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AN EVALUATION OF WATER-QUALITY DATA OBTAINED AT FOUR STREAMFLOW DAILY-RECORD STATIONS IN IDAHO

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 30-73

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16. Abstracts Four streamflow water quality stations in Idaho with historical records ranging from 7 to 22 years were analyzed statistically to show the functional relationships of the major inorganic chemical constituents to specific conductance and stream discharge. The data for each of the three long term stations were subdivided into approximately five-year segments; then plots and regression equations were derived for each record segment in order to assess changes in constituent relations with time. In general highly significant correlations were observed between the major inorganic ions and specific conductance. Distinctly poorer, though still significant, correlations were usually observed between these same ions and discharge. The only significant change in chemical characteristics with time occurred at the Boise River at Notus, where the percentages of chlorides and sulfates in solution declined appreciably between 1940 and 1951 while bicarbonate percentages increased. At two stations the common ion-discharge relations were more highly correlated before 1957 than thereafter, presumably because of construction of upstream dams and changes in water regulation.

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CONTENTS

APPENDIXES

ILLUSTRATIONS

TABLES

AN EVALUATION OF WATER-QUALITY DATA OBTAINED AT FOUR STREAMFLOW DAILY-RECORD STATIONS IN IDAHO

by Kenneth L. Dyer

ABSTRACT

Chemical data for four stream-gaging stations in Idaho, each having 6 to 22 years of available records, were analyzed to determine functional relations between concentrations of the major inorganic constituents, specific conductance, and stream discharge. Three of the four stations had sufficient available record for assessing changes in constituent relations with time. The records for each long-term station were subdivided into segments of approximately 5 years each. Plots and regression equations were derived for each record segment to show the relation of each major constituent value to levels of specific conductance and stream discharge. At only one station, Boise River at Notus, was there an apparent significant change in chemical characteristics with time. Between 1940 and 1951, the percentages of chloride and sulfate in solution at this station declined appreciably and were largely replaced by bicarbonate.

In general, there were highly significant correlations between the major inorganic ions and specific conductance, although those observed at Bear River at Border were distinctly poorer than those observed for the other stations. Corresponding correlations between the major ions and discharge were almost always less significant than those observed between the same ions and specific conductance. The common ion-discharge relations observed on the Snake River near Heise were more highly correlated before 1957 than thereafter--probably because of changes induced by the construction of Palisades Dam. A similar decline in correlation of common ion-discharge relations was observed at the Snake River at King Hill station after 1957, and this also might be attributable to changes in water regulation at various upstream impoundments.

INTRODUCTION

The design and operation of any water-quality information system should be subject to continual reappraisal so that the greatest possible value may be obtained from its operation. This evaluation should include such factors as need for and projected use of the information obtained, number and types of variables to be measured, frequency of measurement, accuracy commensurate with needs, and the money and manpower available for operation of the system.

This study is limited to four U.S. Geological Survey streamflow stations located in Idaho (figure 1). The 6 to 22 years of stations were assembled and evaluated through use of computer techniques for data plotting and regression analysis developed by Steele (1972). Objectives of this evaluation were (1) to show which parameters were highly correlative with the levels of specific conductance and(or) discharge and (2) to see if any changes in overall chemical character of the stream had occurred over the long term.

Data for three stations with approximately 20 years of record were subdivided into four or five segments of approximately five years each and evaluated individually. The sub-periods of record that were used in the plotting program and in regression analysis are shown in table 1. This evaluation of chemical data was limited to the major inorganic ions and related constituents. This is not to suggest that the data available on pesticides, total nutrients, radiochemicals, and temperature are not of interest and of increasing importance, but data limitations precluded statistical analysis of data for these latter variables.

The great bulk of the analyses up to and including the 1969 water year represent samples composited for periods of time ranging from 2 to 31 days. These composite samples were usually grouped so that waters of similar conductivity were combined. Occasional single samples of a markedly different conductivity were analyzed separately. Composite sampling was discontinued at station 10039500, Bear River at Border, at the end of the 1970 water year and replaced with monthly sampling. This replacement of composite samples with monthly samples was instituted at the other three stations at the end of the 1969 water year.

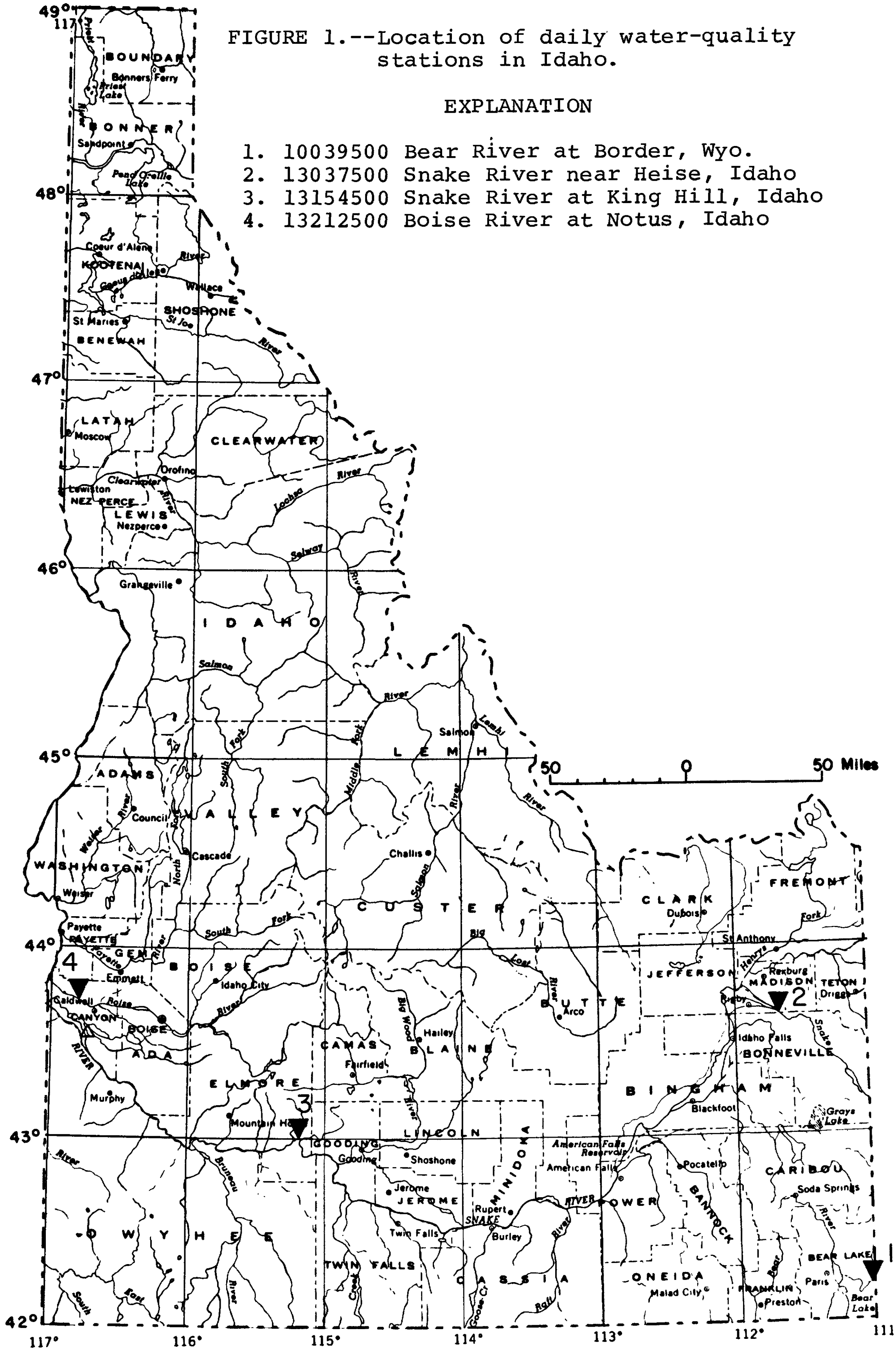

FIGURE 1.--Location of daily water-quality stations in Idaho.

EXPLANATION

1. 10039500 Bear River at Border, Wyo.
2. 13037500 Snake River near Heise, Idaho
3. 13154500 Snake River at King Hill, Idaho
4. 13212500 Boise River at Notus, Idaho

Table 1.--Summary of the chemical data subdivisions used in this study

Station number	Period of record	Subdivision of period of record by water year 1/	Number of years	Number of analyses 2/
10039500	Oct.1965-Sept.1971	1966-71	6	105
13037500	Jan.1953-Sept.1971		19	454
		1953-56	4	133
		1957-61	5	105
		1962-66	5	118
		1967-71	5	98
13154500	Mar.1951-Sept.1971		21	480
		1951-56	6	191
		1957-61	5	86
		1962-66	5	104
		1967-71	5	99
13212500	Jan.1939-Jan.1940 Nov.1950-Sept.1971		22	661
		1939-40	1	36
		1950-56	6	225
		1957-61	5	146
		1962-66	5	150
		1967-71	5	104

1/ A water year is the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months.

2/ Includes either daily composite or monthly common-ion analyses, but excludes the available daily conductivity and temperature measurements.

APPROACH

This data evaluation was accomplished through use of a series of computer programs developed by Steele (1972) for the data analysis of water-quality records. Other statewide water-quality evaluation studies using this method have been reported by Steele (1971) and Blakey and others (1972).

In making this evaluation, the selected data were first retrieved from the Geological Survey's data storage and retrieval system in punched card form. A statistical summary for each station period of record was then obtained showing means, maxima, minima, standard deviations, and other statistical measures. This summary was used to initially screen the data and to determine coordinate values for data plots. Data plots were printed by computer showing each chemical variable plotted against both specific conductance and discharge. Cartesian-coordinate plots were obtained for specific conductance versus each of the following parameters as available: silica, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, dissolved solids, hardness, non-carbonate hardness, boron, percent sodium, fluoride, nitrate, pH, color, and, in most cases, discharge. Similar plots were obtained using log-log coordinates for discharge versus the above variables and specific conductance.

These data plots were carefully reviewed to detect extremes of data which did not fit the general pattern or scatter. All highly questionable data were checked against the original laboratory results for errors, corrected when possible, or otherwise deleted from the analysis. Three selected examples of these data plots are shown in figures 2, 3, and 4.

As a fourth and final computerized step in this data assessment, regression equations were determined for selected dependent water-quality parameters as functions of specific conductance and of stream discharge. Summaries of these regression results are tabulated in appendix A. The specific-conductance regressions were made using numerical values of analytical data while the stream-discharge regressions were made using log-transformed values of the data. In most instances, a regression for specific conductance versus stream discharge was obtained using both the numerical-value and log-transformed models for purposes of comparison. For the three stations with long-term records, the regression analyses and data plots for the sequence of time segments were studied further to determine whether or not there had been apparent long-term changes in water quality at each station. The standard error of the estimate as a percentage of the mean value was used to show approximately how closely values for

