QUALITY-ASSURANCE DATA FOR ROUTINE WATER ANALYSIS IN THE LABORATORIES OF THE U.S. GEOLOGICAL SURVEY FOR WATER YEAR 1985

By Keith J. Lucey and Dale B. Peart

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ABSTRACT

The U.S. Geological Survey maintains a quality-assurance program based on the analysis of reference samples for its two water-analysis laboratories located in Atlanta, Georgia, and Denver, Colorado. Reference samples containing selected inorganic constituents are prepared at the Survey's Ocala, Florida, office, disguised as routine samples, and sent daily or weekly, as appropriate, to each laboratory through other Survey offices. The results are stored permanently in the National Water Data Storage and Retrieval System (WATSTORE), the Survey's data base for all water data. These data are analyzed statistically for precision, bias, and comparability. The results of these statistical analyses are discussed for data collected during water year 1985. Nutrient samples, simulated-precipitation (low-concentration) samples, and selected pesticide samples also were submitted as samples of unknown concentrations. The results were analyzed statistically for comparability, and these data also are discussed.

An overall evaluation of the major and trace constituent data for water year 1985 indicated a lack of precision in the Atlanta laboratory for the determination of seven constituents and in the Denver laboratory for eight constituents. There were fewer constituents showing positive or negative bias during water year 1985 than in water year 1984 at both laboratories. A biased condition existed in the determination of 16 common constituents at both laboratories. Finally, if any constituent determined by the total recoverable method indicated bias, the bias tended to be positive.

Both laboratories performed similarly for all constituents in nutrient samples. Significant differences were indicated in the data for one constituent in the simulated-precipitation samples and for two constituents in the pesticide samples.

INTRODUCTION

The water-quality laboratories of the U.S. Geological Survey, located in Atlanta, Ga., and Denver, Colo., routinely analyze water, suspended sediment, streambed, and lakebed materials for inorganic constituents, many organic substances, including common pesticides, priority pollutants as defined by the U.S. Environmental Protection Agency (Keith and Telliard, 1979), and some physical properties. Results of the quality-assurance program used to monitor the quality of work at these two laboratories are discussed in this report. Previous reports (Peart and Thomas, 1983a, 1983b, 1984; Peart and Sutphin, 1987) document results from February 1981 through September 1984.

Factors that need to be considered for data interpretation for October 1984 through September 1985 in conjunction with the results presented in this report include the following:

1. Nonanalytical errors were not corrected so the data are preserved as the laboratory produced them. Therefore, if the data reviewer, in the Survey's office that collected the sample, is familiar with the collection site or the historical data from that site, many errors of this type easily could be corrected. For example, two samples from different sites are submitted to the laboratory on the same day and are misidentified in a way that the analytical data reported for one would actually belong to the other. A data reviewer who was familiar with the site or its historical data usually could detect the problem and correct it.

2. No quality-assurance samples had any constituents redetermined except those requested by the laboratory quality-assurance group. Survey data reviewers in the offices that collected the samples are expected to scrutinize incoming new data for discrepancies and make requests for reanalysis. These requests may result in the detection of analytical and nonanalytical errors, and data quality would improve, when compared to data quality presented in this report.

3. Figures included in this report may be used to determine analytical conditions at any given time for water year 1985. Where figures show that an analytical process has been in statistical control for most of the year, but the process also has been out of statistical control for a certain period, that period may be long enough that the statistical tests applied indicate lack of precision or significant bias for the year. The data from that period when the analytical process was in control can be considered to have acceptable precision and bias.

During water year 1985, the following constituents were included in this quality-assurance program:

Inorganic constituents--alkalinity, aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, copper, dissolved solids (residue on evaporation), fluoride, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, potassium, selenium, silica, silver, sodium, strontium, sulfate, and zinc.

Nutrients--ammonia, as nitrogen; ammonia plus organic nitrogen as nitrogen; carbon, organic, dissolved; carbon, organic, total; nitrite plus nitrate as nitrogen; orthophosphate as phosphorus; and phosphorus.

Constituents in simulated-precipitation samples--minute concentrations of: ammonia, as nitrogen; bromide; calcium; chloride; fluoride; magnesium; nitrate; as nitrogen; orthophosphate, as phosphorus; phosphorous; potassium; sodium; and sulfate.

Pesticides--organophosphate and organochlorine insecticides and chlorophenoxyacid herbicides.

PROGRAM DESCRIPTION

Standard reference water samples (SRWS's) (Skougstad and Fishman, 1975; Schroder and others, 1980) are used as the principal component of the reference samples used in this program. The SRWS's are diluted with deionized water, mixed in varying proportions with other SRWS's, or used undiluted. A large range of concentrations of chemical constituents is achieved, thereby increasing the number of unique samples available for quality-assurance purposes. This increase, in turn, decreases the probability that quality-assurance samples will be recognized in the laboratory because of frequency of analyses or unique sample behavior.

In addition to the SRWS's, synthetic samples made from reagent-grade chemicals are used in preparing reference samples. All samples are prepared in the Survey's Ocala, Fla., office, and are made to appear as much like environmental samples as possible. This preparation is coordinated with other Survey offices that will be shipping the samples during any particular calendar month. When the samples are prepared and proper forms are completed to ensure that appropriate constituents have been requested for the sample, the samples and the forms are shipped to selected Survey offices across the country. These Survey offices then ship the quality-assurance samples to the laboratories on a daily or weekly basis, as appropriate, with their regular samples.

The number of quality-assurance determinations requested for inorganic constituents and nutrients are in direct proportion to the total number of requests for those determinations from all sources in the laboratory. The program goal is to have at least one quality-assurance sample analyzed daily for those constituents that are analyzed daily, and, similarly, to have an appropriate number of quality-assurance samples analyzed for those constituents determined less frequently. Simulated-precipitation and pesticide samples were submitted once each week.

All constituents in the reference materials are in the dissolved phase because the reference materials themselves have been filtered in the preparation process. Therefore, those constituents in this report that are designated as "total recoverable" are from reference samples that have undergone a digestion process (Skougstad and others, 1979, p 21–22) during analysis, rather than from unfiltered or whole-water samples. Differences that appear in this report between the dissolved analyses and the total recoverable analyses will be due largely or entirely to the digestion process rather than from any difference in the sampling techniques or sample source.

Quality-assurance samples are processed by each laboratory as routine samples, including the normal laboratory quality-control and quality-assurance procedures. The data then are stored in the Survey's National Water Data Storage and Retrieval System (WATSTORE). After being processed by the laboratories, data from these quality-assurance samples will indicate the quality of the analytical data that the laboratories produce for environmental samples. Laboratory errors, other than those related to analytical chemistry, also will be included in these data. These errors include any made in logging the sample into the laboratory, transcription errors by the analyst, and keypunching errors. No effort was made to correct nonanalytical errors of this type, even when it was obvious which corrective measures were appropriate, and the laboratories' data were preserved as they produced them. Therefore, if a data user is capable of detecting errors of this type, the user can increase the quality of the data, when compared to those data presented in this report.

STATISTICAL EVALUATION

The SRWS's initially are analyzed by many laboratories throughout the United States, using several different analytical methods. The results are compiled by calculating the means, standard deviations, and 95-percent confidence limits and by applying a rejection routine (American Society for Testing and Materials, 1980). Resultant means are the most probably correct values or the most probable values (MPV's). These MPV's are used in this quality-assurance program for comparison with laboratory data. For reference samples composed of a mixture of two SRWS's, or SRWS's and deionized water, the MPV's for each constituent are weight-averaged according to their respective percentage contributions to determine a new set of MPV's for the mixture.

Standard deviations were determined by using linear least squares equations developed by regressing the means of each constituent obtained from all the SRWS's for which data existed against the corresponding standard deviations for those constituents. This method enabled an estimation of a most probable standard deviation (MPSD) for each constituent on a sample-by-sample basis to ascertain whether the determination in question was statistically in or out of control. The standard deviations are specific to the analytical methods used in the two Survey laboratories and are documented in Friedman and Fishman (in press). An individual reported value was considered acceptable if it was within two standard deviations of the MPV.

In certain situations, the standard deviation criterion was impossible to meet; this was true for cadmium, chromium, copper, lead, molybdenum, silver, and zinc. An administrative decision was made to establish a minimum standard deviation for each of these constituents equal to three-quarters of the value of the reporting level to allow at least one reportable value on each side of the MPV to be accepted. For example, the minimum standard deviation for copper reported to the nearest 10 µg/L (micrograms per liter) is set to 7.5 µg/L; the minimum standard deviation for silver, reported to the nearest 1 µg/L, is 0.75 µg/L.

The number of standard deviations each constituent differs from the MPV was calculated by dividing the difference of the reported value and the MPV by the MPSD. This number was used in determining precision and bias. The results for each laboratory and each constituent are shown in figures 1 through 106 in the "Supplemental Data" section at the back of this report. Three symbols are used in the figures to indicate results from the lower (+), middle (x), and upper (o) one-thirds of the potential analytical range tested in this program. This range does not necessarily correspond with the analytical capabilities of the laboratory instrumentation or methods but rather corresponds with the analytical range tested using the available SRWS's or other reference samples. The three parts of this range are based on the MPV's of the quality-assurance samples and not on the reporting policy; for example, available resources limit the maximum MPV for sodium to be 119.0 mg/L (figs. 93 and 94) and still allow a correctly reported value of 120 mg/L, based on the policy to report sodium to the nearest 10 mg/L at this concentration. Not all figures will show all three parts of the analytical range, because some flexibility is given to the Ocala, Fla., office in sample selection. Points outside the range of the plots are forced to appear at the limit (±6 standard deviations), with the actual number of standard deviations indicated adjacent to the point (see Figure 2 for example).

Precision and bias are determined by applying binomial-probability-distribution equations to the data using procedures described by Friedman, Bradford, and Peart, (1983); and by Peart and Thomas, (1983a). When precision is determined using these procedures, it contains an element of bias because MPV's, rather than analyzed means, are used as the basis for determining the number of standard deviations each constituent deviates from that value. Therefore, in this analysis, precision, or lack of it, is based on whether or not the analytical process was statistically in or out of control. Figures 1-106 are control charts.

Calculation of means and relative standard deviations (Miller and Freund, 1977) were made for each major constituent with sufficient data. Because standard deviations may vary proportionally as constituent concentration in chemical analyses varies, these calculations were done separately for individual sample mixtures; therefore, the resultant standard deviations do not result in overall evaluations of the analytical processes. Relative standard deviations for inorganic constituents were calculated and plotted as a percent against their mean concentrations (figures 107 through 210 in the "Supplemental data" section at the back of this report.) These plots allow a data reviewer to estimate the error at any concentration shown for all constituents. For example, the precision of the alkalinity values from the Atlanta laboratory are estimated to be ±1 percent from figure 107. The precision of the alkalinity values from the Denver laboratory are estimated to be ±3 percent from figure 108 . If the relative standard deviation for a given mix has a value of zero, the data point will plot on the horizontal axis, as in figures 119, 195, and 196. There are no data points in figure 167 but the plot was kept in the report to maintain the established format, enabling the same data from the two laboratories to be shown on the same page.

Because of an insufficient supply of SRWS's for nutrients and pesticides, most of the reference materials for these categories were made from reagent-grade chemicals in the Ocala, Fla., office. Preparation methods used for these samples were virtually the same as those used for preparing samples for the SRWS program. Simulated-precipitation samples were either SRWS's initially prepared with minute constituent concentrations or were regular SRWS's that were diluted so that the constituent concentrations were similar to those in natural precipitation. However, because of a lack of stability data for these samples and because there were no independent analyses for most of them, these samples were processed as split samples of unknown concentrations and statistical tests were used to determine whether or not significant differences existed at the 95-percent confidence level between the performances of the two laboratories.

To determine a measure of comparability between the two laboratories for nutrient, simulated-precipitation, and pesticide samples, the analytical data were evaluated using a paired t statistic. Using this procedure, each mixture is compared separately so that the actual concentration differences between mixtures did not affect the outcome of the test.

COMPARISON OF STATISTICAL DATA FOR INORGANIC-CONSTITUENT SAMPLES BETWEEN LABORATORIES

Several data points seemed to be in error because of an incorrectly applied dilution factor. Dilutions of the sample are made routinely in the laboratory to bring the sample concentration into analytical range. If the dilution factor is not applied or is applied incorrectly, the reported value will be in error by the amount of the dilution factor. For example, if several analyses of a solution result in reported values of 250 mg/L each and one analysis results in a reported value of 25 mg/L, a 10X dilution may have been used and not applied to the final results. These kinds of errors are difficult to confirm. Their detection and correction in the field offices will increase the reliability of the data above that stated in this report.

Precision

The results of statistical testing for lack of precision for each inorganic constituent are presented in table 1. For each constituent, this table indicates significant lack of precision (indicated by "LOP") as well as all acceptable results (indicated by "+").

Evaluating the data for the year, cadmium (AA); cobalt, total recoverable; dissolved solids; fluoride; iron, total recoverable; lead, total recoverable; and selenium indicated LOP in the Atlanta laboratory. Barium, total recoverable; fluoride; iron, total recoverable; magnesium (AA); molybdenum (AA); selenium; sodium (AA); and zinc (ICP) indicated LOP in the Denver laboratory. Constituents indicating LOP in both laboratories during 1985 are fluoride; iron, total recoverable and selenium.

Iron, total recoverable, failed the precision criteria in the Atlanta laboratory during water year 1985 as it did during water years 1982, 1983, and 1984. Dissolved solids also indicated lack of precision during water years 1983 and 1984 and again during water year 1985. In the Denver laboratory, molybdenum (AA) failed the precision criteria during water years 1984 and 1985 (Peart and Thomas, 1983b, 1984; Peart and Sutphin, 1987).

