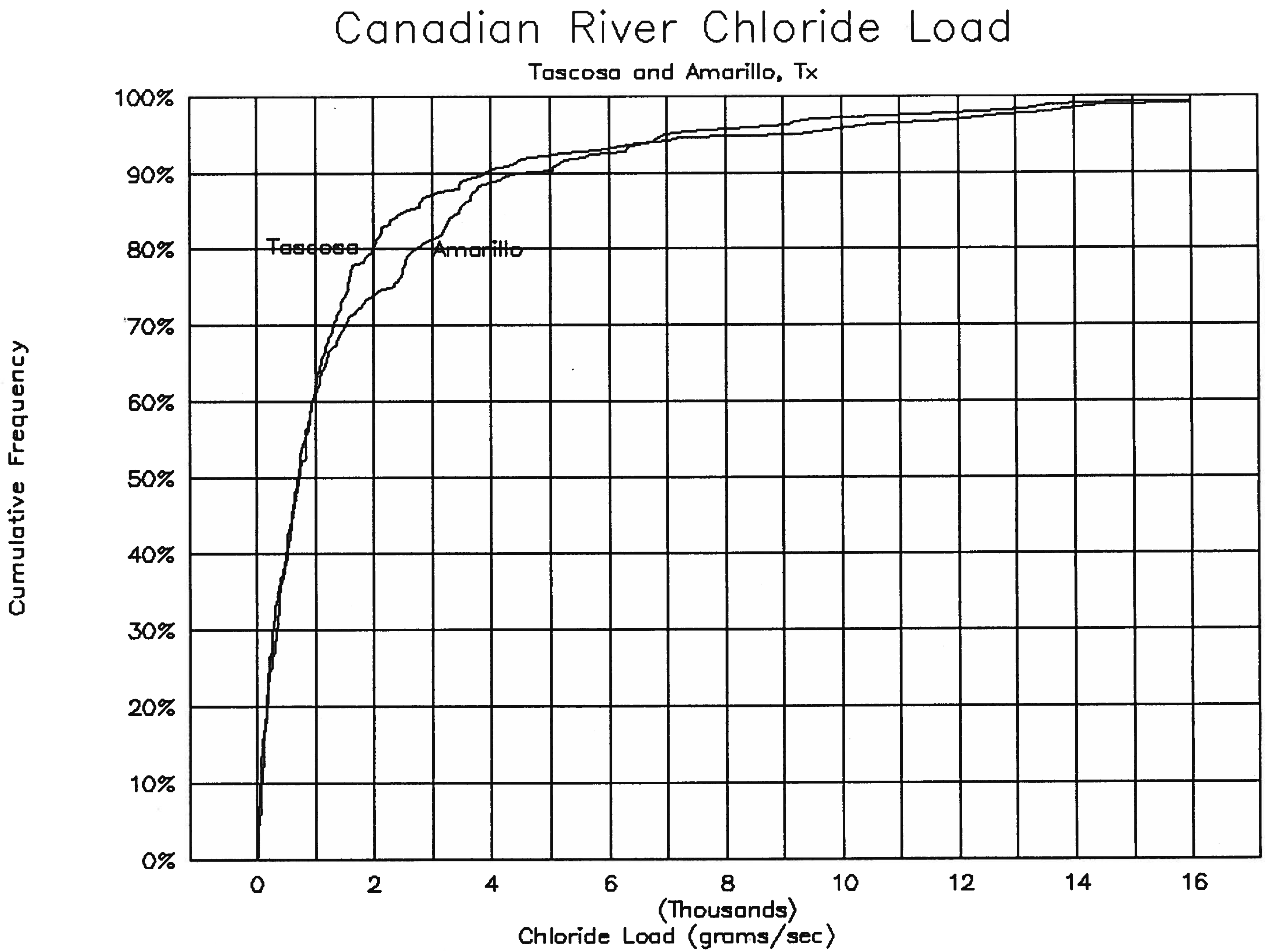
Sulfate Mass and Water Volume



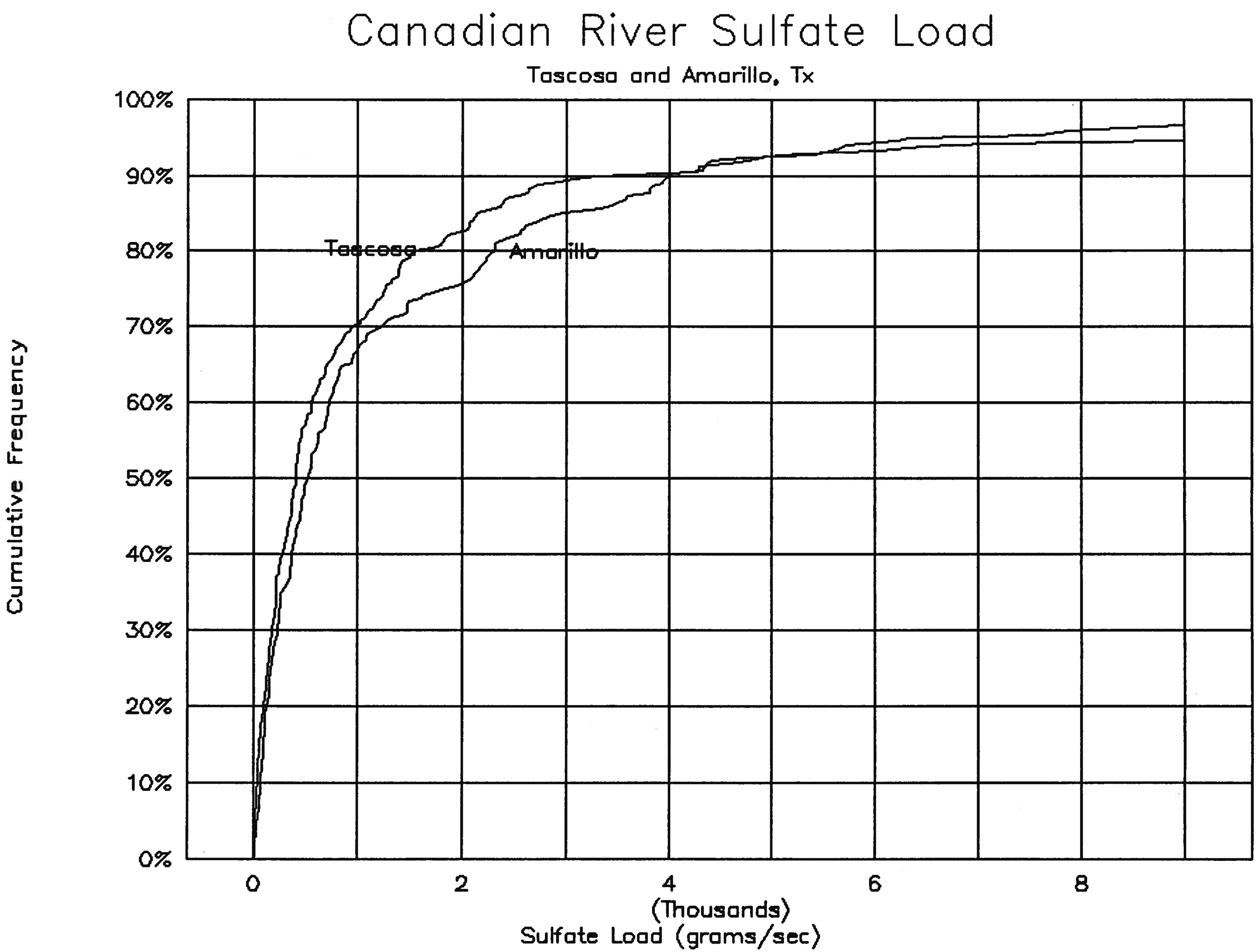
Canadian River At Tascosa Tx

salt transport





Canadian River Chloride Load
Tascosa and Amarillo, Tx
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Cumulative Frequency
Tascosa
Amarillo
0
2
4
6
8
10
12
14
16
(Thousands)
Chloride Load (grams/sec)


Canadian River Sulfate Load
Tascosa and Amarillo, Tx
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Cumulative Frequency
Tascosa
Amarillo
0
2
4
6
8
(Thousands)
Sulfate Load (grams/sec)

Canadian River at Amarillo, Tx

Chloride Concentration and Discharge