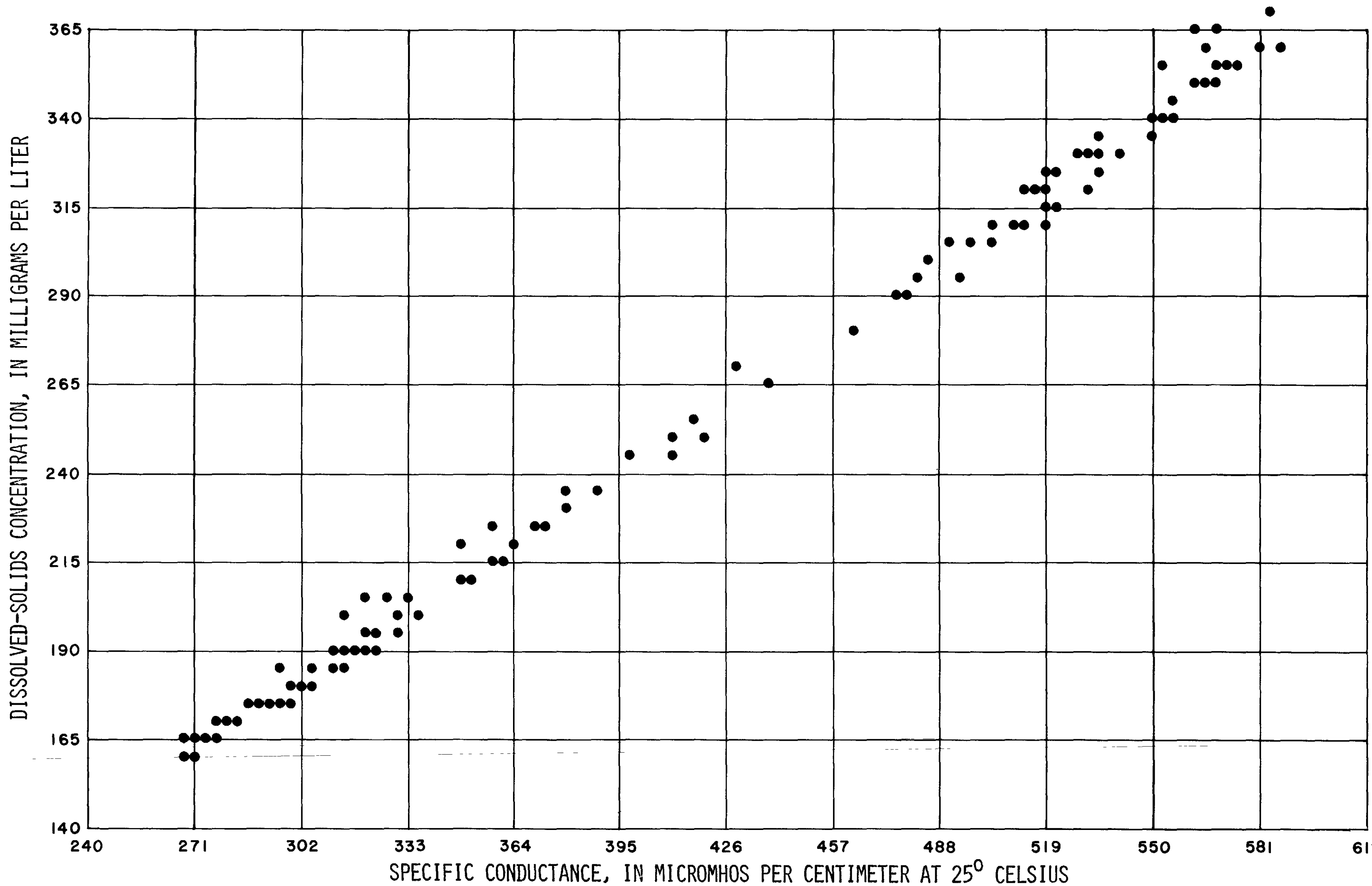

FIGURE 2.--DISSOLVED-SOLIDS CONCENTRATION VERSUS SPECIFIC CONDUCTANCE AT SNAKE RIVER NEAR HEISE, IDAHO, 1953-56 WATER YEARS.

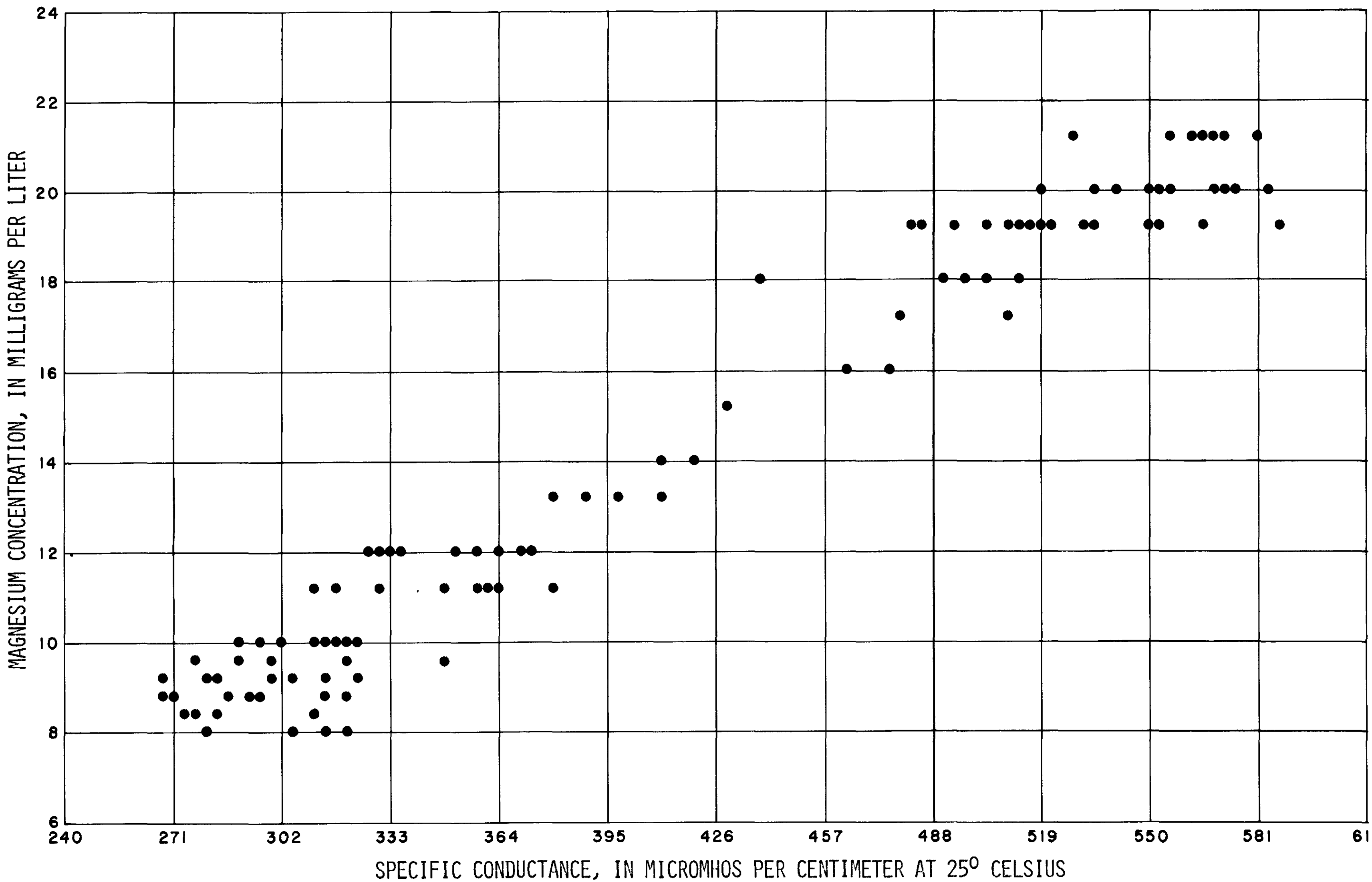

FIGURE 3.--Dissolved-magnesium concentration versus specific conductance at Snake River near Heise, Idaho, 1953-56 water years.

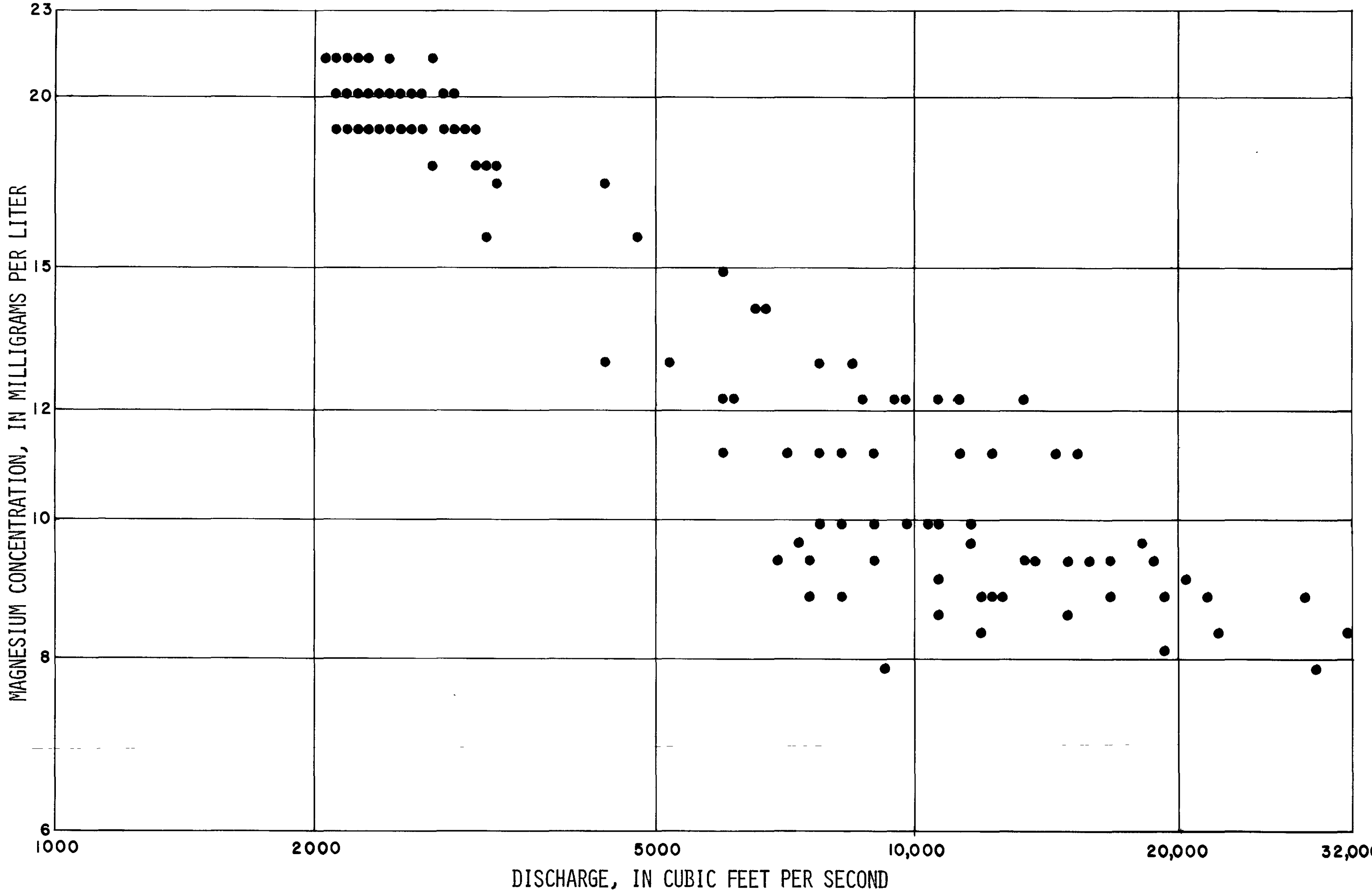

FIGURE 4.--DISSOLVED-MAGNESIUM CONCENTRATION VERSUS DISCHARGE AT SNAKE RIVER NEAR HEISE, IDAHO, 1953-56 WATER YEARS.

different parameters could be estimated from measurements of specific conductance. Information obtained by application of these techniques will be discussed in the next section. It is generally possible to simulate a record of the major inorganic constituent concentrations in streamflow by using the daily or periodic records of specific conductance and the results of the regression analysis. Such a streamflow chemical-quality simulation program has been developed by Steele (1973), and typical results and comparisons with independent test data are given in Steele (1971), and Blakey and others (1972). However, simulation of data was not undertaken as part of the present study.

DISCUSSION

The sample correlation coefficient, r, was used to indicate the degree of linear relations between the two variables. The more linear this relationship is, the closer r will be to a +1 or -1. A sample correlation coefficient of zero would indicate a completely random distribution of paired data points. All correlation coefficients for each station were copied from appendix A to a single table (appendix B) so that they might be more readily compared. The highly significant relations between specific conductance and most of the major inorganic constituents are readily apparent. In a lesser number of cases, significant correlations were observed for the relations between discharge and these same parameters.

The relatively poor correlations and standard errors of estimate for concentration-conductance and concentration-discharge relations for station 10039500, Bear River at Border, indicate that the proposed technique for summarization of geochemical relations in streamflow may not apply equally well to all cases. In this instance, the poor results of regression analysis are thought to be caused, at least in part, by inaccuracy in the available data. This stream is relatively high in concentrations of dissolved calcium and bicarbonate ions, and historical samples collected at this station are known to be especially prone to precipitation of calcium carbonate while awaiting analysis. The majority of samples from which data in this study were obtained were not preserved in any way, so one might suspect that many of the analyses do not accurately represent ionic concentrations in the stream. It is believed that analytical data more accurately representative of streamside conditions obtained now and in future sample collections at this station will result in better correlations between the various major ions and specific conductance or discharge.