In the Atlanta laboratory during water year 1985, barium (ICP); chromium, total recoverable; and molybdenum (AA) had acceptable results after failing the precision tests during water year 1984. In the Denver laboratory, barium (ICP); copper, total recoverable; iron (AA); lead (AA); lead, total recoverable; and nickel, total recoverable, had acceptable results during water year 1985 after having a lack of precision during water year 1984 (Peart and Sutphin, 1987).

Bias

Results of the statistical tests for bias are shown in table 2. When the method described in the Statistical Evaluation section was used, bias could not be determined when results from less than eight samples were available. This situation occurred for antimony at both laboratories during the year.

There were fewer constituents indicating bias for water year 1985 than for water year 1984 at the Atlanta laboratory (Peart and Sutphin, 1987). Negatively biased constituents, consistent with results for water year 1984, were: arsenic, boron, and nickel. Additional constituents that had negative bias during water year 1985 that indicated none during the previous water year were: barium (ICP), cobalt (ICP), copper (ICP), iron (AA), lithium, manganese (AA), and molybdenum (AA). Results for manganese (ICP) indicate a negative bias for water year 1985 after having a positive bias in water year 1984. The bias results for nickel during water year 1985 were similar to those for the three previous water years.

Table 1. *Results of statistical testing for lack of precision in inorganic constituent data from the Atlanta and Denver laboratories*

[+, acceptable results; ICP, inductively coupled plasma emission spectrometry; AA, atomic absorption spectrometry; LOP, significant lack of precision]

Constituent (dissolved, except as indicated)	Results from the Atlanta laboratory Oct. 1984–Sept. 1985	Results from the Denver laboratory Oct. 1984–Sept. 1985
Alkalinity	+	+
Aluminum	+	+
Antimony	+	+
Arsenic	+	+
Barium (ICP)	+	+
Barium (AA)	+	+
Barium, total recoverable	+	LOP
Beryllium	+	+
Boron	+	+
Cadmium (ICP)	+	+
Cadmium (AA)	LOP	+
Cadmium, total recoverable	+	+
Calcium (ICP)	+	+
Calcium (AA)	+	+
Chloride	+	+
Chromium	+	+
Chromium, total recoverable	+	+
Cobalt (ICP)	+	+
Cobalt (AA)	+	+
Cobalt, total recoverable	LOP	+
Copper (ICP)	+	+
Copper (AA)	+	+
Copper, total recoverable	+	+
Dissolved solids	LOP	+
Fluoride	LOP	LOP
Iron (ICP)	+	+
Iron (AA)	+	+
Iron, total recoverable	LOP	LOP
Lead (ICP)	+	+
Lead (AA)	+	+
Lead, total recoverable	LOP	+
Lithium	+	+
Magnesium (ICP)	+	+
Magnesium (AA)	+	LOP
Manganese (ICP)	+	+
Manganese (AA)	+	+
Manganese, total recoverable	+	+
Molybdenum (ICP)	+	+
Molybdenum (AA)	+	LOP

Table 1. *Results of statistical testing for lack of precision in inorganic constituent data from the Atlanta and Denver laboratories* **continued**

Constituent (dissolved, except as indicated)	Results from the Atlanta laboratory Oct. 1984–Sept. 1985	Results from the Denver laboratory Oct. 1984–Sept. 1985
Nickel	+	+
Nickel, total recoverable	+	+
Potassium	+	+
Selenium	LOP	LOP
Silica	+	+
Silver	+	+
Silver, total recoverable	+	+
Sodium (ICP)	+	+
Sodium (AA)	+	LOP
Strontium	+	+
Sulfate	+	+
Zinc (ICP)	+	LOP
Zinc (AA)	+	+
Zinc, total recoverable	+	+

Table 2. *Results of statistical testing for bias in inorganic constituent data from the Atlanta and Denver laboratories*

[+, acceptable results; N, negative bias; *, too few analyses to determine; ICP, inductively coupled plasma emission spectrometry; AA, atomic absorption spectrometry; P, positive bias]

Constituent (dissolved, except as indicated)	Results from the Atlanta laboratory Oct. 1984–Sept. 1985	Results from the Denver laboratory Oct. 1984–Sept. 1985
Alkalinity	+	N
Aluminum	+	N
Antimony	*	*
Arsenic	N	N
Barium (ICP)	N	N
Barium (AA)	P[1]	P[1]
Barium, total recoverable	P[1]	P[1]
Beryllium	+	+
Boron	N	N
Cadmium (ICP)	+	+
Cadmium (AA)	+	P
Cadmium, total recoverable	+	P
Calcium (ICP)	+	P
Calcium (AA)	+	+

Table 2. *Results of statistical testing for bias in inorganic constituent data from the Atlanta and Denver laboratories* **continued**

Constituent (dissolved, except as indicated)	Results from the Atlanta laboratory Oct. 1984–Sept. 1985	Results from the Denver laboratory Oct. 1984–Sept. 1985
Chloride	+	+
Chromium	P[1]	P[1]
Chromium, total recoverable	+	P[1]
Cobalt (ICP)	N	N
Cobalt (AA)	+	+
Cobalt, total recoverable	+	+
Copper (ICP)	N	+
Copper (AA)	+	N
Copper, total recoverable	+	+
Dissolved solids	P	P
Fluoride	P	+
Iron (ICP)	P	+
Iron (AA)	N	P
Iron, total recoverable	+	+
Lead (ICP)	P	P
Lead (AA)	P	+
Lead, total recoverable	+	+
Lithium	N	N
Magnesium (ICP)	+	P
Magnesium (AA)	+	+
Manganese (ICP)	N	+
Manganese (AA)	N	+
Manganese, total recoverable	+	+
Molybdenum (ICP)	+	+
Molybdenum (AA)	N	N
Nickel	N	N
Nickel, total recoverable	+	+
Potassium	+	N
Selenium	+	P
Silica	+	P
Silver	+	+
Silver, total recoverable	+	+
Sodium (ICP)	+	P
Sodium (AA)	+	+
Strontium	+	+
Sulfate	P	P
Zinc (ICP)	P	P
Zinc (AA)	+	P
Zinc, total recoverable	P	P

[1]Bias occurs because some most probable values are less than the lowest reporting limit.

For the Atlanta laboratory, positively biased constituents during water year 1985, consistent with results for water year 1984, were: dissolved solids, fluoride, iron (ICP), lead (ICP), sulfate, and zinc (ICP). Additional constituents that had positive bias in 1985, and indicated no bias during water year 1984 were barium (AA); barium, total recoverable; chromium; lead (AA); and zinc, total recoverable (Peart and Sutphin, 1987).

There were fewer constituents showing bias during water year 1985 than during water year 1984 at the Denver laboratory. Negatively biased constituents, consistent with results for water year 1984, were: aluminum, arsenic, barium (ICP), boron, molybdenum (AA), nickel, and potassium. Additional constituents that indicated negative bias during water year 1985 that did not have a negative bias during water year 1984 were: cobalt (ICP), copper (AA), and lithium. Results for alkalinity also indicate a negative bias after having a positive bias during water year 1984. Positively biased constituents consistent with results for water year 1984 were: chromium; chromium, total recoverable; iron (AA); lead (ICP); magnesium (ICP); selenium; silica; sodium (ICP); sulfate; zinc (ICP); zinc (AA); and zinc, total recoverable. Additional positively biased constituents that indicated no bias during water year 1984 were: barium (AA); barium, total recoverable: cadmium (AA); cadmium, total recoverable; and calcium (ICP). Finally, results for dissolved solids had a positive bias during water year 1985 after having a negative bias during water year 1984.

There were no predominant patterns for bias between dissolved versus total recoverable analyses or between ICP and AA determinations for either laboratory. For barium (AA); barium, total recoverable; chromium; and chromium, total recoverable, a biased condition occurred because the minimum reporting levels (chromium, 10 μg/L and barium, 100 μg/L) were greater than the MPV's. In general, if a constituent determined by the total recoverable method indicated bias, the bias tended to be positive.

Because the Denver laboratory has more constituents that indicate bias than does the Atlanta laboratory, the problems related to bias seem unlikely to be inherent in the methods used for determination of these constituents, except where that bias is persistent in both laboratories. During water year 1985 the following eight constituents had positive bias in both laboratories: barium (AA); barium, total recoverable; chromium; dissolved solids; lead (ICP); sulfate; zinc (ICP) and zinc, total recoverable. The following seven constituents had negative bias in both laboratories: arsenic, barium (ICP), boron, cobalt (ICP), lithium, molybdenum (AA), and nickel. When quality assurance data from previous years are used, (Peart and Sutphin, 1987) a persistent bias is indicated for arsenic, boron, lead (ICP), nickel, sulfate, and zinc (ICP); that is, only these five constituents have failed the bias test for the past 2 years in both laboratories.

The control chart for dissolved alkalinity shows a trend to a negative bias beginning in the first quarter of water year 1985 at the Denver laboratory (fig. 2). The change from ±0.25 standard deviation from the MPV to -1.0 standard deviation by the end of the water year may be due to a deterioration in one or more instrumental components. The determination of dissolved alkalinity at the Atlanta laboratory remained ±0.5 standard deviation from theoretical throughout the water year (fig. 1).

The control charts for dissolved boron (figs. 17 and 18), dissolved solids (figs. 47 and 48), and dissolved fluoride (figs. 49 and 50) indicate more consistent results at the Denver laboratory than at the Atlanta laboratory. Interestingly, the determination of dissolved calcium by the ICP method tended to have a negative bias at the Atlanta laboratory (fig. 25) and a positive bias at the Denver laboratory (fig. 26).

Figure 78 indicates a problem in the determination of dissolved molybdenum by the AA method at the Denver laboratory during the months of April and May when the number of standard deviations from the MPV increased substantially. During this period, results of the Atlanta laboratory remained in control (fig. 77).

Several factors may have affected the results for other constituents that indicated occasional bias; the factors may include deterioration of standard calibrating solutions or reagents, improper or inaccurate reagent or standard-solution preparation, undetected problems with analytical instrumentation, undefined matrix effects caused by mixing together two very different SRWS's, reporting levels being higher than the MPV's or undetected contamination. When bias is statistically significant but precision is acceptable, the bias may have minimal effect on data interpretation and minimal practical significance.

COMPARISON OF STATISTICAL DATA FOR NUTRIENT, SIMULATED-PRECIPITATION, AND PESTICIDE SAMPLES BETWEEN LABORATORIES

As explained in the Statistical evaluation section, the nutrient samples were treated as split samples of unknown concentrations. The yearly summaries in table 3 indicate that both laboratories reported similar results for all nutrient constituents.

Table 3. *Results of statistical evaluation for comparison of means and standard deviations for nutrient samples between the Atlanta and Denver laboratories*

[A, no significant difference]

Constituent	Comparison of means	Comparison of standard deviations
Ammonia, as nitrogen	A	A
Ammonia plus organic nitrogen, as nitrogen	A	A
Carbon, organic, dissolved	A	A
Carbon, organic, total	A	A
Fluoride	A	A
Nitrate plus nitrite, as nitrogen	A	A
Nitrite, as nitrogen	A	A
Orthophosphate, as phosphorus	A	A
Phosphorus	A	A

Data for simulated-precipitation samples are summarized in table 4. No significant difference occurs in the mean values reported by the two laboratories for any constituents in this category; however, there is a significant difference in the standard deviation results for potassium.

The pesticide data in table 5 show that all constituents, except for DDE and Dieldrin, compare well between the laboratories. The means are significantly different for DDE and Dieldrin. The standard deviations are significantly different only for DDE.

Table 4. *Results of statistical evaluation for comparison of means and standard deviations for simulated-precipitation samples between the Atlanta and Denver laboratories*

[A, no significant difference; B, significant difference]

Constituent	Comparison of means	Comparison of standard deviations
Ammonia, as nitrogen	A	A
Bromide	A	A
Calcium	A	A
Chloride	A	A
Fluoride	A	A
Magnesium	A	A
Nitrate,	A	A
Orthophosphate, as phosphorus	A	A
Phosphorus	A	A
Potassium	A	B
Sodium	A	A
Sulfate	A	A

Table 5. *Results of statistical evaluation for comparison of means and standard deviations for pesticide samples between the Atlanta and Denver laboratories*

[A, no significant difference, B, significant difference]

Constituent	Comparison of means	Comparison of standard deviations
2, 4-D	A	A
2, 4-DP	A	A
2, 4 5-T	A	A
Aldrin	A	A
DDD	A	A
DDE	B	B
DDT	A	A
Diazinon	A	A
Dieldrin	B	A
Endrin	A	A
Ethion	A	A
Heptachlor epoxide	A	A
Heptachlor	A	A
Lindane	A	A

Table 5. *Results of statistical evaluation for comparison of means and standard deviations for pesticide samples between the Atlanta and Denver laboratories* **continued**

Constituent	Comparison of means	Comparison of standard deviations
Malathion	A	A
Methoxychlor	A	A
Methylpharathion	A	A
Mirex	A	A
Parathion	A	A
Silvex	A	A

SUMMARY AND CONCLUSIONS

Reference water samples that had known MPV's were disguised as regular samples and submitted with environmental water samples by selected offices of the Survey to the two water-analysis laboratories operated by the Survey in Atlanta, Ga., and Denver, Colo. The resulting data were stored in WATSTORE. Inorganic-constituent data then were analyzed statistically for precision and bias by using a binomial-probability-distribution equation. Analytical data for nutrient, simulated-precipitation, and pesticide samples were tested for comparability by using a paired t statistic.

Iron, total recoverable, failed the precision criteria in the Atlanta laboratory for water year 1985, as it did in water years 1982, 1983, and 1984. Similarly, dissolved solids failed the precision criteria in water year 1985 as it did in water years 1983 and 1984. In the Denver laboratory, molybdenum (AA) failed the precision criteria during water year 1985 as it did in water year 1984.

An overall evaluation of the data for water year 1985 indicates a lack of precision in results from the Atlanta laboratory for cadmium (AA); cobalt, total recoverable; dissolved solids; fluoride; iron, total recoverable; lead, total recoverable, and selenium (AA). Similar results were obtained from the Denver laboratory for barium, total recoverable; fluoride; iron, total recoverable; magnesium (AA); molybdenum (AA); selenium; sodium (AA); and zinc (ICP).

Fewer constituents showed bias in water year 1985 than in water year 1984 at both laboratories. For the Atlanta laboratory, negatively biased constituents that were consistent with results for water year 1984 were: arsenic, boron, and nickel. Positively biased constituents, consistent with the results from water year 1984, were: dissolved solids, fluoride, iron (ICP), lead (ICP), sulfate, and zinc (ICP). For the Denver laboratory, negatively biased constituents that were consistent with results for water year 1984 were: aluminum, arsenic, barium (ICP), boron, molybdenum (AA), nickel, and potassium; whereas, positively biased constituents were: chromium, iron (AA), lead (ICP), magnesium (ICP), sulfate, and zinc (ICP).

An overall evaluation of the data for water year 1985 indicates a significant bias in results from the Atlanta laboratory for arsenic; barium (ICP); barium (AA); barium, total recoverable; boron; chromium; cobalt (ICP); copper (ICP); dissolved solids; fluoride; iron (ICP); iron (AA); lead (ICP); lead (AA); lithium; manganese (ICP); manganese (AA); molybdenum (AA); nickel; sulfate; zinc (ICP) and zinc, total recoverable. The evaluation of data from the Denver laboratory indicates a significant bias for alkalinity; aluminum; arsenic; barium (ICP); barium (AA); barium, total recoverable; boron; cadmium (AA); cadmium, total recoverable; calcium (ICP); chromium; chromium, total recoverable; cobalt (ICP); copper (AA); dissolved solids; iron (AA); lead (ICP); lithium; magnesium (ICP); molybdenum (AA); nickel; potassium; selenium; silica; sodium (ICP); sulfate and all zinc.

Both laboratories reported similar results for all constituents in nutrient samples. No significant difference between the mean values or the standard deviations were indicated. Both laboratories reported similar results for constituents in simulated-precipitation samples, except for potassium, which indicated a significant difference in the standard deviations. Both laboratories also reported similar results for constituents in pesticide samples, except for DDE and Dieldrin for which the means were significantly different. DDE also had a significant difference in the standard deviations between the two laboratories.

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SUPPLEMENTAL DATA

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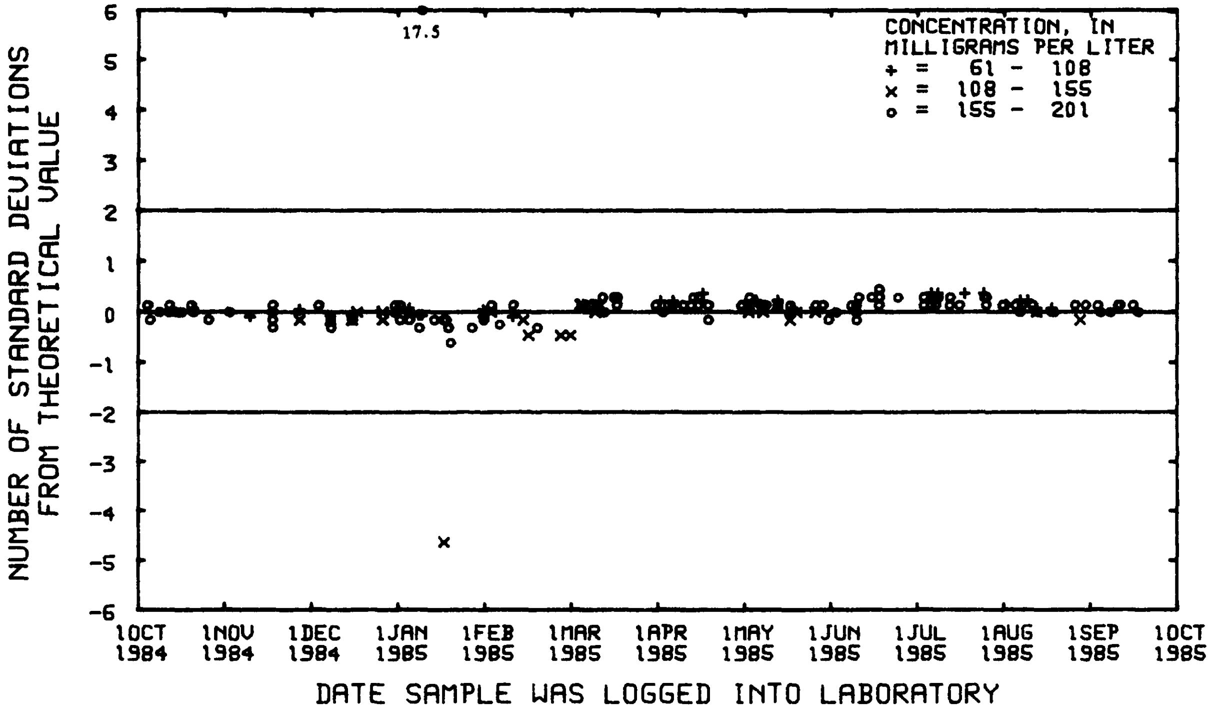

Figure 1--Alkalinity, dissolved, data from the Atlanta laboratory.

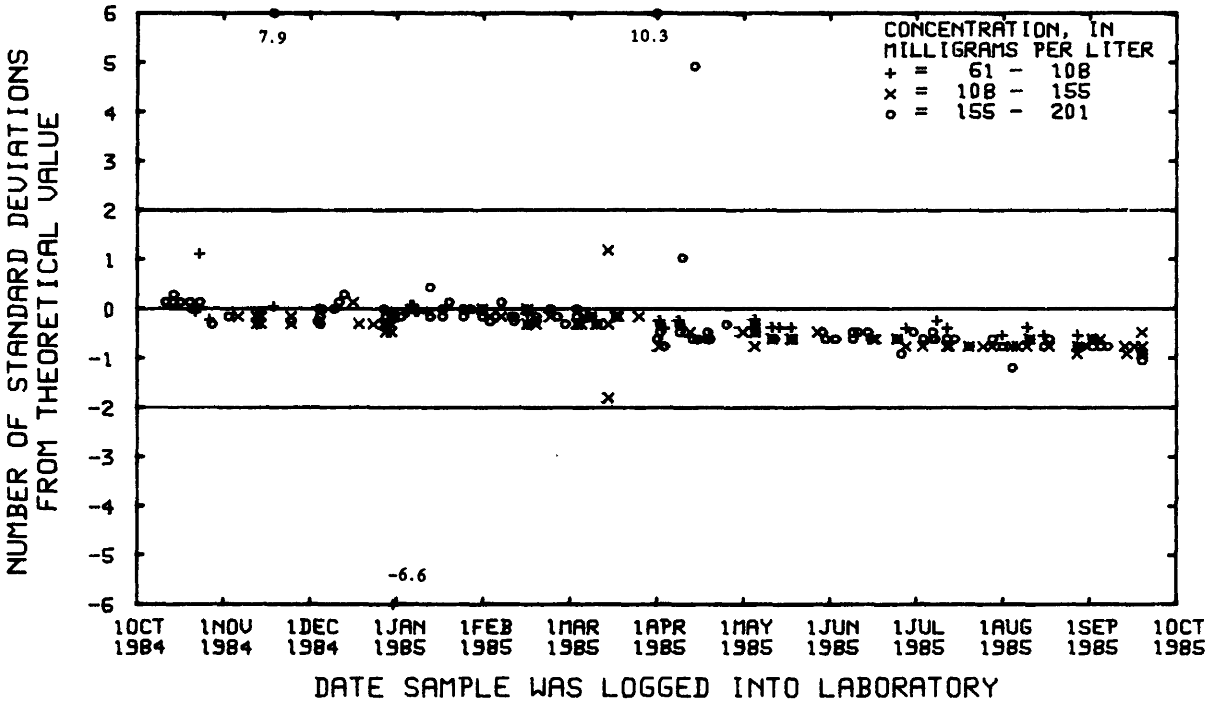

Figure 2--Alkalinity, dissolved, data from the Denver laboratory.

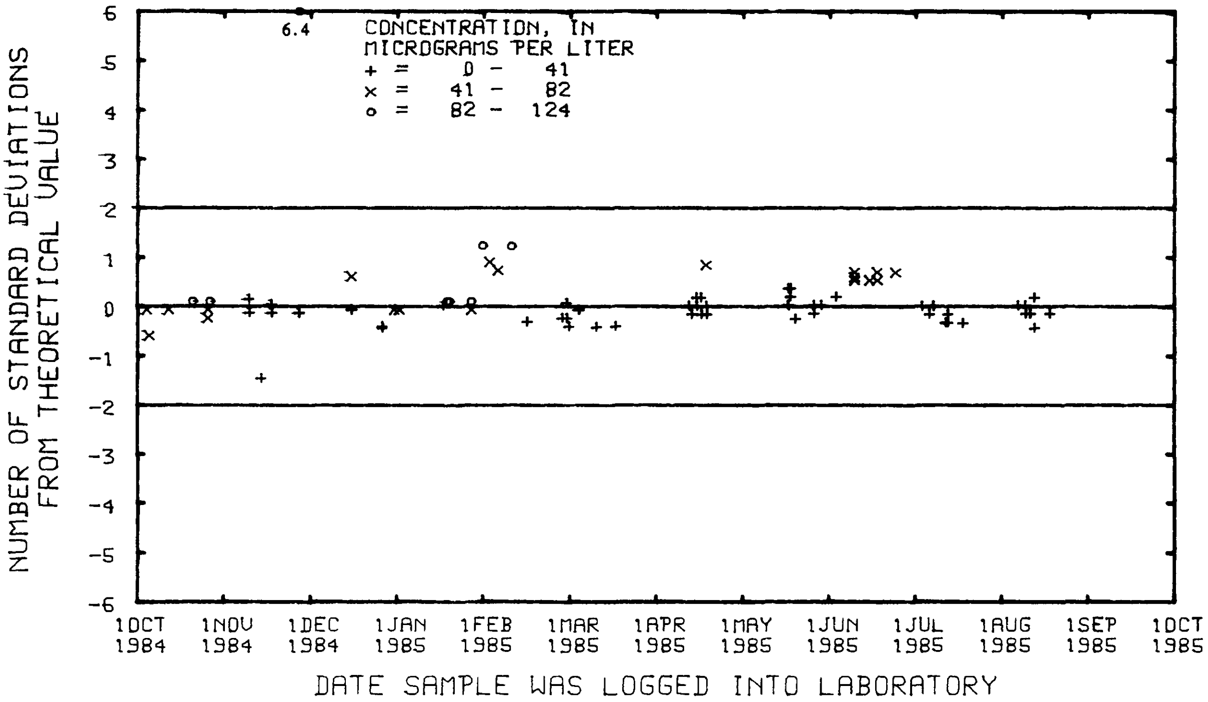

Figure 3--Aluminum, dissolved, data from the Atlanta laboratory.

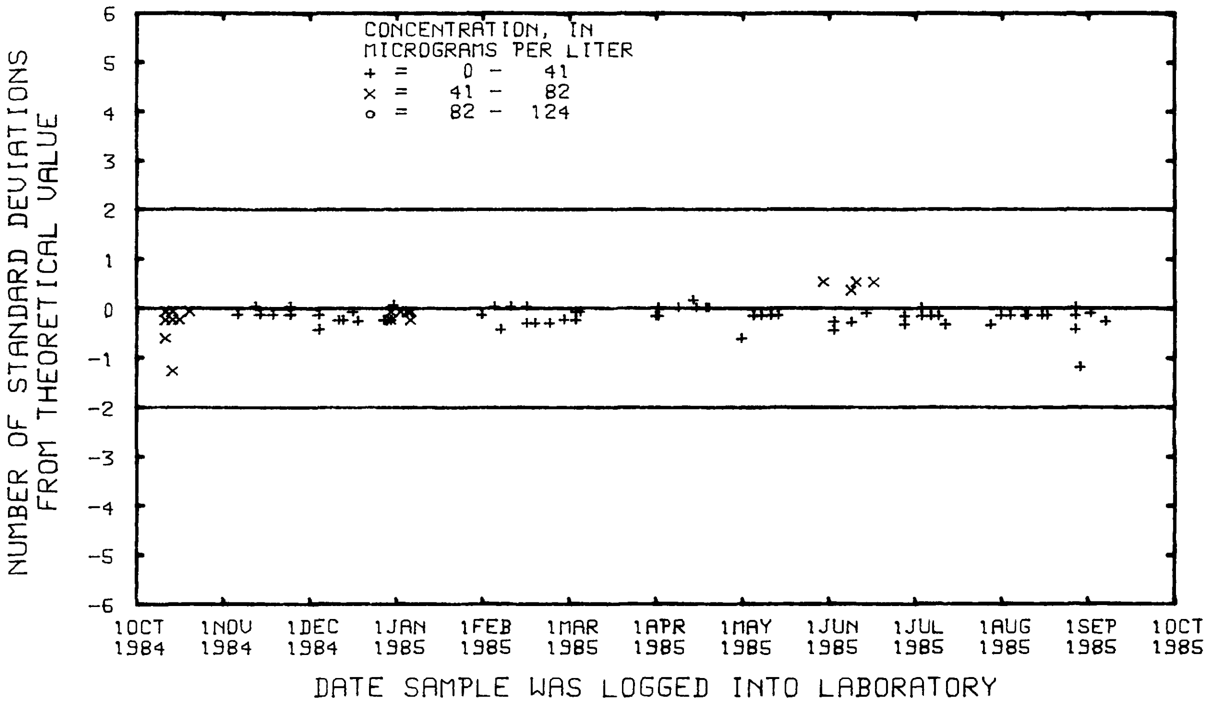

Figure 4--Aluminum, dissolved, data from the Denver laboratory.