Streamflow sampling station 13037500, Snake River near Heise, monitors the Snake River before it enters the Snake River Plain. The analytical data obtained for this station are probably more reliable than those obtained for the other three. This would be expected since this station near Heise has the lowest concentration of those dissolved salts most subject to precipitation from solution prior to analysis. In all cases the regression of each major inorganic constituent against specific conductance and against discharge was highly significant for all four time segments. Prior to the construction of Palisades Dam in 1956, the regressions against discharge were almost as good, and in some cases even better, than those against specific conductance; but after 1956 the discharge relations became less well defined. No major land-use changes have occurred in the Snake River basin upstream from Palisades Reservoir since 1956; therefore, by using these same regression relations and a reconstructed river flow estimated from the gage records upstream from Palisades Reservoir it should be possible to make a good estimate of what the chemical composition of streamflow would have been had Palisades Dam not been constructed. Since construction of Palisades Dam, short-term water-quality fluctuations at this station have been largely damped out. There appears to be little present need to continue a daily record of specific conductance at this site. A weekly or monthly record of specific conductance along with other pertinent data should be adequate for any anticipated information needs. Although information on the major ions cannot now be simulated from discharge at this station with a high degree of accuracy, excellent estimates of these same ions may be provided from specific-conductance records in conjunction with the appropriate regression functions.

Streamflow sampling station 13153500, Snake River at King Hill, was established to measure quality conditions in water leaving the Snake River Plain of south central Idaho. Although this station may be adequate for determining discharge, it is not well situated for monitoring water quality with once-daily grab samples. The river flow at this point is highly regulated by power dams, which can cause sharp fluctuations in the mixture of spring waters and stream water. The concentration-conductance regression relations were, in general, less well-defined than for the station upstream near Heise, especially for data collected after 1956. The concentration-discharge regression relations would have been even poorer had instantaneous discharge values been used instead of the daily mean values used prior to the 1970 water year. Many samples collected at this site appear to be affected by precipitation of calcium carbonate but the worst of these were deleted and not used in the regression analysis. A digital recorder for monitoring specific conductance was installed at this site in January, 1973; consequently, future records of this parameter collected at this site should be much more adequate than those collected in the past.

The purpose of streamflow station 13212500, Boise River at Notus, is to monitor the quality of water leaving the rather highly-developed Boise basin. Highly significant regressions of the major inorganic ions versus both specific conductance and discharge were obtained for each of the five time intervals at this station. Selected data plots for each multi-year increment of the total period of record were visually inspected and compared to determine whether there had been discernable shifts in the relations with time. Significant shifts in concentration-conductance regressions were observed when data for 1939-40 were compared to time segments for 1950-71. To illustrate these shifts with time at this station, plots of the regression lines for specific conductance versus calcium, magnesium, sodium, bicarbonate, sulfate, chloride, and discharge are shown in appendix C. In these plots the regression lines for the five time increments (table 1) were superimposed so that shifts in the regression functions with time would be more readily apparent. Between 1941 and 1950, there was a significant decline in the chloride and sulfate ion concentrations relative to a given level of specific conductance; but unfortunately no records of chemical quality are available for this period of time. This decline in chloride and sulfate was largely compensated for by an increase in the proportion of bicarbonate ion. Calcium ion concentrations also increased significantly relative to specific conductance during this interval of time.

The significant change in proportions of chloride, sulfate, and bicarbonate after 1940 raised a question as to whether the annual loads of these ions in the Boise River had changed since 1940 as a consequence of man's activities in the basin. Estimates of total chloride load were made for each year for which data were available and it was observed that there had been no significant change in total chloride loads carried from the basin in the years during the period of record. It was concluded that the different proportions of ions observed for 1939-40 can be attributed to the fact that this was near the end of an exceptionally long dry cycle. The chloride ion is highly soluble and little affected by ion exchange, therefore it varies in concentration in inverse proportion to the water available. Much of the time the Boise River at Notus is saturated with calcium and bicarbonate ions so the concentrations of these ions are not so greatly affected by the stage or flow of the river; however, in dry years the proportions of chloride and sulfate in solution at a given river stage can increase greatly as observed in 1939-40. This means that the simple regression relationships derived in a normal or wet weather cycle from paired data sets would not be applicable to an extended dry cycle and vice versa. Multiple regression techniques using both discharge and specific conductance as independent variables should produce relations of greater validity for both wet and dry years, but it was beyond the scope of this study to pursue this line of investigation further. Also curvilinear regression would have shown improved relations, especially in 1939-40.

The regression relations obtained permit estimation of chemical composition of streamflow from either records of stream discharge or specific conductance. It is beyond the scope of this study to simulate such records and to compare them with actual data. The probable accuracy of a simulated record may be determined from the standard error of estimate, a complete listing of which may be found in appendix A for the selected stations. The standard error of estimate is an indication of how accurate the estimate can be relative to the true value (Ezekiel and Fox, 1959). Approximately two-thirds of the true values will be in the interval of plus or minus one standard error of estimate from the regression line, if the data values are assumed to be normally distributed. An estimated value plus or minus two times the standard error should encompass the true value about 95 percent of the time. A list of the standard errors of estimate expressed as percentage of the mean is given for each station in appendix D. This percentage is an approximate measure of the percentage of error which can be expected in individual estimates obtained through use of regression equations. At three of the four stations under investigation in this study (Snake River near Heise, Snake River at King Hill, and Boise River at Notus), it should be possible to obtain estimates based on specific conductance that are within 10 percent of the correct value two-thirds of the time for the major common ions such as calcium, magnesium, sodium, bicarbonate, and sulfate. In general, estimates of dissolved solids, hardness and pH should be within 5 percent of the correct value about two-thirds of the time.

SAMPLE COLLECTION TECHNIQUES

Much of the water-quality data collected at the four streamflow stations under study may not be representative of water in the streams at the time they were sampled. This is because certain chemical changes can occur in a water sample between the time it is collected and the time it is analyzed. For samples used in this study, the period of time between sample collection and analysis ranged from a few days to about a year, with an average delay of perhaps 1 or 2 months. Not all chemical constituents are equally affected by the ageing process. The relatively stable constituents in samples collected from the four streamflow stations under study include chloride, sulfate, magnesium, and sodium. The constituents or parameters most likely to change in ageing, non-preserved samples include calcium, potassium, bicarbonate, carbonate, nitrate, phosphate, fluoride, pH, boron, silica, dissolved solids, specific conductance, and hardness.

Water from all four of the sampling stations under study can at times be saturated or supersaturated with calcium, carbonate and bicarbonate ions. Growth of bacteria, algae or diatoms in the sample, changes in temperature or presence of any of several other catalytic agents can cause the precipitation of a major portion of the calcium and bicarbonate ions from solution as calcium carbonate. This in turn reduces the dissolved solids, the hardness, and the specific conductance, while at the same time the pH, percent sodium and carbonate levels would have to increase. The concentrations of nitrate, phosphate and any other nutrients present may be greatly affected by the growth or decay of micro-organisms in the sample. Silica and potassium may both dissolve from sediment in the sample and both can be affected by pH changes induced by microbial growth or decay. Silica and boron can also gradually dissolve in significant quantities from the glass bottles in which samples were commonly stored in the past.

Water-quality samples now being collected at these four streamflow stations are being analyzed more promptly than in the past and also are preserved to retard deterioration of nutrients and acidified to prevent any change in cation concentrations. It is recommended that in the future all analyses at these stations for pH, carbonate and bicarbonate be performed in the field. It is recommended that all samples for dissolved cations (calcium, magnesium, sodium, potassium, and minor elements) be filtered and acidified. The silica sample should be collected in a plastic bottle and the boron sample should be collected in either boron-free glassware, or a plastic container known to not adsorb significant quantities of boron.

CONCLUSIONS

At three of the four stations studied, very good regression relations were observed between specific conductance and most of the major ions. These three stations were Snake River near Heise, Snake River at King Hill, and Boise River at Notus. It seems probable that a simulated record of these major ions based on daily specific conductance (or possibly even on daily discharge) would be adequate for most current needs at these three stations. For some purposes the simulated record might actually be more useful. For example, total annual loads of given chemical species might be estimated more closely from simulated daily data than from data representing monthly grab samples. It would always be necessary to analyze three or four samples a year to make sure that the regression equations remain valid. The savings in analytical costs could be transferred to the analysis for other parameters which would be more relevant to a pollution-conscious society, and which would not be so readily predictable by data-simulation techniques. Those parameters not commonly analyzed in the past include nutrients, dissolved oxygen, biochemical oxygen demand, pesticides, and the minor elements.

In general, both specific conductance and discharge correlations obtained for station 10039500, Bear River at Border, are distinctly poorer than those obtained at the other three stations. The correlations with discharge obtained at both Snake River near Heise and Snake River at King Hill were appreciably poorer after 1957 than they were before. The lesser degree of correlation with discharge for the Snake River near Heise after 1957 might be attributed to the construction of Palisades Dam and subsequent regulation of streamflow. Similarly, the change in correlations with discharge observed on the Snake River at King Hill can be attributed to changes in regulation of streamflow from upstream impoundments or changes in daily sampling routine, or a combination of both. At both of these Snake River stations, corresponding correlations with conductance were relatively constant over all time intervals, indicating the utility of using these relations for estimating chemical composition of streamflow despite changes in the hydrologic regime.

At the station, Boise River at Notus, highly significant regressions of the major inorganic ions versus both specific conductance and discharge were obtained for each of the five time intervals; nevertheless, it was noted that different regression equations were needed for wet and dry precipitation cycles. The dissolved constituents at this station, especially the chloride and sulfate, vary far more in concentration than at any of the other three stations investigated. The simple regression technique used was not completely adequate because the concentrations of chloride and sulfate depended on phase in the weather cycle as well as on stage of the river and level of specific conductance. Curvilinear regression would have yielded improved relations, especially in 1939-40. Multiple-regression techniques using both discharge and specific conductance as independent variables should produce relations having somewhat greater validity for both wet and dry years at this station.

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APPENDIXES

Appendix A -- Summary of regression data

Bear River at Border, Wyoming (1966-71 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge											
SiO_2	9.2	0.293	0.00792	4.9	1.7	103	-0.054	0.0214	0.90	0.084	95
Ca	56	.450	.0462	31	6.2	104	.421	-.0648	1.9	.049	96
Mg	24	.788	.0518	-4.5	2.7	104	-.061	-.0189	1.4	.081	96
Na	25	.834	.0880	-24	4.1	105	-.017	.0341	1.3	.12	97
K	2.5	-.029	.00105	1.9	1.0	105	.480	.207	-.17	.13	97
HCO_3	240	.736	.324	62	21	105	-.C66	.0123	2.3	.058	97
SO_4	58	.713	.143	-21	9.7	105	.514	-.163	2.2	.095	97
Cl	25	.804	.0831	-21	4.3	105	-.076	-.0239	1.4	.12	97
Dis.Solids	328	.954	.595	.85	13	102	-.022	-.0170	2.6	.057	94
Spec. Cond.	549	-	-	-	-	-	.138	-.0261	2.8	.053	97
Hardness	239	.879	.334	56	13	105	.322	-.0463	2.5	.046	97
Noncarb.Hrd.	40	.255	.0557	9.5	14	105	.638	-.342	2.5	.15	97
B	.064	.169	.00012	0.00	.042	102	-.095	.0641	-1.5	.56	95
Na %	18	.557	.0290	1.9	3.0	104	.240	.0609	1.1	.081	96
F	.30	-.045	.00003	.29	.12	101	.195	-.240	.060	.37	94
pH	8.0	-.056	.00009	8.0	.24	105	.106	-.00535	.92	.013	97
Color	-	-	-	-	-	-	-	-	-	-	-
NO_3	.55	.158	-.00136	1.3	.56	101					

Snake River near Heise, Idaho (1953-56 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	7400	0.817	(*)	26900	3600	133	-	-	-	-	-
SiO_2	12	.387	-0.00643	15	1.7	132	0.180	0.0364	0.94	.062	132
Ca	55	.982	.128	.97	2.7	132	.889	-.303	2.9	.054	132
Mg	15	.982	.0427	-3.5	.91	132	.944	-.415	2.7	.051	132
Na	13	.902	.0328	-1.1	1.8	131	.939	-.419	2.6	.054	131
K	2.1	.575	.00257	1.0	.41	132	.620	-.226	1.2	.10	132
HCO_3	178	.971	.327	38	9.1	133	.850	-.233	3.1	.050	133
SO_4	57	.980	.210	-32	4.8	132	.990	-.572	3.8	.029	132
Cl	15	.964	.0581	-10	1.8	132	.977	-.641	3.5	.049	132
Dis.Solids	261	.998	.639	-11	4.3	133	.951	-.338	3.7	.038	133
Spec. Cond.	426	-	-	-	-	-	.953	-.324	3.8	.036	133
Hardness	199	.992	.493	-12	7.1	133	.918	-.335	3.5	.050	133
Noncarb.Hrd.	53	.975	.225	-43	5.7	133	.967	-.671	4.2	.061	133
B	.074	.108	.00004	.055	.027	45	.283	-.163	-.56	.17	45
Na %	12	-.066	.00093	11.8	2.2	132	.309	-.0737	1.4	.077	132
F	.38	.300	-.00037	.53	.13	66	-.119	.0259	-.55	.17	61
pH	7.7	.652	.00122	7.1	.16	133	.559	-.0190	.95	.0098	133
Color	6.9	.344	.00883	11	2.6	60	.408	.234	-.076	.17	60
NO_3	1.1	.206	.00102	.69	.56	132	.195	-.0876	.34	.19	132