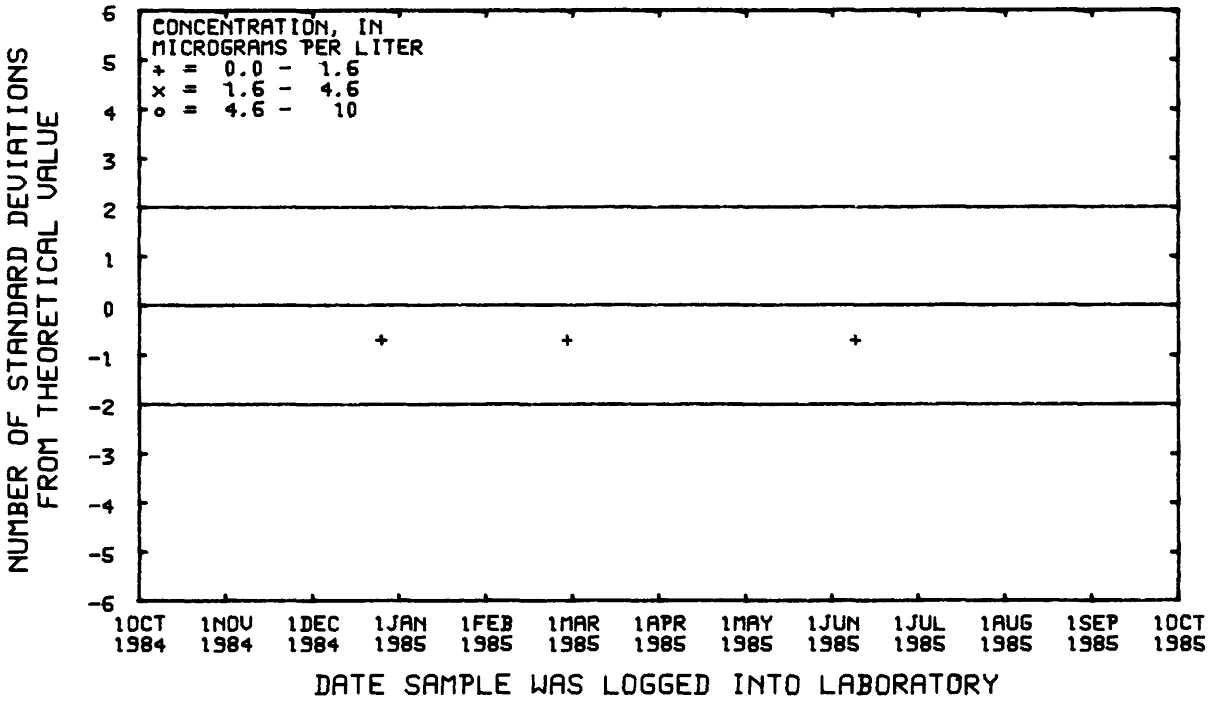

Figure 5--Antimony, dissolved, data from the Atlanta laboratory.

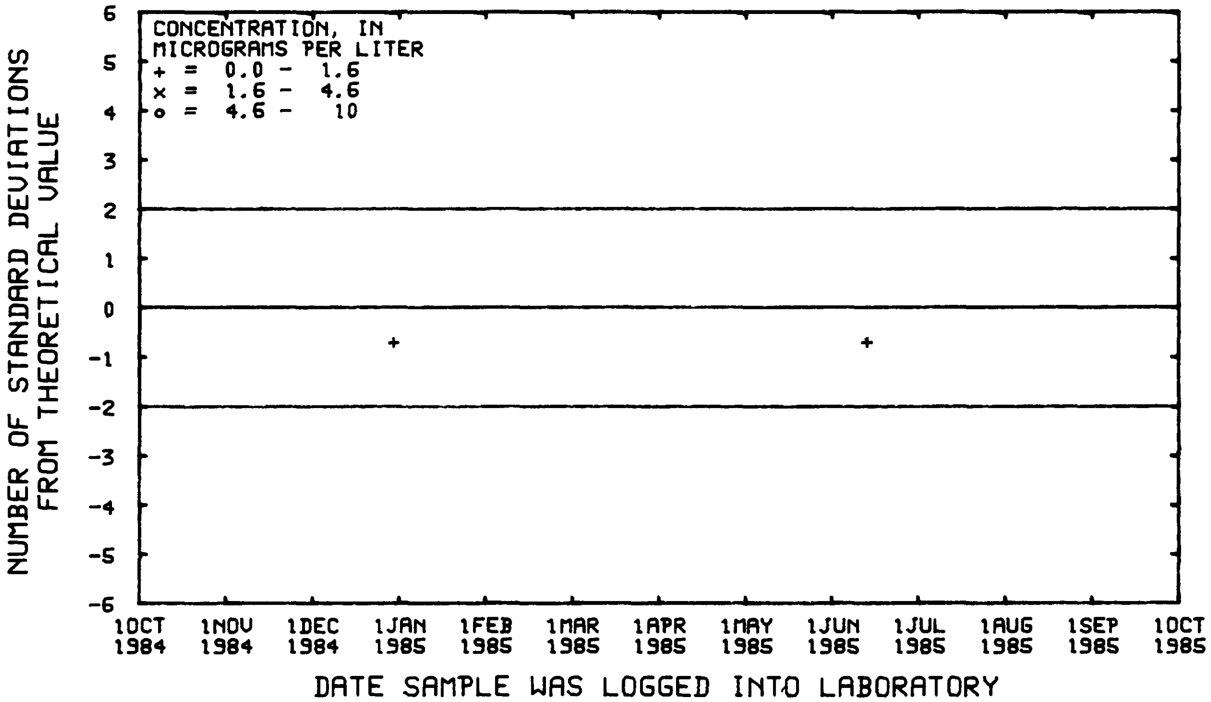

Figure 6--Antimony, dissolved, data from the Denver laboratory.

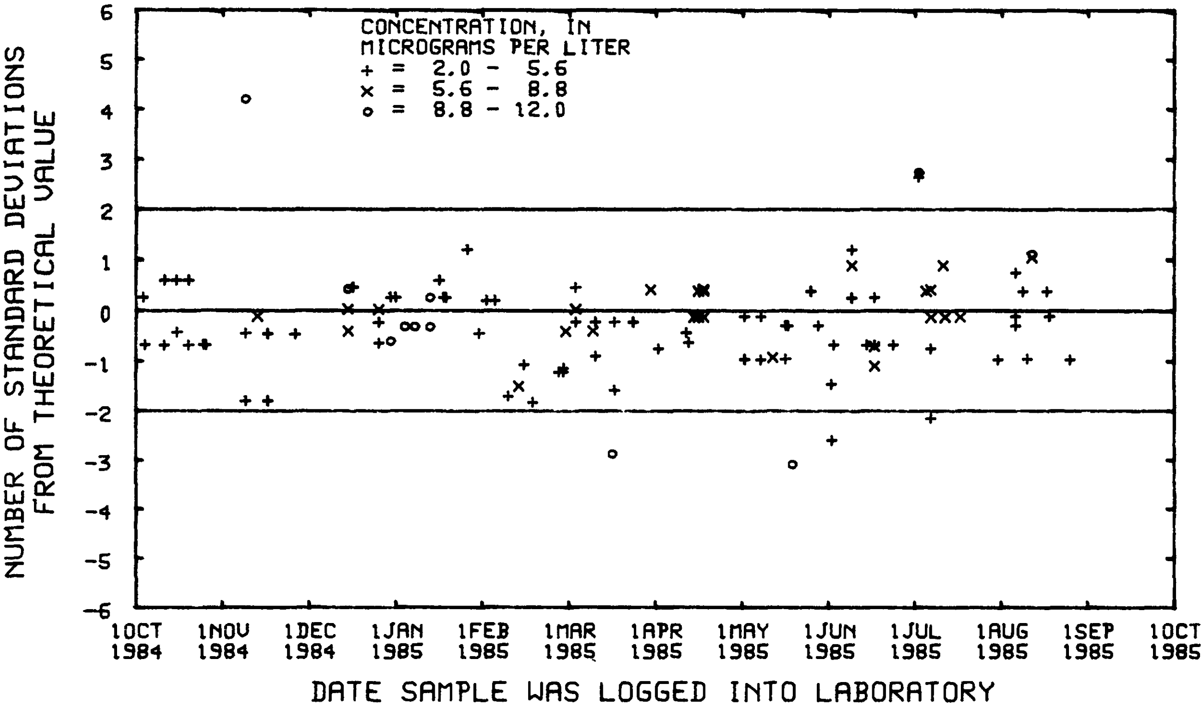

Figure 7--Arsenic, dissolved, data from the Atlanta laboratory.

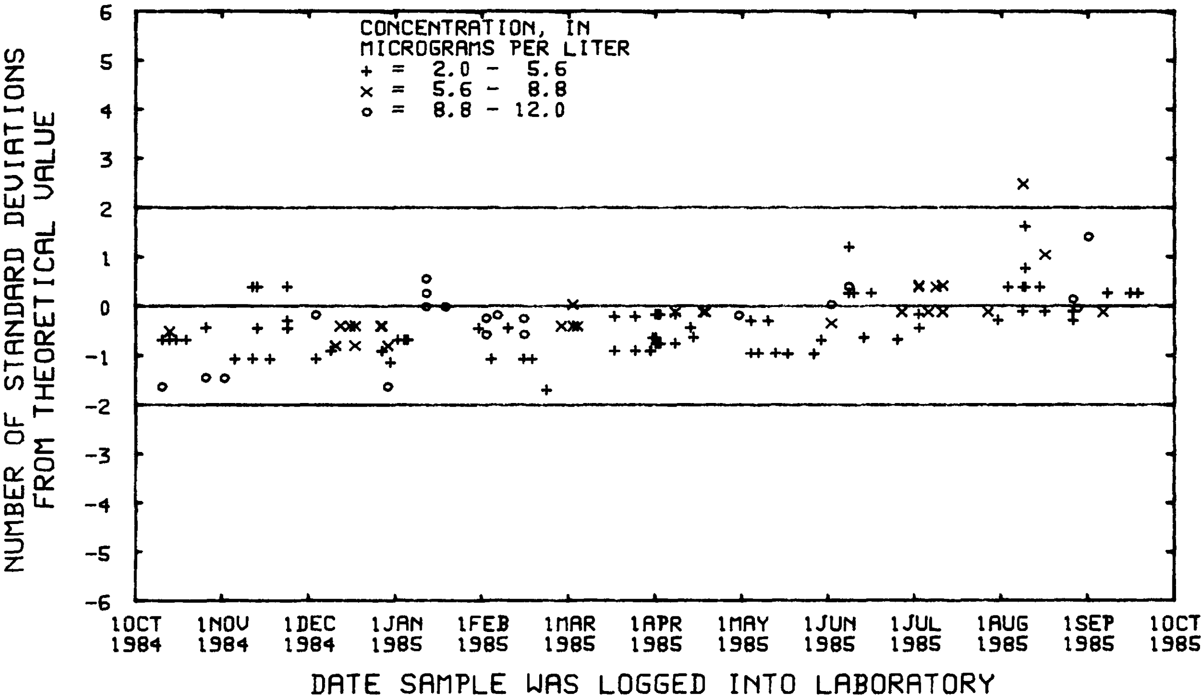

Figure 8--Arsenic, dissolved, data from the Denver laboratory.

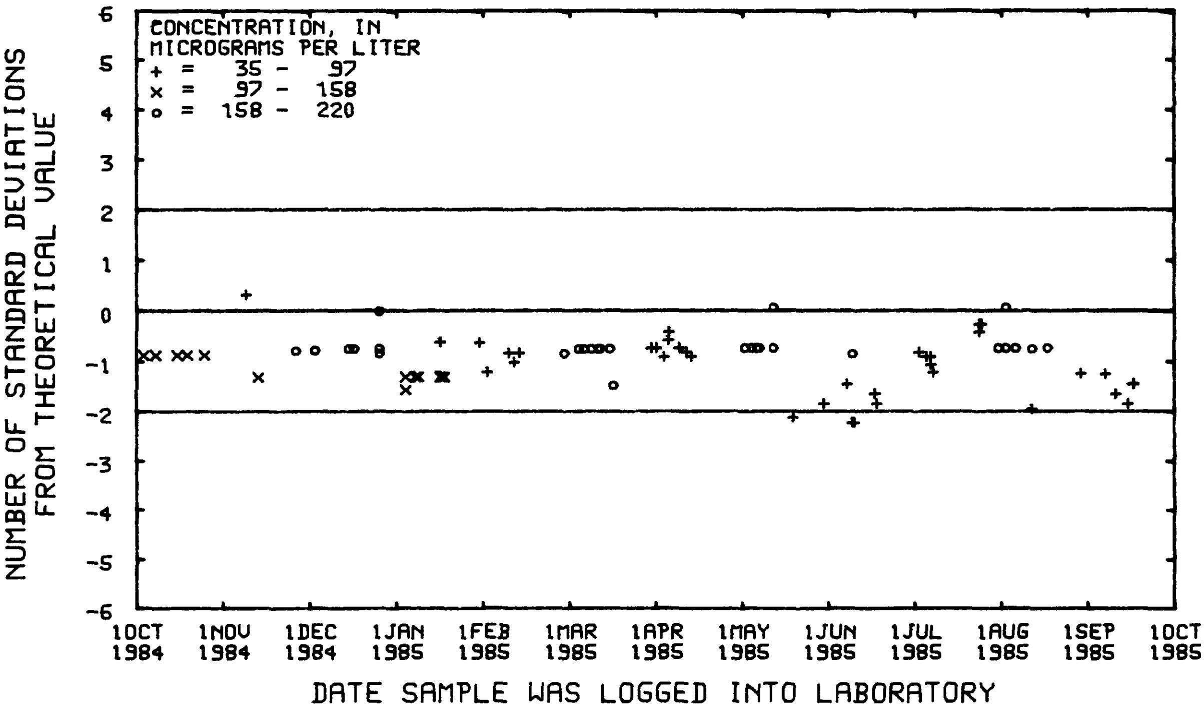

Figure 9--Barium, dissolved, (inductively coupled plasma emission spectrometry) data from the Atlanta laboratory.

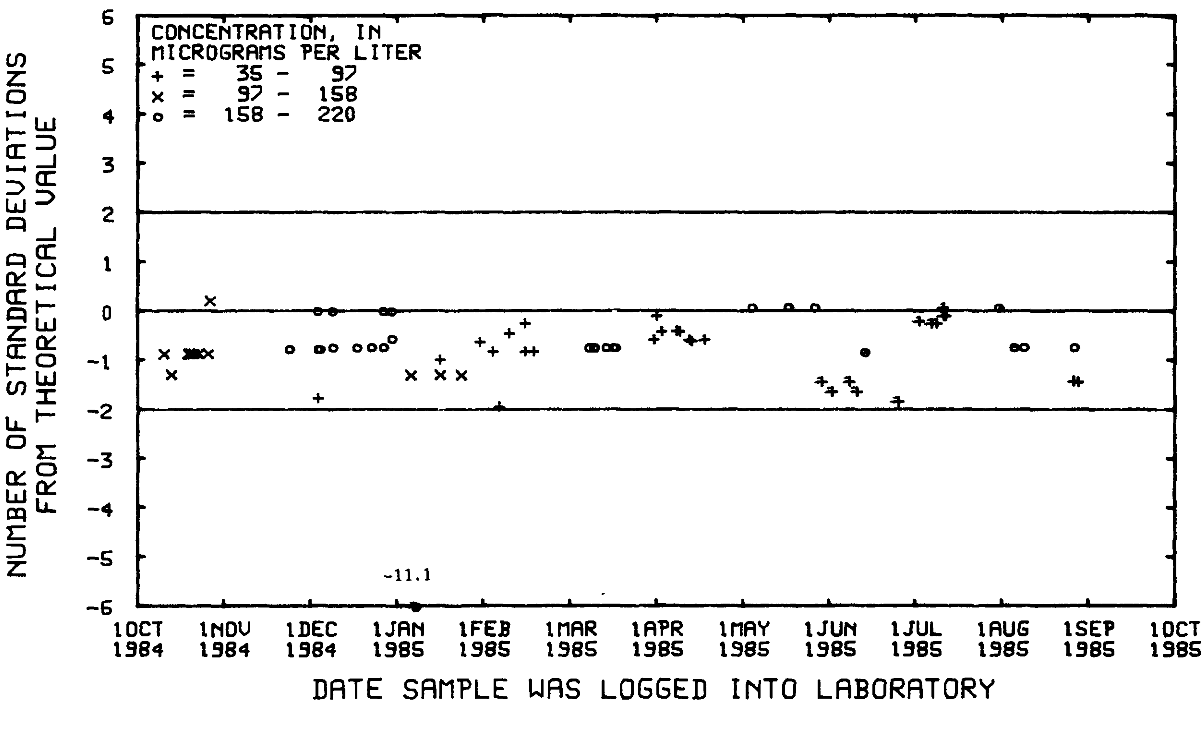

Figure 10--Barium, dissolved, (inductively coupled plasma emission spectrometry) data from the Denver laboratory.

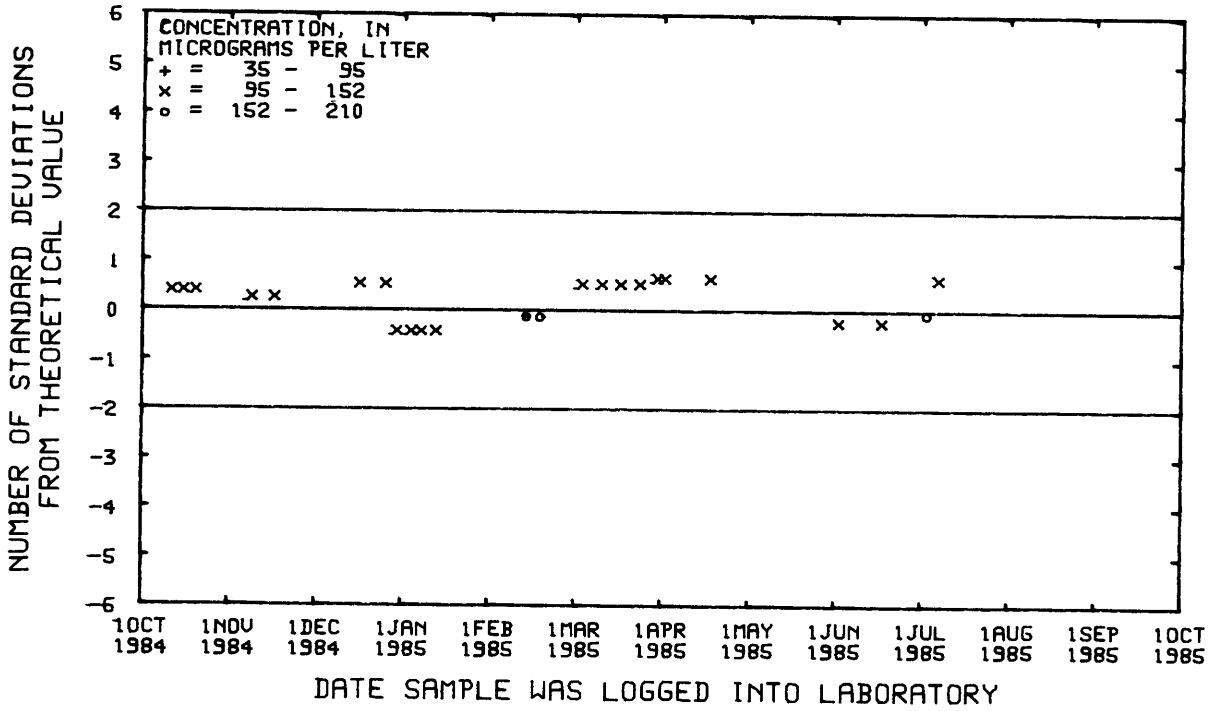

Figure 11--Barium, dissolved,
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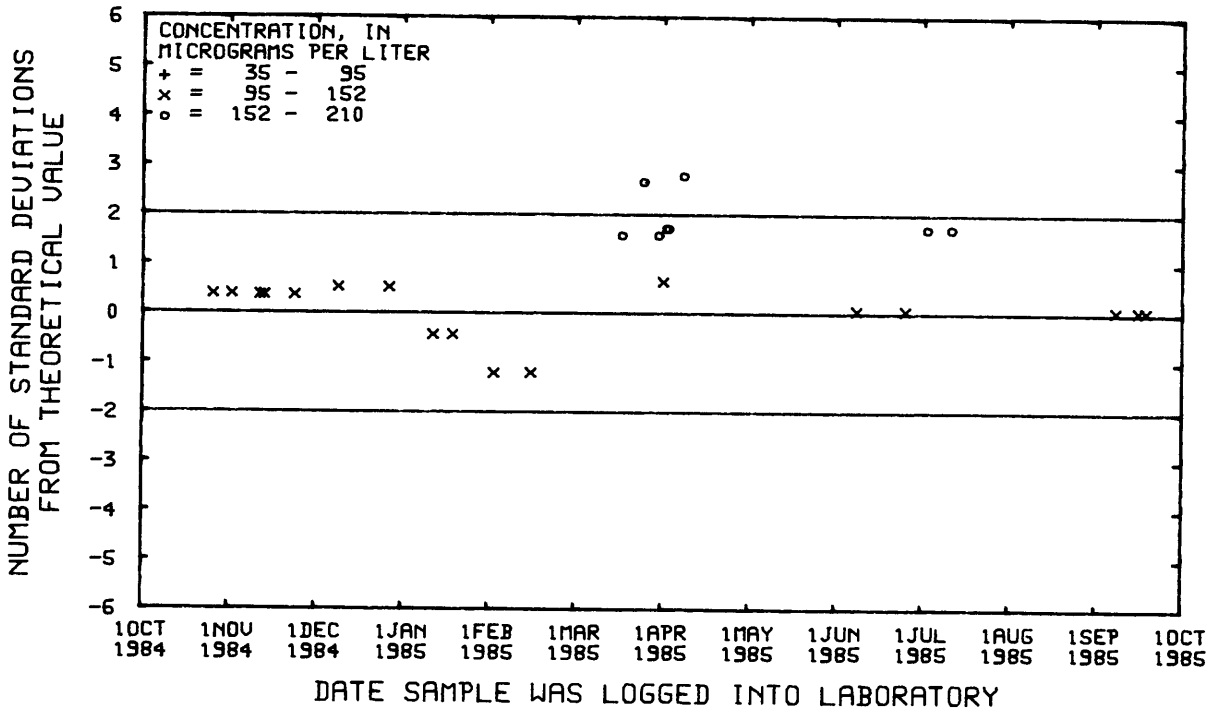

Figure 12--Barium, dissolved,
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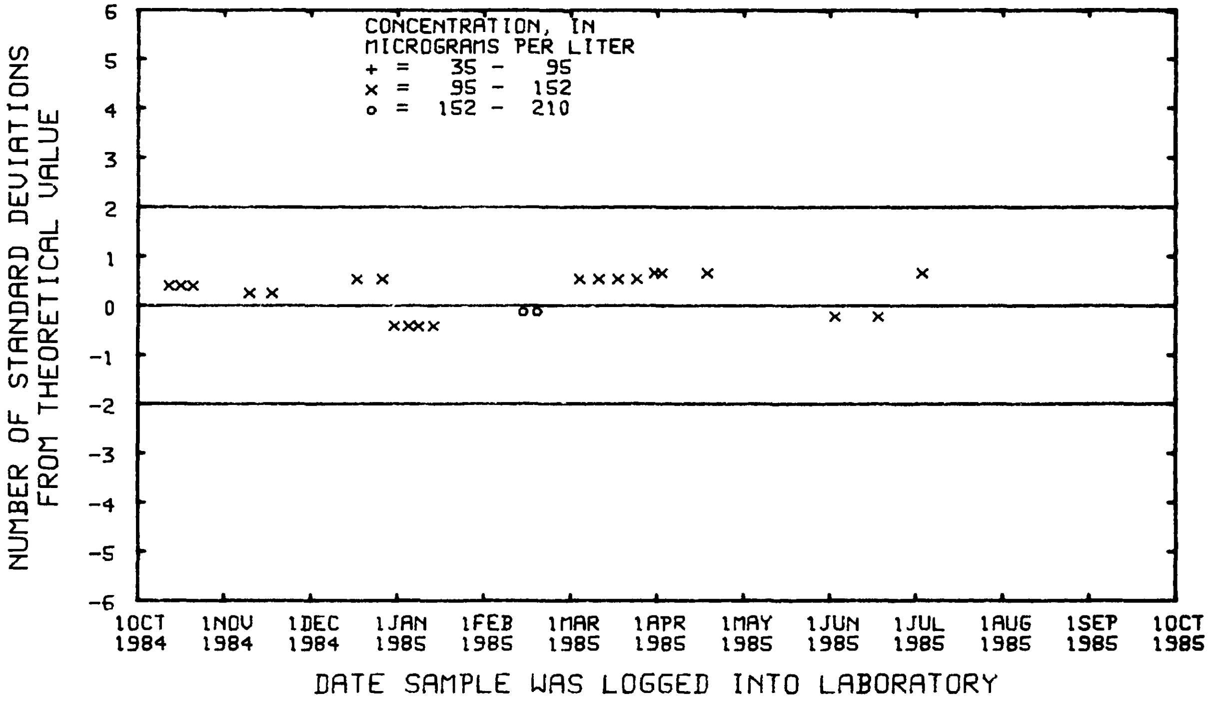

Figure 13--Barium, total recoverable, data from the Atlanta laboratory.

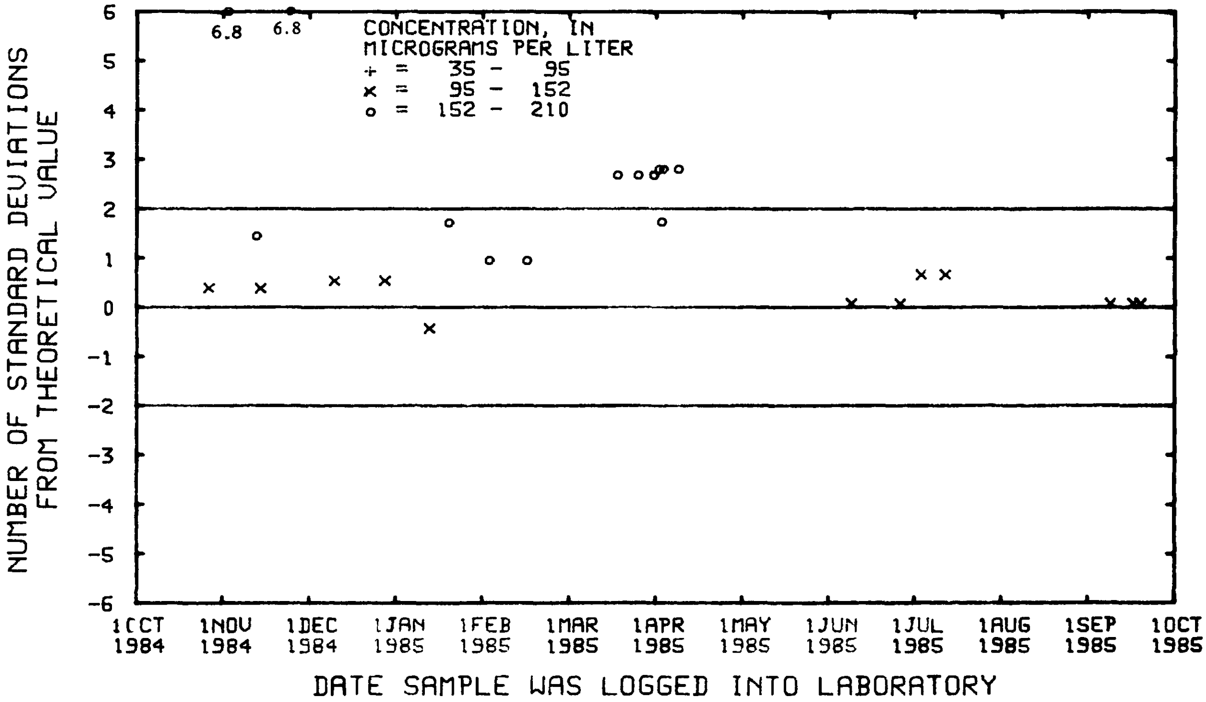

Figure 14--Barium, total recoverable, data from the Denver laboratory.