* Not available, overflow on computer printout

Snake River near Heise, Idaho (1957-61 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	5630	0.812	(*)	25900	2630	105	-	-	-	-	-
SiO_2	9.9	-.090	0.00225	9.0	2.1	69	-0.080	-0.0244	1.1	0.092	69
Ca	53	.980	.114	6.4	1.8	66	.774	-.165	2.3	.046	66
Mg	13	.962	.0363	-2.3	.77	66	.796	-.229	1.9	.059	66
Na	14	.913	.0492	-6.9	1.7	105	.922	-.362	2.4	.054	105
K	2.2	.818	.00464	.24	.25	69	.853	-.220	1.1	.046	69
HCO_3	175	.970	.291	53	5.6	105	.787	-.127	2.7	.035	105
SO_4	51	.971	.194	-29	3.7	69	.829	-.331	2.9	.076	69
Cl	15	.925	.0822	-19	2.6	68	.931	-.606	3.3	.081	68
Dis.Solids	253	.992	.619	-6.8	6.0	105	.863	-.203	3.1	.042	105
Spec. Cond.	419	-	-	-	-	-	.869	-.197	3.3	.040	105
Hardness	188	.988	.428	8.5	5.2	105	.809	-.176	2.9	.045	105
Noncarb.Hrd.	44	.952	.190	-36	4.6	105	.793	-.358	2.9	.097	105
B	.057	.311	.00013	.0036	.027	45	.058	-.285	-.36	.61	45
Na %	13	.647	.0190	4.9	1.7	65	.840	-.185	1.8	.041	65
F	.44	-.173	.00051	.24	.14	9	-.140	-.103	.0011	.13	9
pH	7.8	.384	.00150	7.2	.34	105	.402	-.0196	.96	.019	105
Color	-	-	-	-	-	-	-	-	-	-	-
NO_3	.91	.213	.00146	.31	.45	69	.082	-.111	.30	.26	69

* Not available, overflow on computer printout

Snake River near Heise, Idaho (1962-66 water year)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	6490	0.708	(*)	28200	3800	118	-	-	-	-	
SiO_2	8.4	-.229	-.00070	8.7	1.0	20	-0.207	0.0139	0.87	0.052	20
Ca	50	.990	.114	5.9	1.2	25	.852	-.165	2.3	.039	25
Mg	12	.955	.0338	-.67	.79	25	.857	-.206	1.8	.047	25
Na	13	.953	.0530	-8.3	1.2	115	.860	-.288	2.1	.067	115
K	2.1	.956	.00653	-.46	.16	20	.865	-.241	1.2	.055	20
HCO_3	172	.970	.302	50	5.3	117	.703	-.0990	2.6	.040	117
SO_4	47	.984	.176	-23	2.5	20	.874	-.308	2.8	.068	20
Cl	13	.984	.0790	-18	1.1	20	.913	-.518	3.0	.091	20
Dis.Solids	244	.991	.633	-12	6.2	118	.797	-.167	3.0	.050	118
Spec. Cond.	404	-	-	-	-	-	.795	-.157	3.2	.048	118
Hardness	183	.987	.421	13	4.9	118	.742	-.139	2.8	.050	118
Noncarb.Hrd.	42	.944	.166	-25	4.2	118	.732	-.270	2.6	.099	118
B	.045	-.208	.00005	.026	.036	20	-.025	-.646	.50	1.1	20
Na %	13	.419	.0158	7.2	2.1	75	.570	-.109	1.5	.058	75
F	.37	.381	.00036	.22	.061	20	.388	-.0965	-.087	.080	20
pH	8.0	.314	.00082	7.6	.17	118	.368	-.00930	.93	.0093	118
Color	5.0	-	-	-	-	4	-	-	-	-	
NO_3	.59	-.220	.00030	.47	.29	20	.182	.0651	-.50	20	20

* Not available, overflow on computer printout

Snake River near Heise, Idaho (1967-71 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	6850	0.748	(*)	28600	3490	98	-	-	-	-	-
SiO_2	8.7	.292	-.00904	12	1.9	24	0.522	0.198	0.21	0.10	24
Ca	50	.950	.109	6.1	2.6	91	.736	-.148	2.2	.049	91
Mg	13	.962	.0332	-.21	.68	92	.814	-.199	1.8	.051	92
Na	12	.940	.0495	-7.1	1.3	91	.880	-.333	2.3	.063	91
K	2.3	.860	.00613	-.16	.30	21	.914	-.287	1.4	.046	21
HCO_3	168	.926	.273	58	8.0	91	.692	-.108	2.6	.040	91
SO_4	42	.950	.175	-23	4.1	26	.760	-.340	2.9	.096	26
Cl	13	.926	.0713	-15	2.3	35	.909	-.536	3.0	.092	35
Dis.Solids	235	.951	.562	11	13	93	.756	-.170	3.0	.052	93
Spec. Cond.	396	-	-	-	-	-	.833	-.188	3.3	.044	98
Hardness	177	.976	.414	12	6.6	94	.768	-.164	2.8	.049	94
Noncarb.Hrd.	39	.928	.193	-38	5.6	94	.731	-.436	3.2	.15	94
B	.028	.406	.00016	-.037	.023	9	-.327	-.434	-.26	.88	9
Na %	13	.743	.0196	5.1	1.2	83	.837	-.151	1.7	.034	83
F	.38	.599	.00057	.14	.062	21	.672	-.184	.23	.071	21
pH	8.2	.057	-.00040	8.3	.25	94	-.096	.00184	.90	.013	94
Color	2.5	-.211	.0228	-6.5	2.8	6	.445	-5.48	19	2.3	6
NO_3	.51	.430	.00224	-.34	.32	14	.232	-1.74	5.5	1.6	14

* Not available, overflow on computer printout

Snake River at King Hill, Idaho (1951-56 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	11100	.731	*	52700	2420	191	-	-	-	-	-
SiO_2	34	.723	0.0965	-15	2.8	157	.718	-0.321	2.8	0.038	157
Ca	47	.462	.0337	30	2.1	191	.053	.0284	1.6	.022	191
Mg	20	.862	.0498	-5.8	.94	191	.641	-.219	2.2	.033	191
Na	32	.932	.113	-26	1.4	191	.776	-.346	2.9	.036	191
K	4.7	-.067	-.00137	5.4	.96	157	-.080	-.00029	.66	.080	157
HCO_3	214	.928	.313	53	4.1	191	.545	-.0815	2.7	.019	191
SO_4	55	.937	.162	-29	2.0	191	.661	-.241	2.7	.035	191
Cl	26	.828	.0656	-7.6	1.4	191	.577	-.206	2.2	.037	191
Dis.Solids	326	.976	.661	-15	4.8	191	.675	-.147	3.1	.023	191
Spec. Cond.	516	-	-	-	-	-	.687	-.135	3.3	.021	191
Hardness	199	.821	.287	51	6.5	191	.362	-.058	2.5	.024	191
Noncarb.Hrd.	23	.157	.0312	7.0	5.8	191	.101	.120	.86	.12	191
B	.11	.020	-.00007	.15	.072	50	.253	.552	-3.3	.28	50
Na %	26	.755	.0441	2.8	1.2	157	.758	-.200	2.2	.021	157
F	.58	.153	-.00050	.83	.088	54	.412	.215	-1.1	.061	54
pH	8.0	.221	.00108	7.4	.15	174	.096	-.00575	.92	.0086	174
Color	5.5	-.102	.00625	2.4	2.6	55	-.033	1.34	-5.2		55
NO_3	3.1	.550	.0105	-2.3	.53	191	.489	-.351	1.9	.080	191

* Not available, overflow on computer printout

Snake River at King Hill, Idaho (1957-61 water year)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	8900	-0.106	1.61	8070	1750	86	-	-	-	-	-
SiO_2	34	.485	.0434	12	1.7	12	0.644	0.291	0.40	0.019	12
Ca	48	.639	.0651	14	2.2	40	.368	.131	1.2	.024	40
Mg	20	.542	.0332	2.5	1.4	40	.470	-.224	2.2	.034	40
Na	33	.835	.0844	-11	1.3	86	.287	-.130	2.0	.032	86
K	4.7	-.280	.00229	3.6	.42	12	-.305	-.0549	.89	.039	12
HCO_3	214	.856	.383	16	5.6	86	.076	.0462	2.2	.022	86
SO_4	55	.858	.126	-10	2.2	40	-.151	-.0234	1.8	.034	40
Cl	25	.838	.0538	-3.1	1.0	40	.206	-.104	1.8	.033	40
Dis.Solids	326	.929	.663	-16	6.4	86	-.106	-.00577	2.5	.024	86
Spec. Cond.	517	-	-	-	-	-	-.126	.0303	2.6	.021	86
Hardness	199	.811	.321	33	5.6	86	.122	.0548	2.1	.021	86
Noncarb.Hrd.	22	-.109	.00208	21	5.3	86	.135	.272	.25	.12	86
B	.069	.333	-.00040	.28	.027	36	-.168	-.0799	-.88	.21	36
Na %	26	-.391	.00363	24	.95	8	-.366	-.0562	1.6	.016	8
F	.64	.500	.00178	-.28	.069	12	.203	.332	-1.5	.052	12
pH	8.0	.082	.00138	7.3	.24	86	.278	-.0471	1.1	.013	86
Color	-	-	-	-	-	-	-	-	-	-	-
NO_3	3.4	.700	.0136	-3.7	.40	40	.227	-.260	1.6	.076	40

Snake River at King Hill, Idaho (1962-66 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	10400	0.406	(*)	30000	3390	104	-	-	-	-	-
SiO_2	30	0.578	0.0711	-6.1	3.2	20	.576	-0.311	2.7	0.048	20
Ca	47	.718	.0871	2.1	2.4	27	.464	.155	1.1	.029	27
Mg	19	.718	.0356	1.3	.97	27	.401	-.131	1.8	.029	27
Na	31	.888	.0872	-12	1.8	104	.603	-.254	2.5	.046	104
K	4.6	.458	.00473	2.2	.28	20	.325	-.102	1.1	.028	20
HCO_3	212	.943	.407	6.8	5.7	104	.384	-.108	2.8	.035	104
SO_4	53	.902	.110	-3.0	1.7	20	.098	-.0708	2.0	.033	20
Cl	24	.928	.0523	-2.7	.69	20	.307	-.112	1.8	.033	20
Dis.Solids	318	.964	.628	.70	6.9	103	.377	-.105	2.9	.035	103
Spec. Cond.	504	-	-	-	-	-	.373	-.0989	3.1	.034	104
Hardness	196	.937	.381	3.9	5.6	104	.208	-.0632	2.5	.038	104
Noncarb.Hrd.	21	.327	.0420	.17	4.6	104	.225	.181	.59	.097	104
B	.055	-.225	.00008	.014	.029	19	-.102	-1.21	3.3	.67	19
Na %	26	.252	.0165	17	1.4	38	.828	-.175	2.1	.015	38
F	.71	-.236	.00000	.71	.088	20	.720	.322	-1.4	.035	20
pH	8.1	.459	.00243	6.9	.18	104	.040	-.00681	.93	.011	104
Color	4.0	.301	-.0244	16	2.0	10	-.351	.875	-3.7	2.1	10
NO_3	3.7	.688	.0144	-3.7	.49	20	-.176	-.119	1.0	.091	20