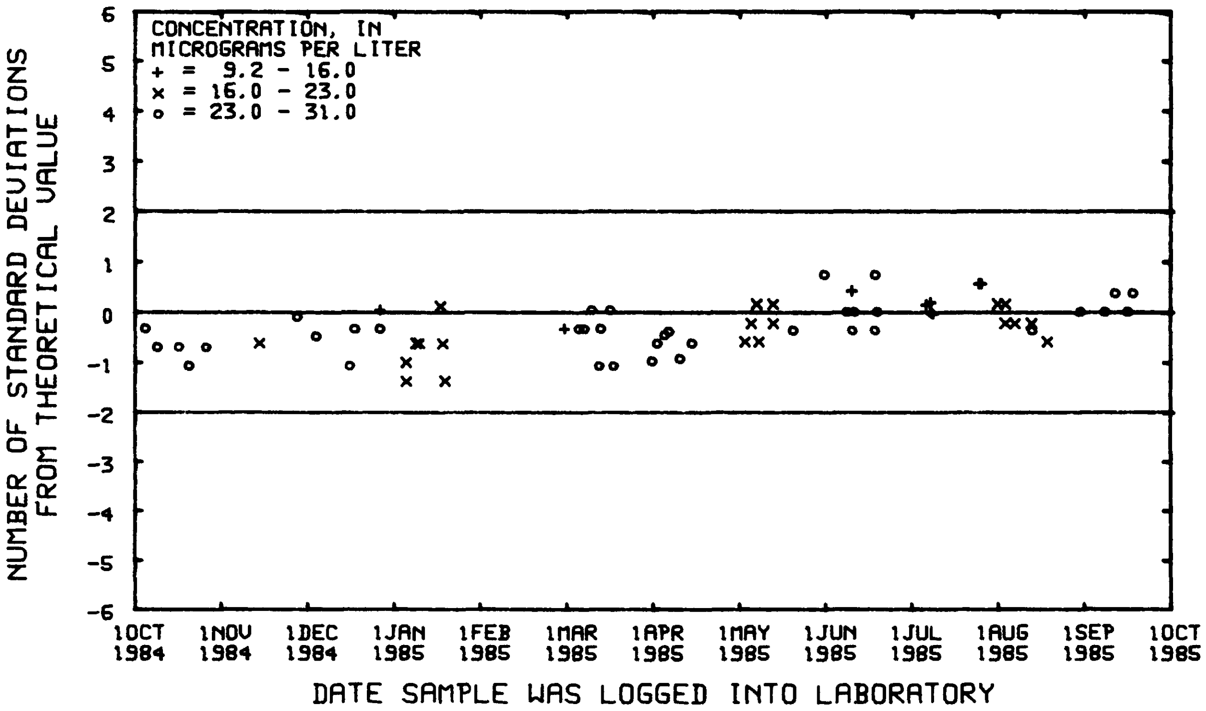

Figure 15--Beryllium, dissolved, data from the Atlanta laboratory.

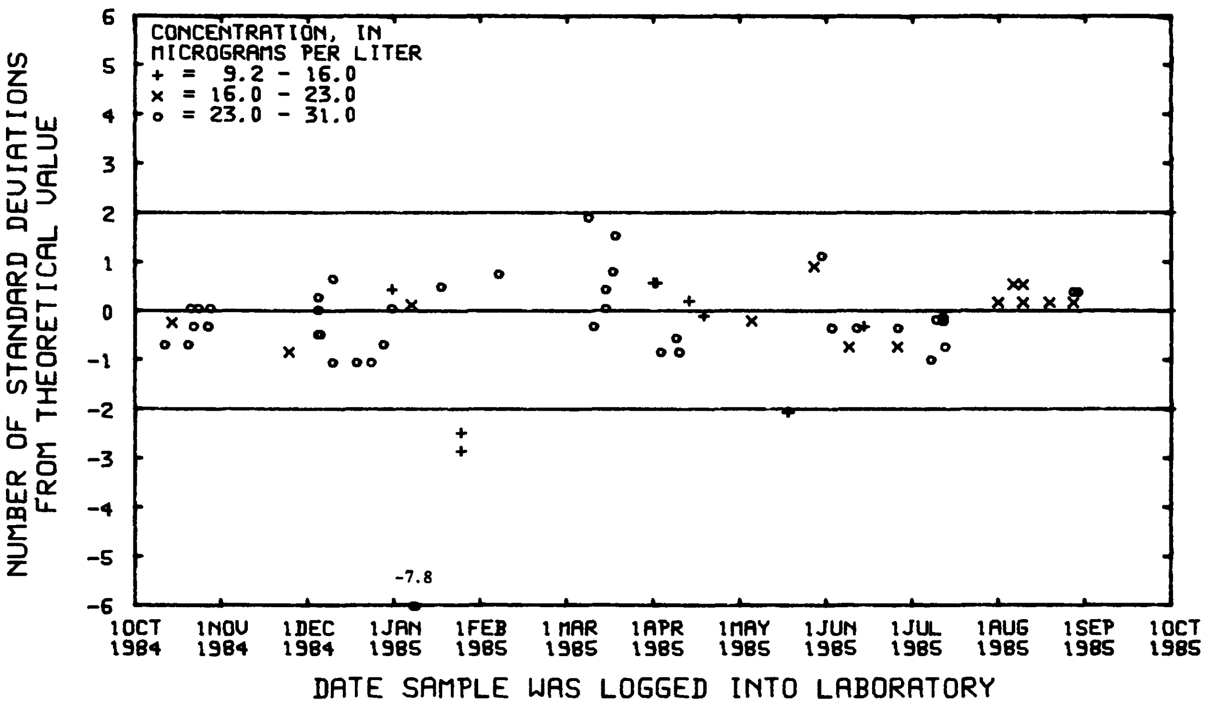

Figure 16--Beryllium, dissolved, data from the Denver laboratory.

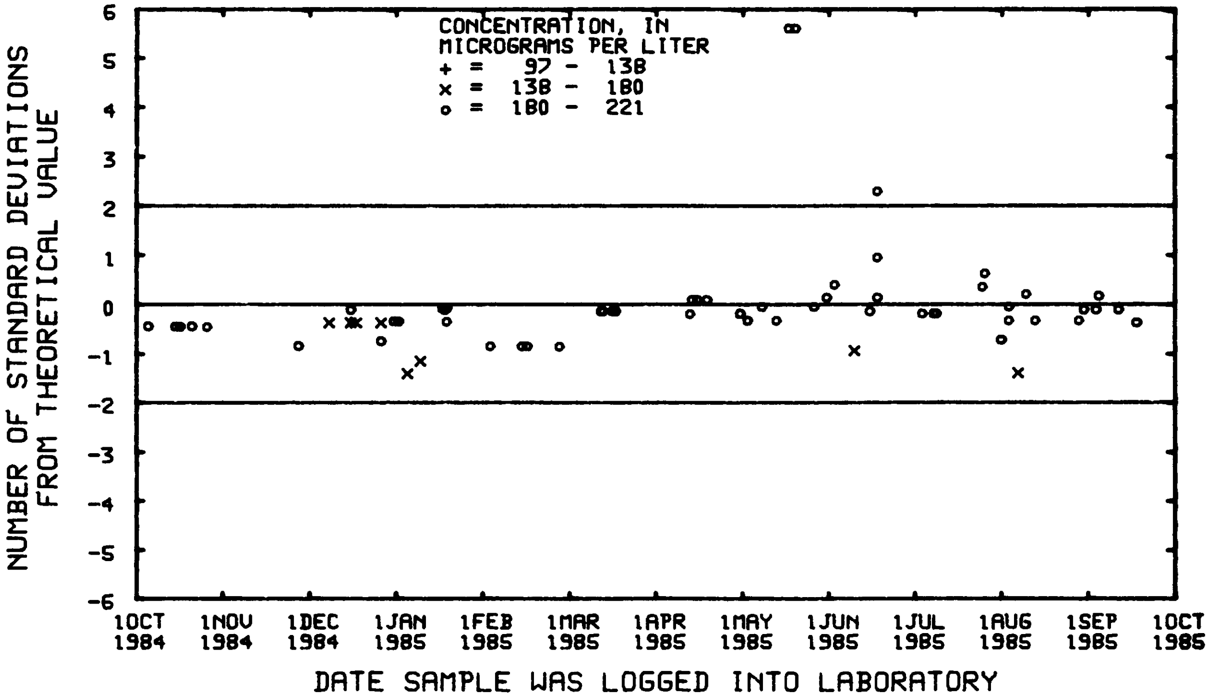

Figure 17--Boron, dissolved, data from the Atlanta laboratory.

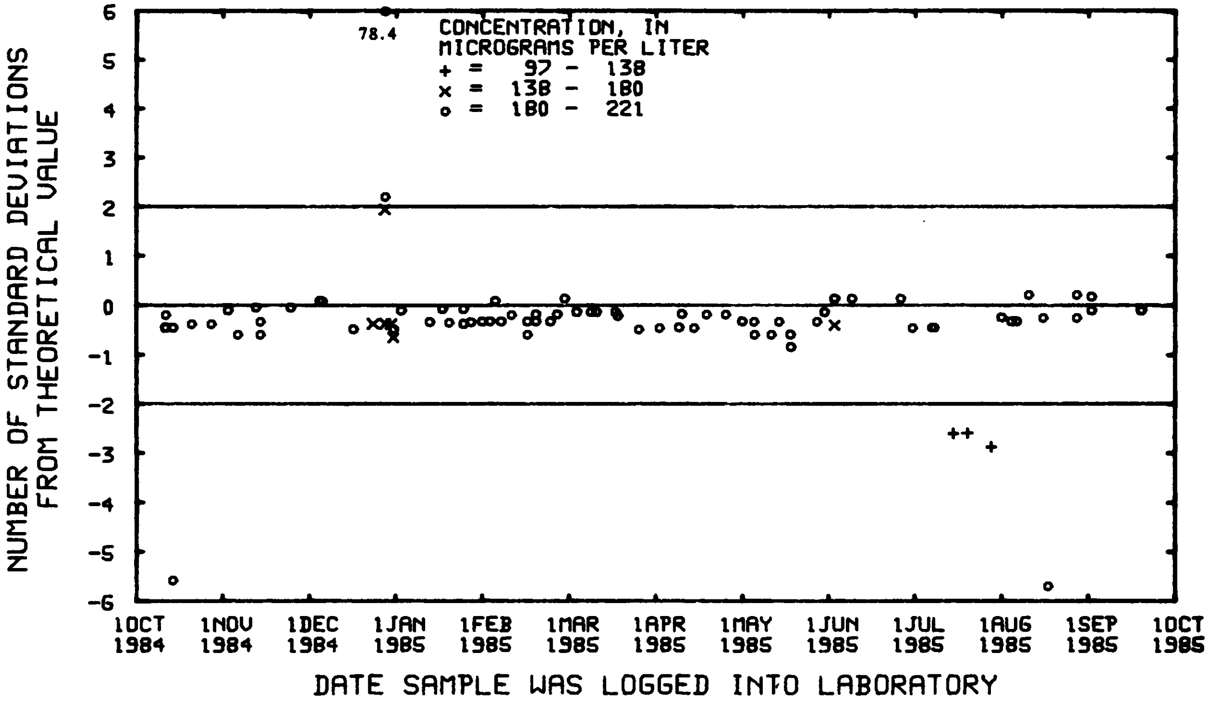

Figure 18--Boron, dissolved, data from the Denver laboratory.