* Not available, overflow on computer printout

Snake River at King Hill, Idaho (1967-71 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	10840	0.426	(*)	33280	3610	85	-	-	-	-	-
SiO_2	28	.632	.173	-60	6.8	20	0.443	-0.822	4.7	0.20	20
Ca	45	.623	.0648	13	3.2	86	-.099	.0146	1.6	.042	85
Mg	19	.886	.0500	-5.6	1.0	86	.574	-.214	2.1	.043	85
Na	31	.882	.0970	-18	2.0	86	.596	-.278	2.6	.053	85
K	4.9	.394	-.00425	7.1	.26	16	.512	.109	.25	.022	16
HCO_3	211	.774	.360	29	12	86	.284	-.0820	2.7	.037	85
SO_4	49	.879	.157	-30	3.6	24	.506	-.232	2.6	.059	23
Cl	24	.535	.0478	.44	2.9	28	.345	-.163	2.0	.063	27
Dis.Solids	310	.831	.710	-47	19	86	.364	-.130	3.0	.046	85
Spec. Cond.	504	-	-	-	-	-	.399	-.101	3.1	.032	85
Hardness	194	.894	.363	11	7.1	82	.252	-.0734	2.6	.037	81
Noncarb.Hrd.	16	.384	.0649	-17	6.1	82	.194	1.83	-6.4	1.1	81
B	.060	.548	-.00089	.54	.022	9	-.332	-.484	.64	.24	9
Na %	26	.307	.0148	18	1.6	79	.504	-.110	1.9	.024	79
F	.67	-.245	.00018	.58	.13	18	.296	.224	-1.1	.075	18
pH	8.3	.137	.00026	8.2	.19	86	.223	-.0153	.98	.0094	85
Color	2.7	-.314	-.0176	12	2.7	11	-.306	-4.34	16	2.6	11
NO_3	3.1	.350	.0473	-22	1.8	12	.284	-4.51	17	1.7	25

* Not available, overflow on computer printout

Boise River at Notus, Idaho (1939-40 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	403	0.728	-1.03	1225	298	36	-	-	-	-	-
SiO_2	33	.762	.0130	19	2.8	13	0.649	-0.0740	1.7	0.046	13
Ca	51	.874	.0360	22	6.2	36	.575	-.153	2.0	.12	36
Mg	16	.992	.0198	.51	.81	36	.749	-.274	1.8	.14	36
Na											
K											
HCO_3	219	.899	.173	80	26	36	.657	-.177	2.7	.11	36
SO_4	150	.993	.238	-41	8.8	36	.763	-.382	3.0	.18	36
Cl	50	.955	.0996	-30	9.7	36	.767	-.521	2.8	.25	36
Dis.Solids	531	.996	.669	-5.6	18	36	.784	-.288	3.4	.13	36
Spec. Cond.	802						.766	-.289	3.5	.14	36
Hardness	194	.954	.171	57	17	36	.663	-.196	2.7	.12	36
Noncarb.Hrd.	6.4	.736	.0288	-17	8.2	36	.667	-2.95	4.9	1.8	36
B											
Na %											
F											
pH											
Color											
NO_3	3.0	.151	-.00132	4.1	1.8	36	-.037	.134	.027	.46	36

Boise River at Notus, Idaho (1951-56 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	1600	0.828	-7.01	4820	1010	225	-	-	-	-	-
SiO_2	29	.956	.0372	11	2.4	188	0.751	-0.207	2.0	0.090	188
Ca	35	.978	.0672	4.4	3.1	225	.798	-.360	2.6	.13	225
Mg	9.8	.978	.0212	.041	.97	225	.801	-.432	2.2	.16	225
Na	51	.991	.129	-8.2	3.6	224	.879	-.592	3.4	.16	224
K	3.8	.687	.00520	1.4	1.2	187	.620	-.262	1.3	.16	187
HCO_3	187	.995	.388	8.9	8.0	225	.841	-.416	3.4	.13	225
SO_4	62	.995	.158	-11	3.3	224	.855	-.598	3.4	.18	224
Cl	15	.974	.0396	-2.8	2.0	225	.877	-.609	2.9	.16	225
Dis.Solids	301	.999	.642	6.7	6.3	224	.853	-.434	3.7	.13	224
Spec. Cond.	459	-	-	-	-	-	.858	-.458	3.9	.14	225
Hardness	128	.985	.255	11	9.6	225	.806	-.380	3.2	.14	225
Noncarb.Hrd.	.00					225					225
B	.11	.466	.00013	.045	.051	53	.180	-.116	-.71	.27	53
Na %	43	.863	.0265	31	3.3	187	.906	-.127	2.0	.030	187
F	.44	.502	.00024	.34	.087	71	.437	-.0945	-.079	.097	71
pH	7.7	.688	.00096	7.2	.22	194	.690	-.0234	.95	.012	194
Color	13	-.086	-.00270	14	7.0	72	-.110	-.0191	1.1	.21	72
NO_3	3.1	.368	.00204	2.1	1.1	225	.333	-.133	.84	.18	225

Boise River at Notus, Idaho (1957-61 water year)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	1050	0.774	-5.77	4030	872	146	-	-	-	-	-
SiO_2	31	.786	.0303	13	3.8	12	0.409	-0.111	1.8	0.097	12
Ca	37	.964	.0760	3.1	4.5	58	.785	-.369	2.6	.14	58
Mg	9.1	.980	.0223	-.91	.98	58	.836	-.532	2.5	.17	58
Na	57	.974	.131	-10	5.6	146	.790	-.418	2.8	.16	146
K	4.7	.882	.00805	-.18	.69	12	.680	-.277	1.4	.13	12
HCO_3	212	.968	.396	7.5	19	146	.582	-.295	3.0	.21	146
SO_4	56	.995	.145	-8.3	3.0	56	.858	-.598	3.4	.18	56
Cl	13	.971	.0338	-2.0	1.8	58	.871	-.625	2.9	.17	58
Dis.Solids	337	.998	.657	-2.1	8.1	146	.746	-.307	3.3	.14	146
Spec. Cond.	517	-	-	-	-	-	.745	-.309	3.5	.14	146
Hardness	144	.968	.264	8.0	13	146	.665	-.254	2.8	.14	146
Noncarb.Hrd.	.00					146					146
B	.075	.366	.00008	.033	.040	37	.534	-.296	-.35	.23	37
Na %	45	.664	.0219	32	4.3	9	.840	-.0934	1.9	.032	9
F	.58	.855	.00108	-.074	.10	12	.701	-1.70	3.9	.78	12
pH	7.8	.371	.00077	7.4	.35	146	.459	-.0185	.94	.018	146
Color											
NO_3	3.5	.700	.00587	.87	1.3	58	.513	-.319	1.4	.26	58

Boise River at Notus, Idaho (1962-66 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	1140	0.775	-6.62	4280	933	149	-	-	-	-	-
SiO_2	28	.950	.0378	9.2	2.1	19	.543	-0.183	1.9	0.10	19
Ca	40	.972	.0670	5.1	2.6	23	.639	-.271	2.3	.12	23
Mg	11	.960	.0226	-1.0	1.0	23	.646	-.376	2.0	.16	23
Na	53	.987	.131	-9.5	3.6	149	.806	-.429	2.9	.16	149
K	4.1	.952	.00577	1.3	.32	19	.636	-.237	1.3	.10	19
HCO_3	199	.986	.392	12	12	149	.719	-.284	3.0	.14	149
SO_4	60	.993	.142	-11	2.9	19	.740	-.529	3.2	.18	19
Cl	15	.960	.0336	1.9	1.7	19	.765	-.532	2.6	.16	19
Dis.Solids	310	.997	.649	1.5	9.0	149	.764	-.312	3.3	.13	149
Spec. Cond.	475	-	-	-	-	-	.767	-.322	3.5	.14	149
Hardness	131	.980	.251	11	8.7	149	.700	-.263	2.8	.14	149
Noncarb.Hrd.	.00					149					149
B	.071	.683	.00019	-.025	.034	19	-.192	-.357	-.47	.95	19
Na %	44	.821	.0215	35	2.4	52	.904	-.0910	1.9	.018	52
F	.55	.802	.00040	.35	.050	19	.537	-.117	.065	.065	19
pH	7.7	.476	.00074	7.4	.23	149	.450	-.0133	.93	.013	149
Color	-	-	-	-	-	-	-	-	-	-	-
NO_3	5.0	.663	.00751	1.2	1.4	19	-.160	-.0769	.88	.16	19

Boise, River at Notus, Idaho (1967-71 water years)

PARAMETER	MEAN	CONDUCTIVITY REGRESSION					DISCHARGE REGRESSION				
		Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs	Correl. Coeff.	Slope	Intercept	Std. Error of Est.	Data Pairs
Discharge	1200	0.792	-8.55	5010	990	104	-	-	-	-	-
SiO_2	22	.760	.0611	-4.4	8.2	22	0.304	-0.433	2.5	0.48	22
Ca	34	.927	.0662	4.2	4.0	104	.701	-.261	2.2	.12	104
Mg	9.5	.976	.0228	-.68	.76	104	.736	-.349	1.9	.15	104
Na	48	.986	.124	-7.8	3.1	104	.798	-.431	2.8	.15	104
K	4.4	.663	.00985	.22	1.8	20	.726	-.416	1.8	.17	20
HCO_3	188	.974	.424	-.79	15	104	.711	-.318	3.1	.14	104
SO_4	43	.992	.128	-9.5	2.8	27	.889	-.609	3.4	.15	27
Cl	12	.948	.0362	-2.3	2.1	32	.894	-.637	2.9	.15	32
Dis.Solids	285	.979	.633	2.7	20	104	.782	-.332	3.4	.12	104
Spec. Cond.	446	-	-	-	-	-	.788	-.336	3.6	.12	104
Hardness	124	.959	.258	8.3	11	103	.718	-.280	2.8	.12	103
Noncarb.Hrd.	0					103					103
B	.11	-.326	-.00008	.15	.044	10	-.250	.124	-1.3	.14	10
Na %	44	.756	.02505	33	3.5	80	.790	-.0879	1.9	.033	80
F	.51	.892	.00068	.22	.057	20	.790	-.233	.37	.080	20
pH	8.1	-.099	.00001	8.0	.40	104	-.049	-.00374	.92	.021	104
Color	6.4	.243	-.0104	12	3.7	7	-.422	-.482	1.5	2.0	7
NO_3	4.8	.493	.0151	-2.4	3.3	16	-.098	-.443	1.6	.73	16

Appendix B -- Summary of mean values and correlation coefficients

Bear River at Border, Wyo. (1965-71 water year)

PARAMETER	MEAN	Conduct. Correl. Coeff.	Discharge Correl. Coeff.
Discharge	581		
SiO_2	9.2	.293**	-.054
Ca	56	.450**	.421**
Mg	24	.788**	-.061
Na	25	.834**	-.017
K	2.5	-.029	.480**
HCO_3	240	.736**	-.066
SO_4	58	.713**	.514**
Cl	25	.804**	-.076
Dis.Solids	328	.954**	-.022
Spec. Cond.	549		.138
Hardness	239	.879**	.322**
Noncarb.Hrd.	40	.255**	.638**
B	.064	.169	-.095
Na %	18	.557**	.240**
F	.30	-.045	.195
pH	8.0	-.056	.106
Color			
NO_3	.55	.158	

* Relationship significant at 5% level
** Relationship significant at 1% level

Snake River at Heise, Idaho

PARAMETER	Mean				Conductivity Correlation Coefficient				Discharge Correlation Coefficient (log-log)			
	1953-1956	1957-1961	1962-1966	1967-1971	1953-56	57-61	62-66	67-71	1953-56	57-61	62-66	67-71
Discharge	7400	5630	6490	6850	.817**	.812**	.708**	.748**				
SiO_2	12	9.9	8.4	8.7	.387**	-.090	-.229	.292	.180*	-.080	-.207	.522**
Ca	55	53	50	50	.982**	.980**	.990**	.950**	.889**	.774**	.852**	.736**
Mg	15	13	12	13	.982**	.962**	.955**	.962**	.944**	.796**	.857**	.814**
Na	13	14	13	12	.902**	.913**	.953**	.940**	.939**	.922**	.860**	.880**
K	2.1	2.2	2.1	2.3	.575**	.818**	.956**	.860**	.620**	.853**	.865**	.914**
HCO_3	178	175	172	168	.971**	.970**	.970**	.926**	.850**	.787**	.703**	.692**
SO_4	57	51	47	42	.980**	.971**	.984**	.950**	.990**	.829**	.874**	.760**
Cl	15	15	13	13	.964**	.925**	.984**	.926**	.977**	.931**	.913**	.909**
Dis.Solids	261	253	244	235	.998**	.992**	.991**	.951**	.951**	.863**	.797**	.756**
Spec. Cond.	426	419	404	396					.953**	.869**	.795**	.833**
Hardness	199	188	183	177	.992**	.988**	.987**	.976**	.918**	.809**	.742**	.768**
Noncarb.Hrd.	53	44	42	39	.975**	.952**	.944**	.928**	.967**	.793**	.732**	.731**
B	.074	.057	.045	.028	.108	.311*	-.209	.406	.283	.058	-.025	-.327
Na %	12	13	13	13	-.066	.647**	.419**	.743**	.309**	.840**	.570**	.837**
F	.38	.44	.37	.38	.300**	-.173	.381	.599**	-.119	-.140	.388	.672**
pH	7.7	7.8	8.0	8.2	.652**	.384**	.314**	.057	.559**	.402**	.368**	-.096
Color	6.9		5.0	2.5	.344**			.211	.408**			.445
NO_3	1.1	.91	.59	.51	.206	.213	-.220	.430	.195*	.082	-.182	.232

* Relationship significant at 5% level

** Relationship significant at 1% level

Snake River at King Hill, Idaho

PARAMETER	Mean				Conductivity Correlation Coefficient				Discharge Correlation Coefficient (log-log)			
	1953-1956	1957-1961	1962-1966	1967-1971	1953-56	57-61	62-66	67-71	1953-56	57-61	62-66	67-71
Discharge	11100	8900	10400	10800	.731**	-.106	.406**	.426**				
SiO_2	34	34	30	28	.723**	.485	.578**	.632**	.718**	.644*	.576**	.443*
Ca	47	48	47	45	.462**	.639**	.718**	.623**	.053	.368*	.464*	-.099
Mg	20	20	19	19	.862**	.542**	.718**	.886**	.641**	.470**	.401*	.574**
Na	32	33	31	31	.932**	.835**	.888**	.882**	.776**	.287**	.603**	.596**
K	4.7	4.7	4.6	4.9	-.067	-.280	.458**	.394**	-.080	-.305	.325	.512*
HCO_3	214	214	212	211	.928**	.856**	.943**	.774**	.545**	.076	.384**	.284**
SO_4	55	55	53	49	.937**	.858**	.902**	.879**	.661**	-.151	.098	.506*
Cl	26	25	24	24	.828**	.838**	.928**	.535**	.577**	.206	.307	.345
Dis.Solids	326	326	318	310	.976**	.929**	.964**	.831**	.675**	-.106	.377**	.364**
Spec. Cond.	516	517	504	504					.687**	-.126	.373**	.399**
Hardness	199	199	196	194	.821**	.811**	.937**	.894**	.362**	.122	.208*	.252*
Noncarb.Hrd.	23	22	21	16	.157*	-.109	.327**	.384**	.101	.135	.225*	.194
B	.11	.069	.055	.060	.020	.333*	-.225	.548	.253	-.168	-.102	-.332
Na %	26	26	26	26	.755**	-.391	.252	.307**	.758**	-.366	.828**	.504**
F	.58	.64	.71	.67	.153	.500	-.236	-.245	.412**	.203	.720**	.296
pH	8.0	8.0	8.1	8.3	.221**	.082	.459**	.137	.096	.278**	.040	.223*
Color	5.5		4.0	2.7	-.102		.301	-.314	-.033		-.351	-.306
NO_3	3.1	3.4	3.7	3.1	.550**	.700**	.688**	.350	.489**	.227	-.176	.284*

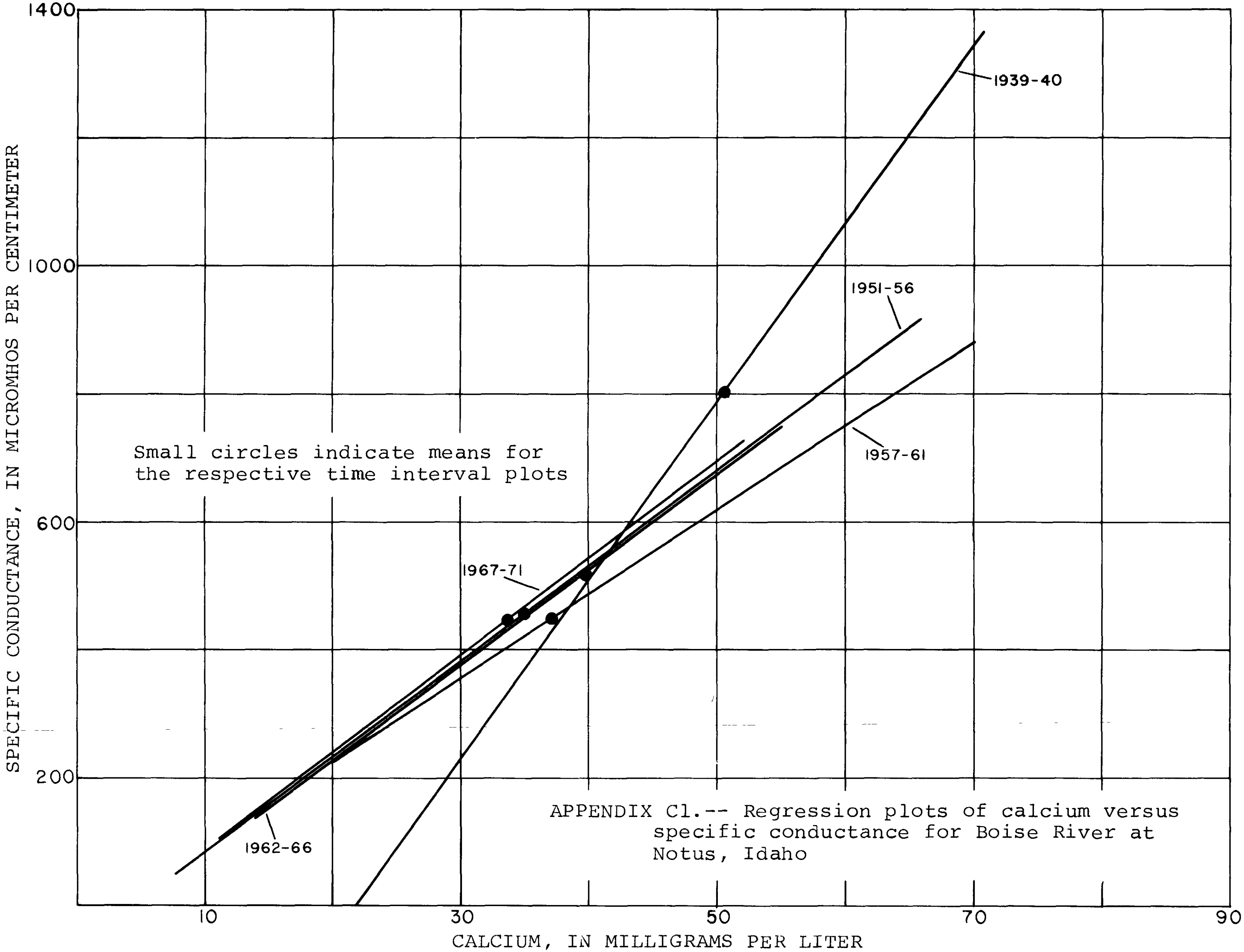
Boise River at Notus

PARAMETER	MEAN				
	1939-40	1951-56	1957-61	1962-66	1967-71
Discharge	403	1600	1050	1140	1200
SiO_2	33	29	31	28	22
Ca	51	35	37	40	34
Mg	16	9.8	9.1	11	9.5
Na		51	57	53	48
K		3.8	4.7	4.1	4.4
HCO_3	219	187	212	199	188
SO_4	150	62	56	60	43
Cl	50	15	13	15	12
Dis.Solids	531	301	337	310	285
Spec. Cond.	802	459	517	475	446
Hardness	194	128	144	131	124
Noncarb.Hrd.	6.4	0.0	0.0	0.0	0.0
B		0.11	0.075	0.071	0.11
Na %		43	45	44	44
F		0.44	0.58	0.55	0.51
pH		7.7	7.8	7.7	8.1
Color		13			6.4
NO_3	3.0	3.1	3.5	5.0	4.8

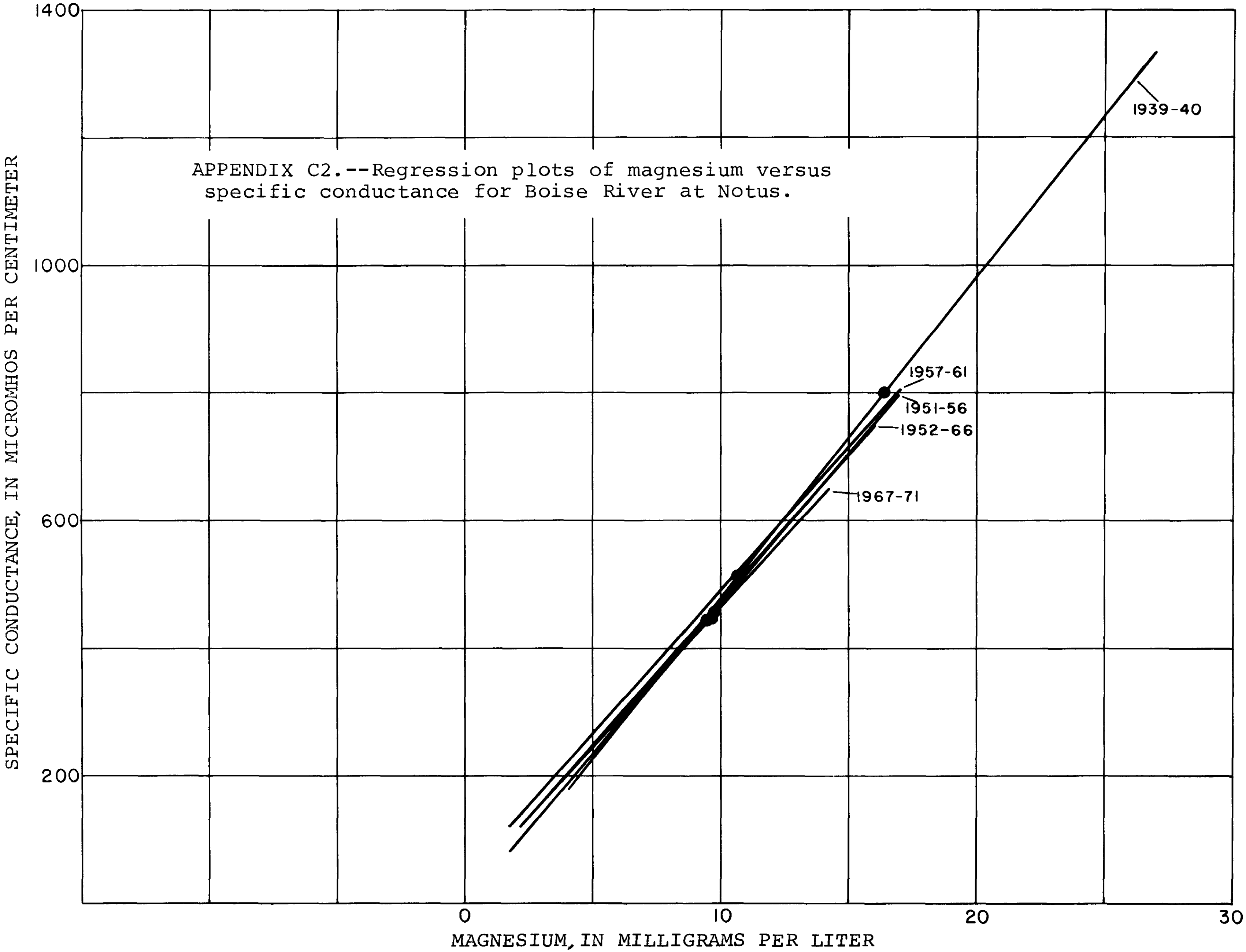
Boise River at Notus, Idaho

PARAMETER	Conductivity Correlation Coefficient					Discharge Correlation Coefficient				
	1939-40	1951-56	1957-61	1962-66	1967-71	1939-40	1951-56	1957-61	1962-66	1966-71
Discharge	.728**	.828**	.774**	.775**	.792**					
SiO_2	.762**	.956**	.786**	.950**	.760**	.649*	.751**	.409	.543*	.304
Ca	.874**	.978**	.964**	.972**	.927**	.575**	.798**	.785**	.639**	.701**
Mg	.992**	.978**	.980**	.960**	.976**	.749**	.801**	.836**	.646**	.736**
Na		.991**	.974**	.987**	.986**		.879**	.790**	.806**	.798**
K		.687**	.882**	.952**	.663**		.620**	.680*	.636**	.726**
HCO_3	.899**	.995**	.968**	.986**	.974**	.657**	.841**	.582**	.719**	.711**
SO_4	.993**	.995**	.995**	.993**	.992**	.763**	.855**	.858**	.740**	.889**
Cl	.955**	.974**	.971**	.960**	.948**	.767**	.877**	.871**	.765**	.894**
Dis.Solids	.996**	.999**	.998**	.997**	.979**	.784**	.853**	.746**	.764**	.782**
Spec. Cond.						.766**	.858**	.745**	.767**	.788**
Hardness	.954**	.985**	.968**	.980**	.959**	.663**	.806**	.665**	.700**	.718**
Noncarb.Hrd.	.736**					.667**				
B		.466**	.366	.683**	-.326		.180	.534**	-.192	-.250
Na %		.863**	.664*	.821**	.756**		.906**	.840**	.904**	.790**
F		.502**	.855**	.802**	.892**		.437**	.701**	.537**	.790
pH		.688**	.371**	.476**	-.099		.690**	.459**	.450**	-.049
Color		-.086			.243		-.110			-.422
NO_3	.151	.368**	.700**	.663**	.493**	-.037	.333**	.513**	-.160	-.098