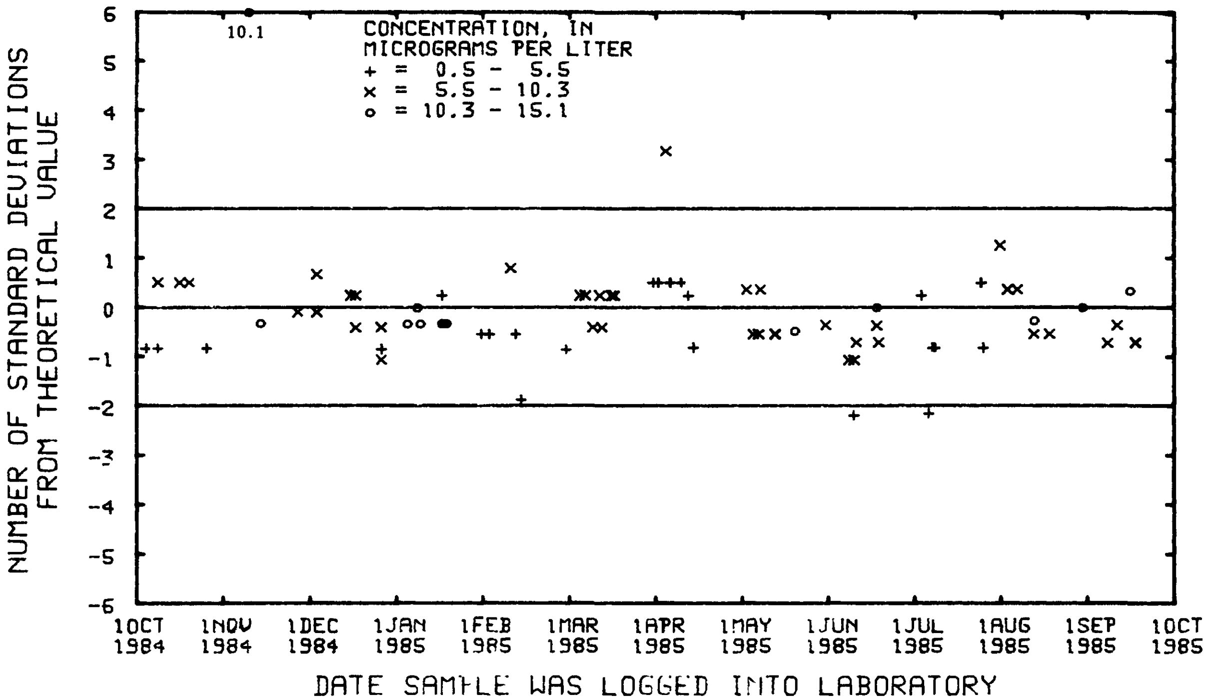

Figure 19--Cadmium, dissolved,
(inductively coupled plasma emission spectrometry)
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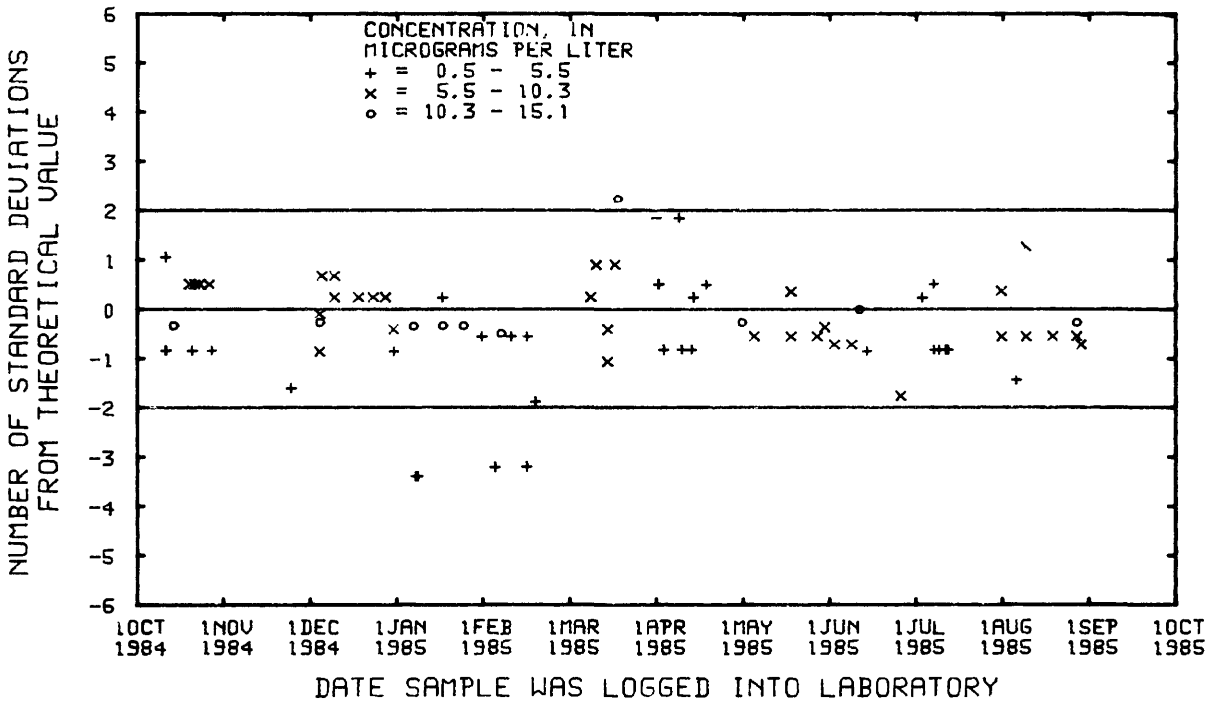

Figure 20--Cadmium, dissolved,
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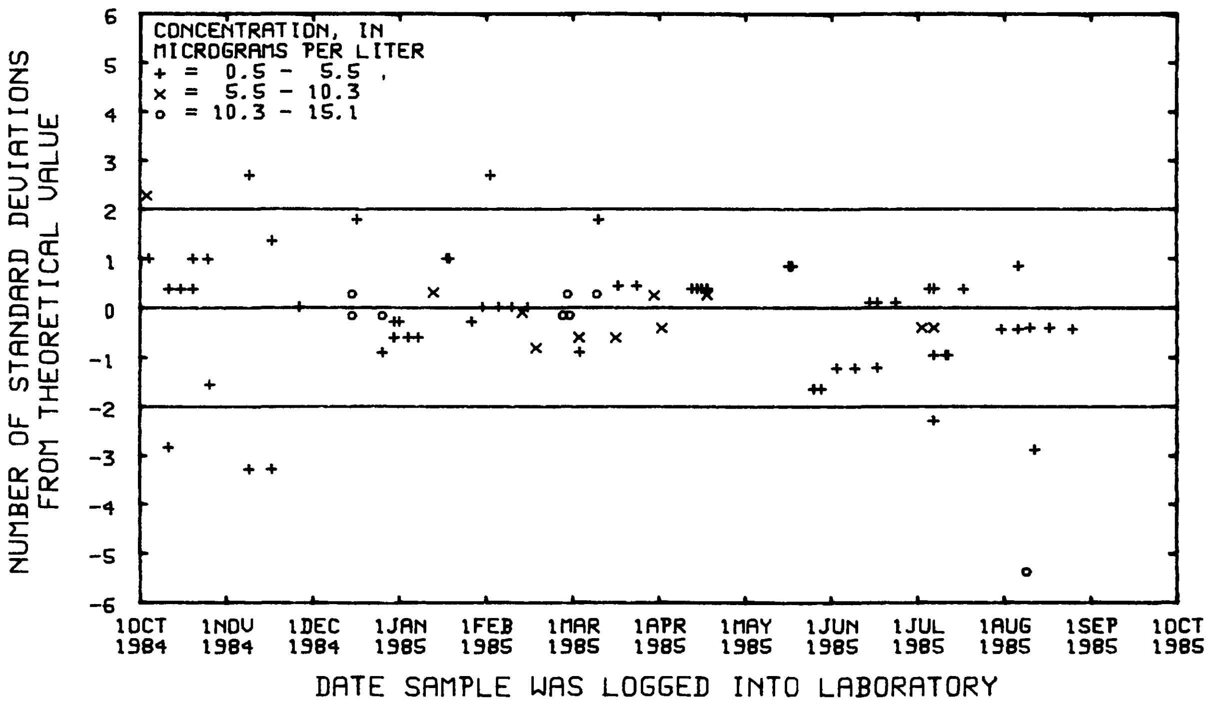

Figure 21--Cadmium, dissolved,
(atomic absorption spectrometry)
data from the Atlanta laboratory.

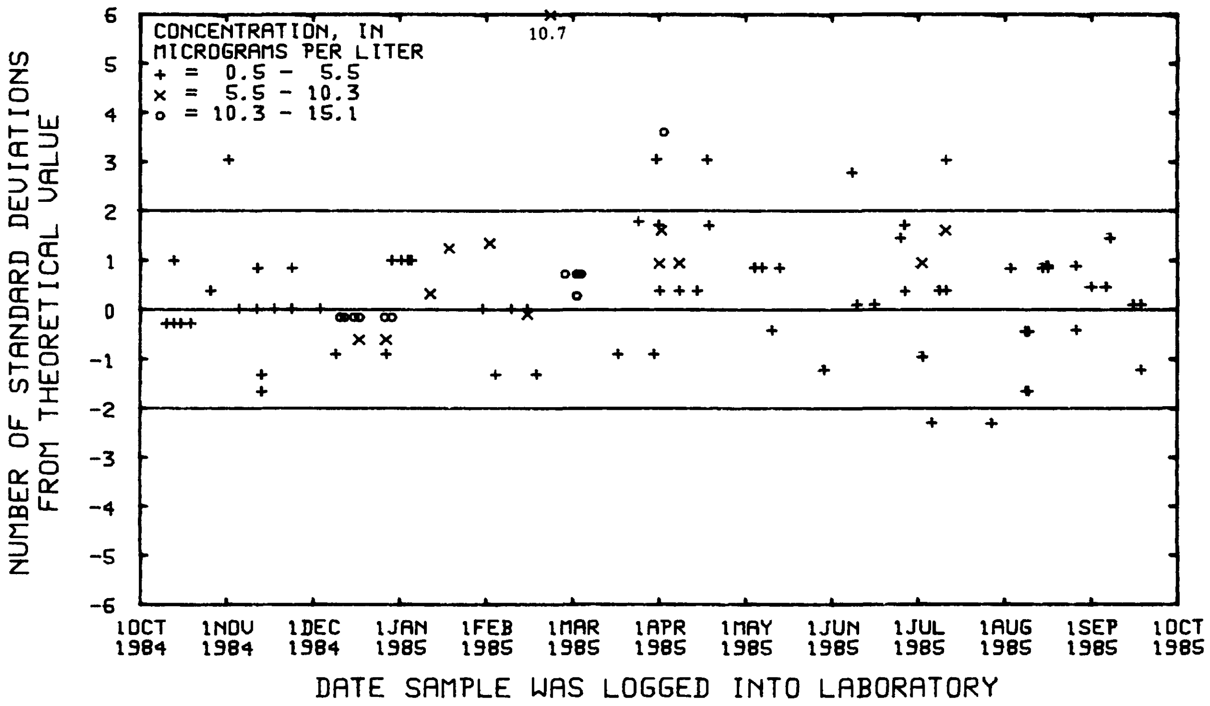

Figure 22--Cadmium, dissolved,
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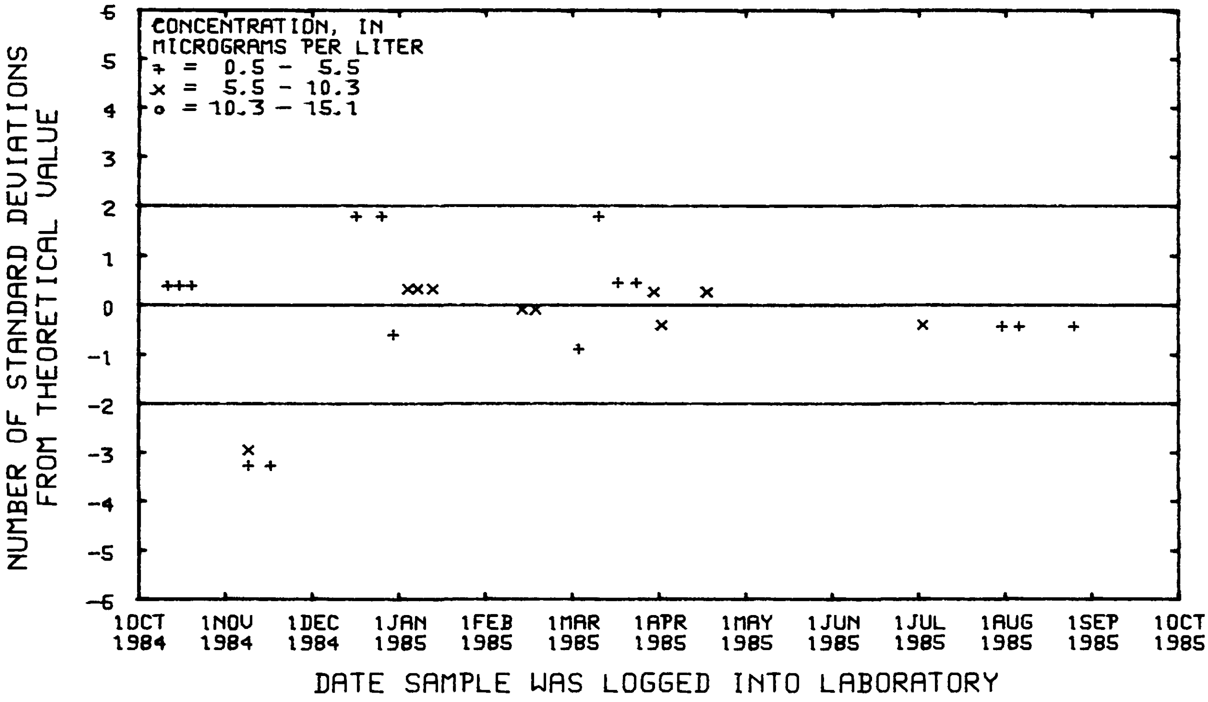

Figure 23--Cadmium, total recoverable, data from the Atlanta laboratory.