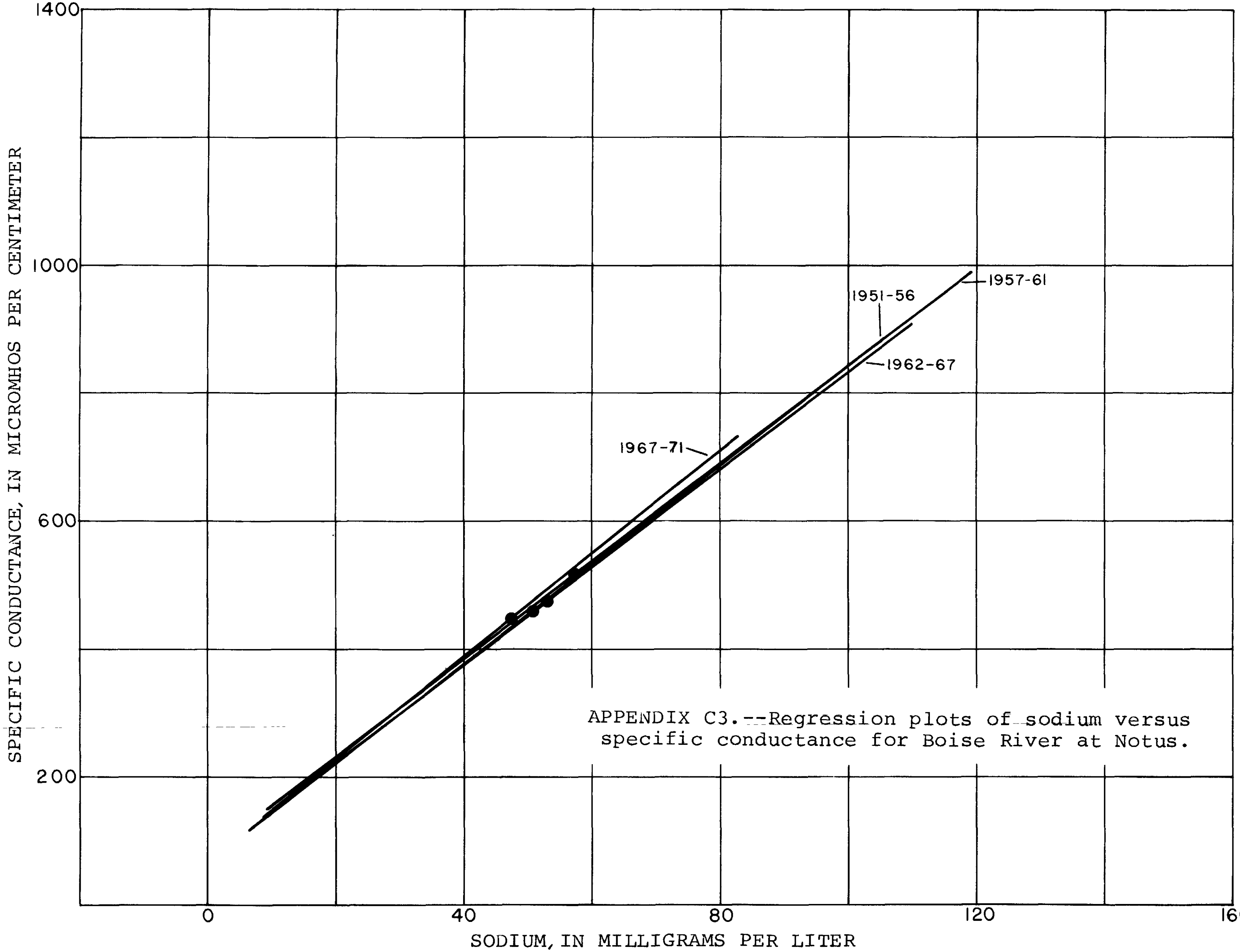
Appendix C -- Plots of specific conductance against selected dissolved ions for station 13-2125, Boise River at Notus, Idaho, 1939-40



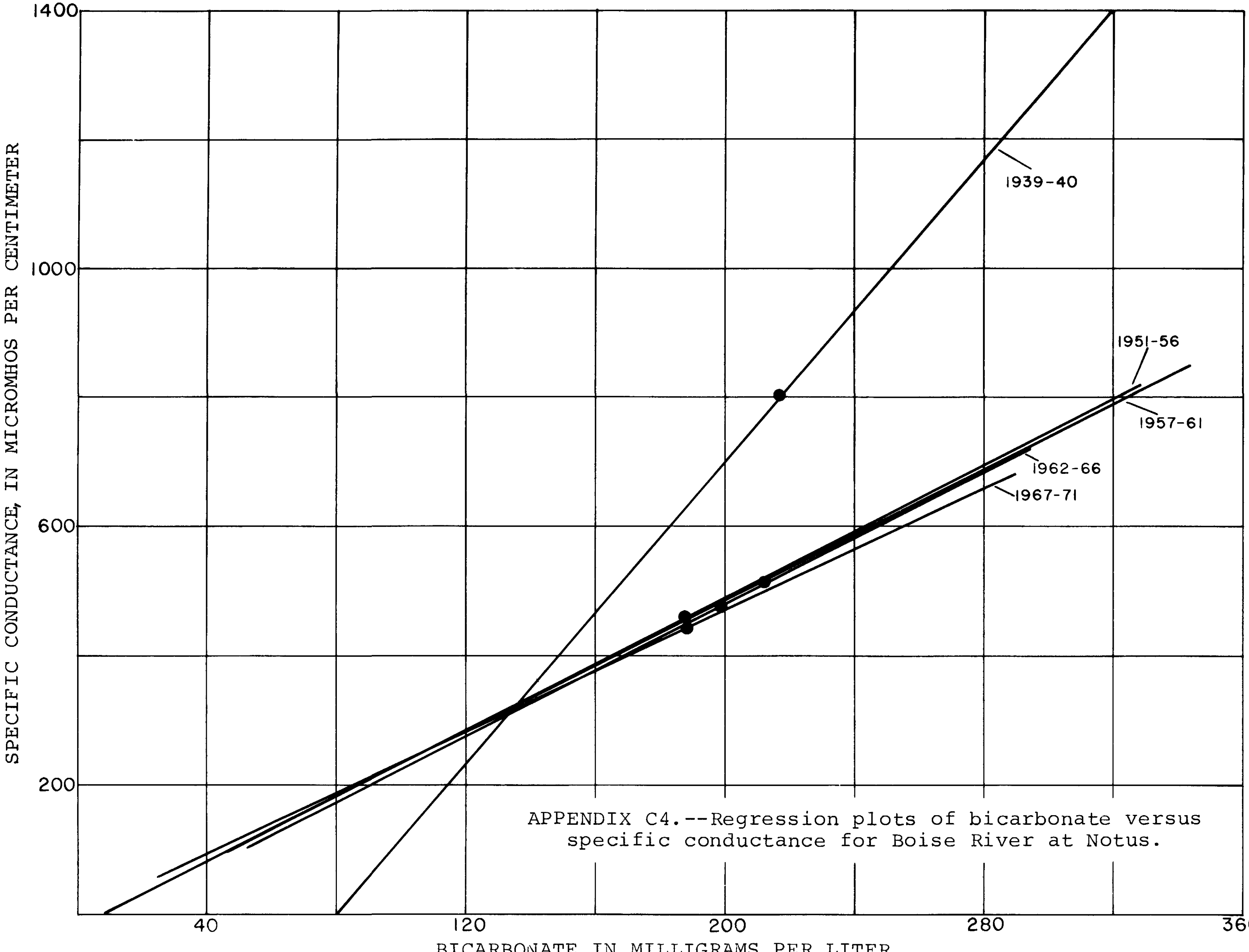
APPENDIX C1.-- Regression plots of calcium versus specific conductance for Boise River at Notus, Idaho



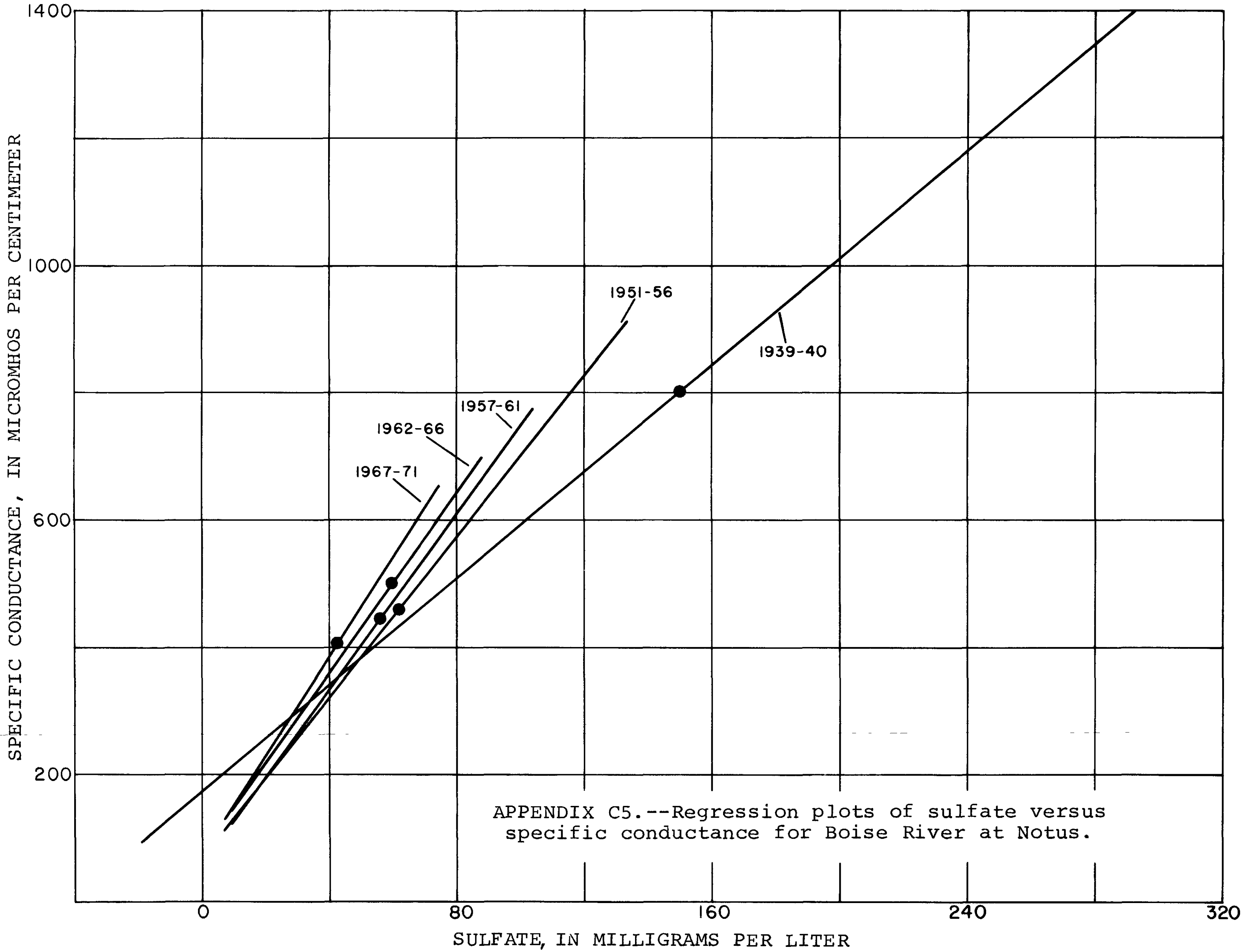
APPENDIX C2.--Regression plots of magnesium versus specific conductance for Boise River at Notus.



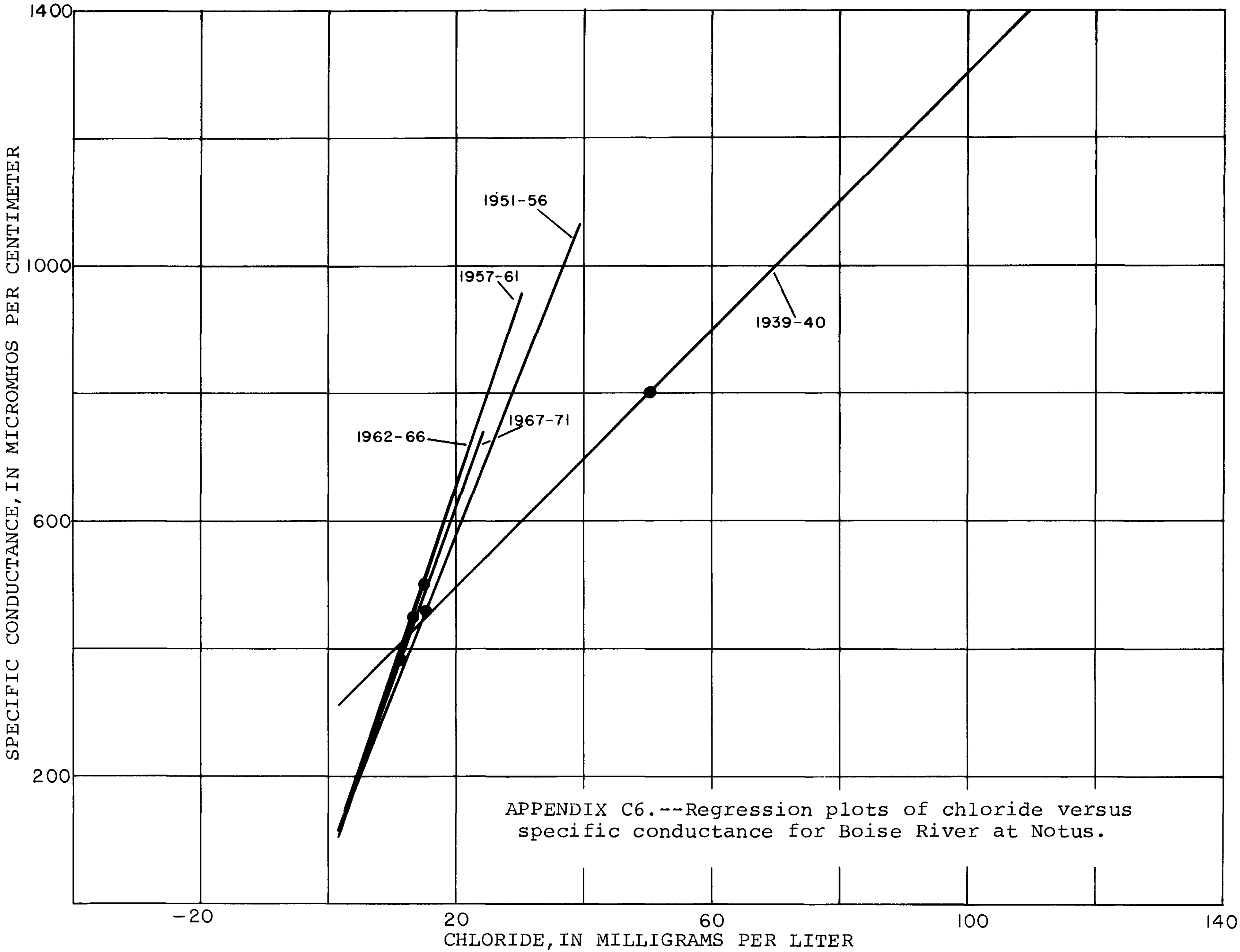
APPENDIX C3.--Regression plots of sodium versus specific conductance for Boise River at Notus.



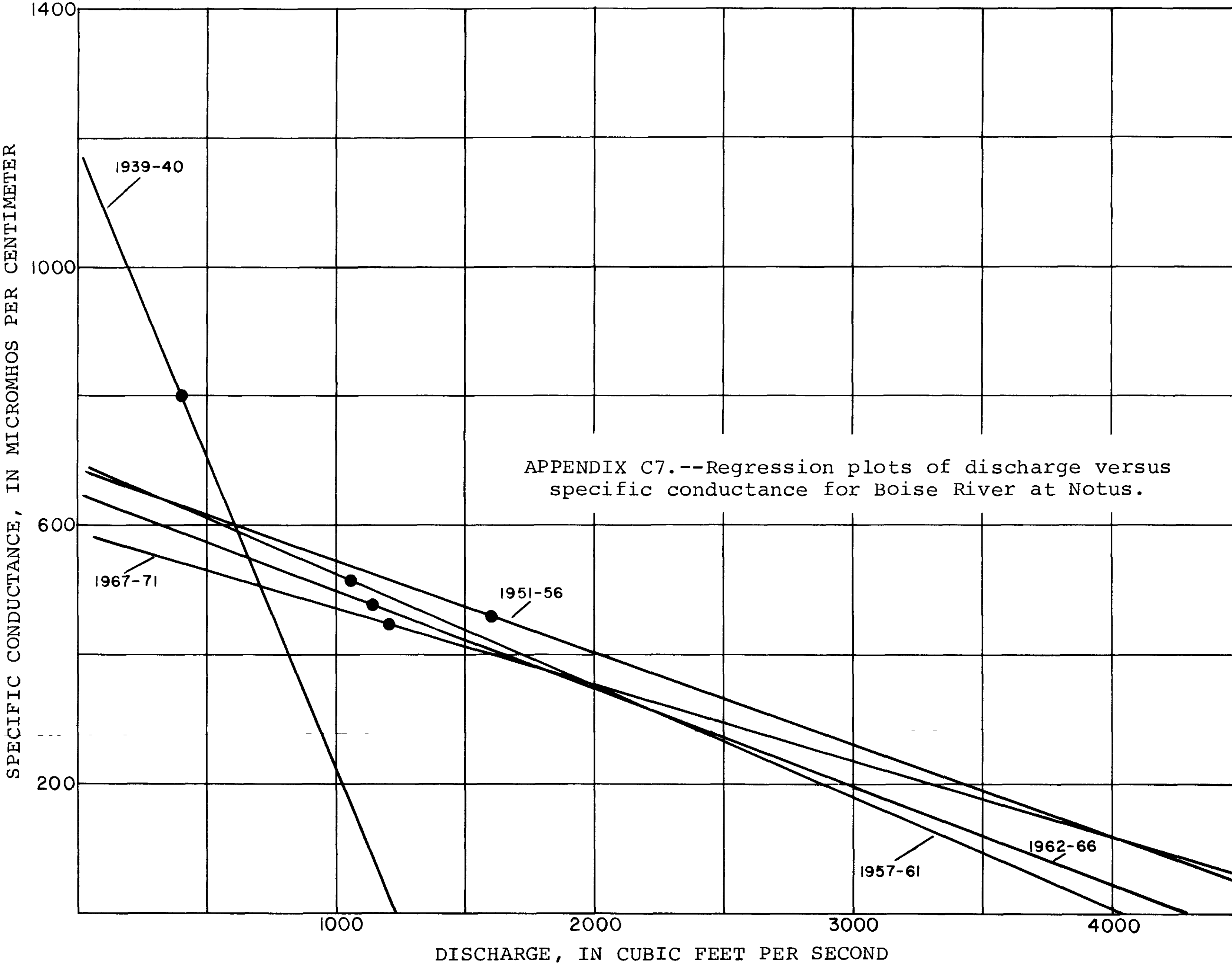
APPENDIX C4.--Regression plots of bicarbonate versus specific conductance for Boise River at Notus.



APPENDIX C5.--Regression plots of sulfate versus specific conductance for Boise River at Notus.



APPENDIX C6.--Regression plots of chloride versus specific conductance for Boise River at Notus.



APPENDIX C7.--Regression plots of discharge versus specific conductance for Boise River at Notus.

Appendix D -- Standard errors of estimate as percentage of mean calculated from regressions against specific conductance

Bear River at Border, Wyo.

Standard error of estimate as % of mean (Calculated from specific conductivity)

PARAMETER	1966-71
Discharge	
SiO_2	18.9
Ca	11.0
Mg	11.5
Na	16.4
K	42.3
HCO_3	8.6
SO_4	16.9
Cl	17.5
Dis. Solids	4.0
Spec. Cond.	
Hardness	5.3
Noncarb. Hrd.	35.5
B	66.7
Na %	16.7
F	39.4
pH	3.0
Color	
NO_3	.102

Snake River near Heise, Idaho

Standard error of estimate as % of mean
(Calculated from specific conductivity)

PARAMETER	1953-56	1957-61	1962-66	1967-71
Discharge	48.7	46.7	59.2	50.9
SiO_2	13.9	21.1	12.4	22.1
Ca	4.9	3.3	2.5	5.2
Mg	6.2	6.1	6.3	5.2
Na	13.8	12.1	8.9	10.3
K	19.7	11.6	7.4	13.0
HCO_3	5.1	3.2	3.1	4.8
SO_4	8.3	7.3	5.3	9.8
Cl	12.3	17.9	8.4	17.7
Dis.Solids	1.6	2.4	2.5	5.6
Spec. Cond.				
Hardness	3.6	2.8	2.7	3.7
Noncarb.Hrd.	10.8	10.5	9.9	14.3
B	36.7	48.0	79.2	83.4
Na %	18.1	13.2	15.9	9.5
F	33.4	30.4	16.4	16.4
pH	2.1	4.4	2.2	3.0
Color	38.4			112.0
NO_3	49.6	49.3	49.7	63.8

Snake River at King Hill, Idaho

Standard error of estimate as % of mean (Calculated from specific conductivity)

PARAMETER	1951-56	1957-61	1962-66	1967-71
Discharge	21.7	19.6	32.7	33.3
SiO_2	8.2	5.0	10.5	24.3
Ca	4.4	4.6	5.1	7.0
Mg	4.7	7.3	5.0	5.2
Na	4.4	4.1	5.7	6.5
K	20.6	8.9	6.0	5.3
HCO_3	1.9	2.6	2.7	5.5
SO_4	3.5	4.0	3.3	7.3
Cl	5.4	4.1	2.9	12.0
Dis.Solids	1.5	2.0	2.2	6.0
Spec. Cond.				
Hardness	3.2	2.8	2.9	3.7
Noncarb.Hrd.	25.2	24.4	21.7	38.8
B	64.9	38.8	52.4	36.9
Na %	4.6	3.7	5.6	6.2
F	15.2	10.7	12.3	19.5
pH	1.9	3.0	2.3	2.2
Color	47.0		50.3	100.2
NO_3	17.1	11.8	13.4	58.8

ɔise River at Notus, Idaho

Standard error of estimate as % of mean
(Calculated from specific conductivity)

PARAMETER	1939-40	1951-56	1957-61	1962-66	1967-71
Discharge	74.1	63.4	82.8	82.0	82.2
SiO_2	8.4	8.4	12.0	7.5	37.3
Ca	12.3	8.7	12.1	6.5	12.0
Mg	4.9	10.0	10.8	9.8	8.0
Na		7.1	9.8	6.9	6.6
K		30.2	14.7	7.6	40.3
HCO_3	12.0	4.3	9.0	5.9	7.9
SO_4	5.9	5.3	5.3	4.9	6.6
Cl	19.3	12.8	13.6	11.1	18.1
Dis.Solids	3.3	2.1	2.4	2.9	7.1
Spec. Cond.					
Hardness	8.6	7.5	8.8	6.7	9.2
Noncarb.Hrd.	127.9	0.0	0.0	0.0	0.0
B		47.5	53.4	47.5	39.8
Na %		7.6	9.4	5.3	7.8
F		19.9	18.1	9.1	11.1
pH		2.8	4.5	3.0	5.0
Color		53.7			57.0
NO_3	59.9	35.6	36.3	28.1	69.2

* U.S. Government Printing Office: 1973—797-937/5 10