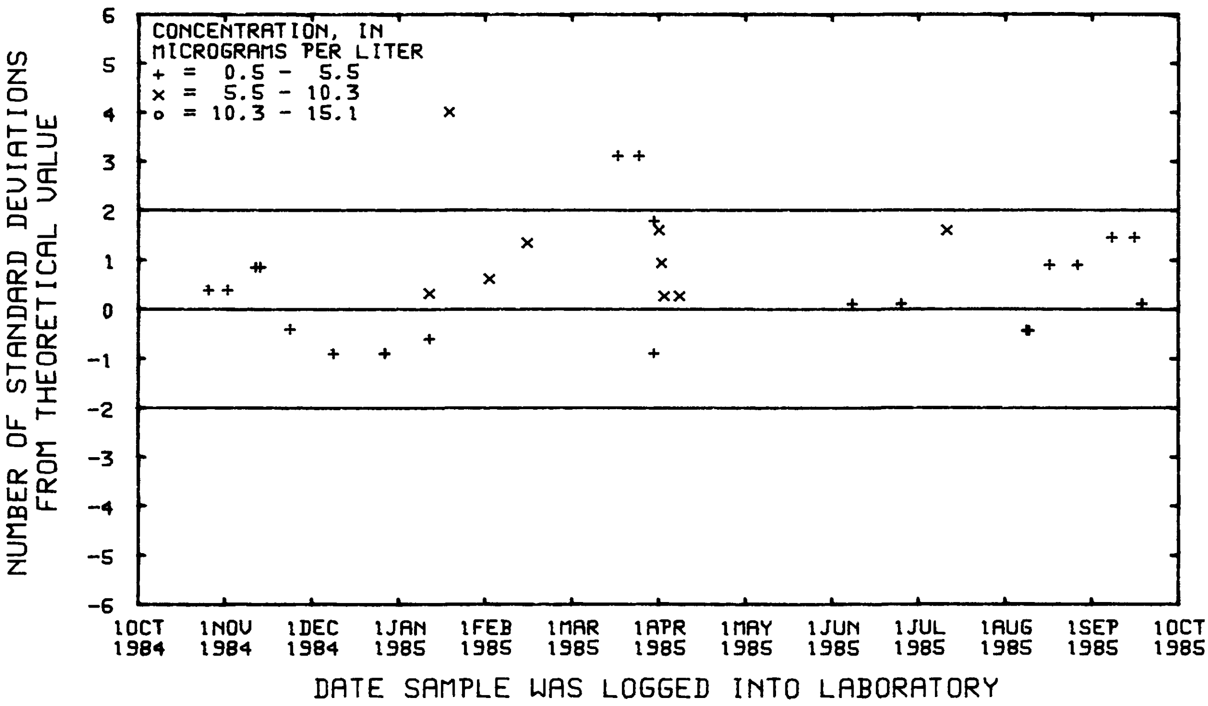

Figure 24--Cadmium, total recoverable, data from the Denver laboratory.

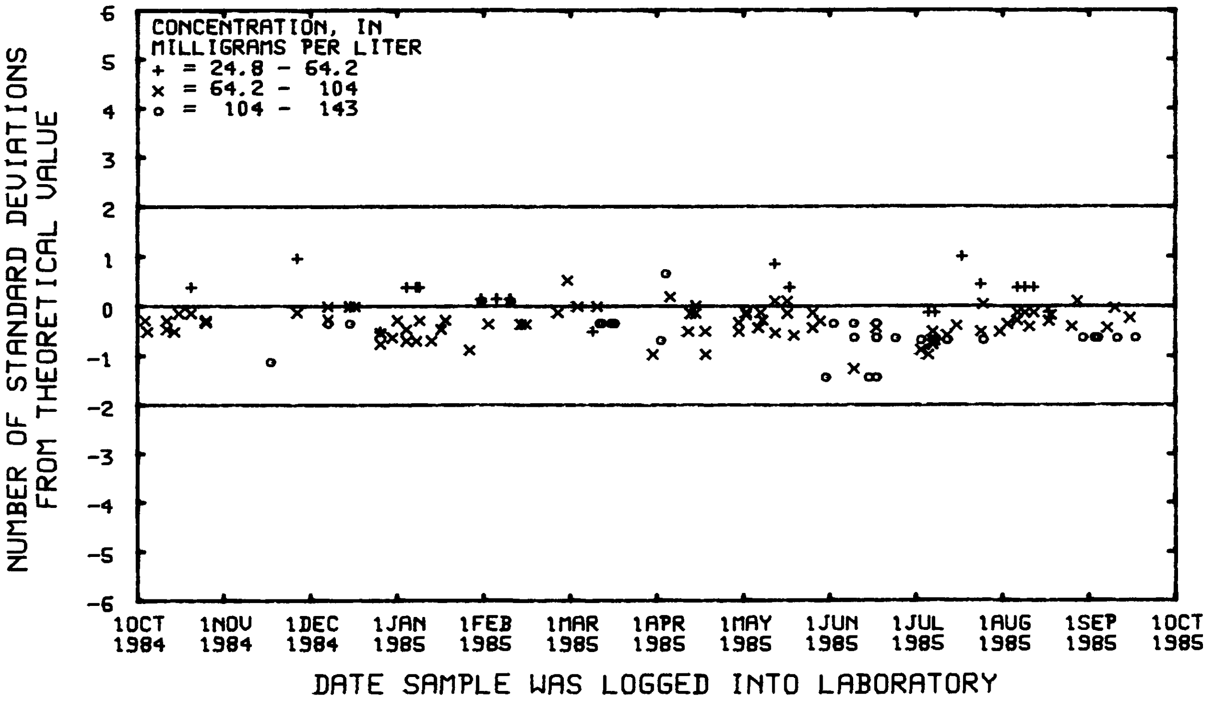

Figure 25--Calcium, dissolved, (inductively coupled plasma emission spectrometry) data from the Atlanta laboratory.

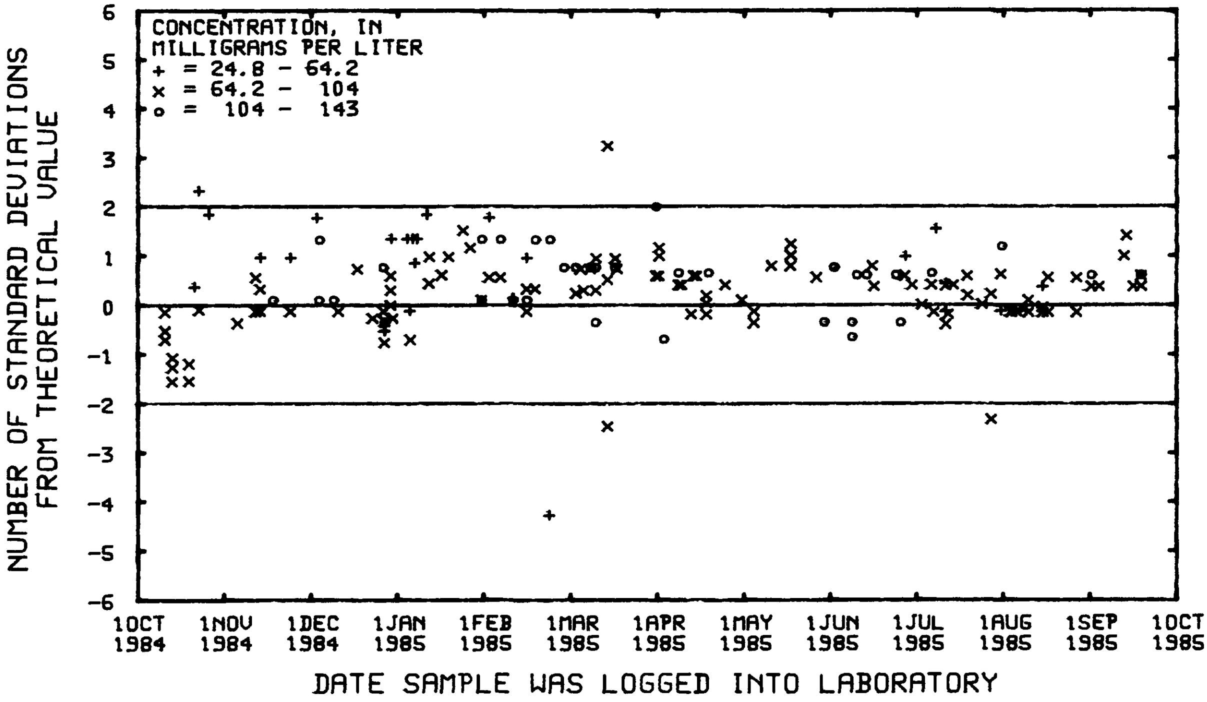

Figure 26--Calcium, dissolved, (inductively coupled plasma emission spectrometry) data from the Denver laboratory.

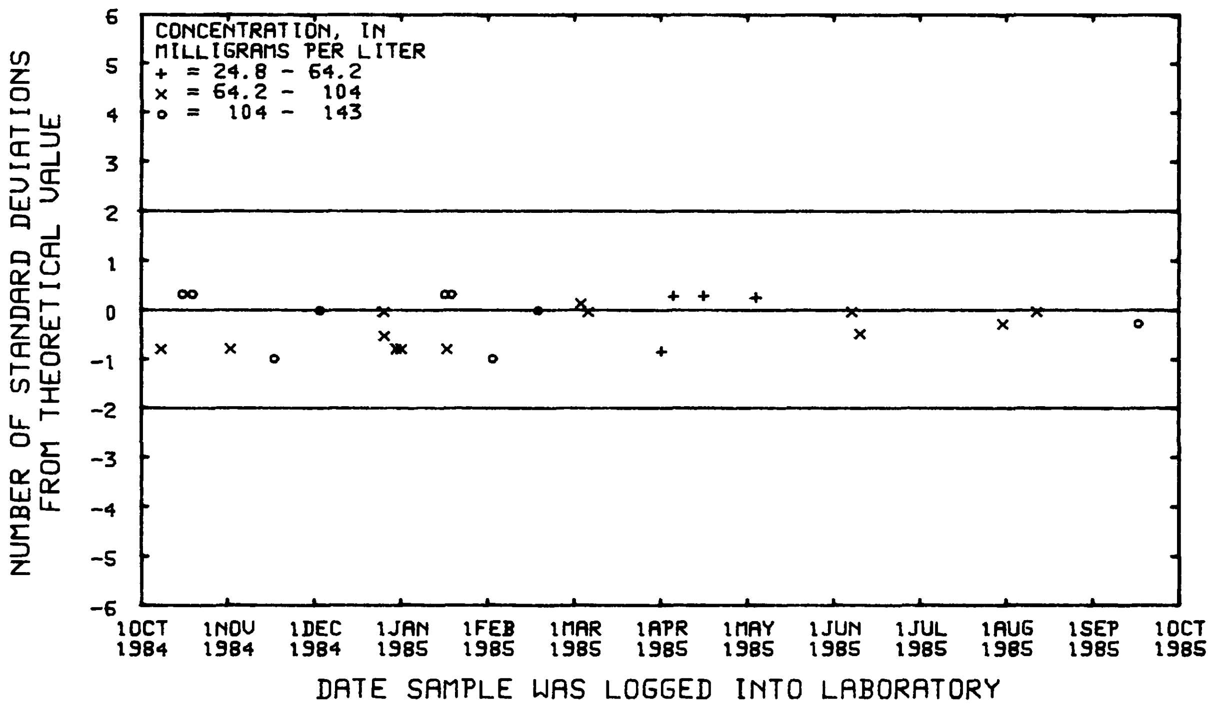

Figure 27--Calcium, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

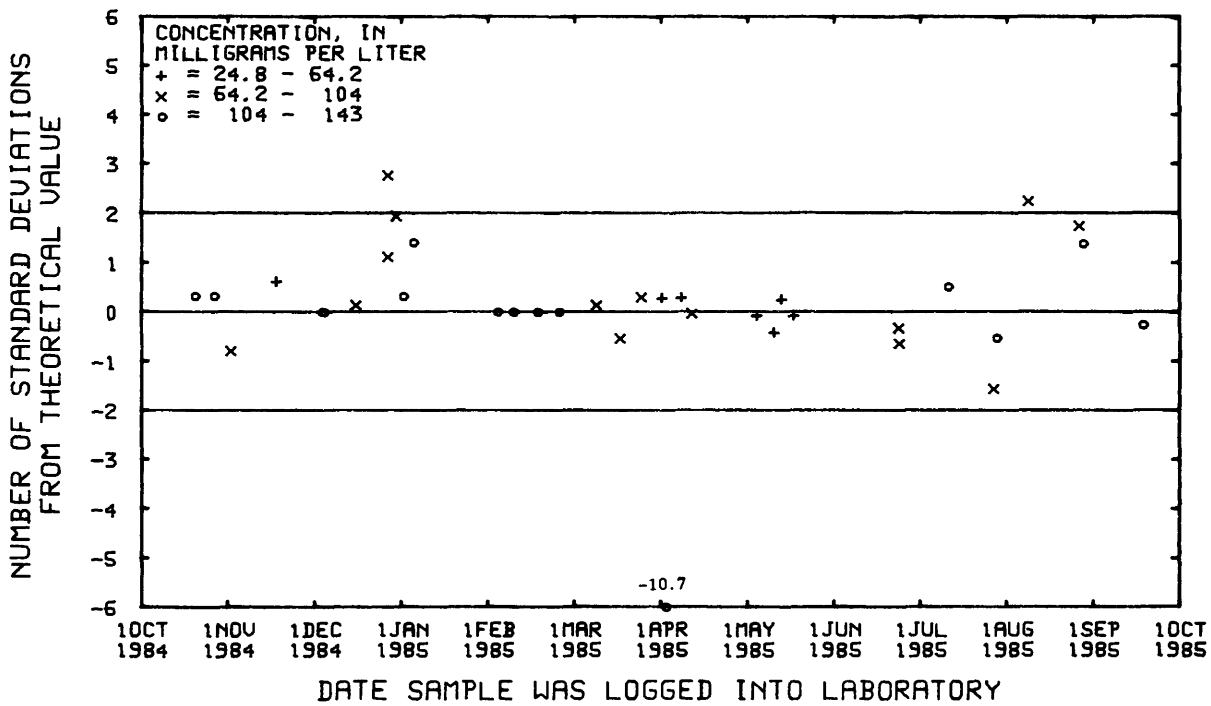

Figure 28--Calcium, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

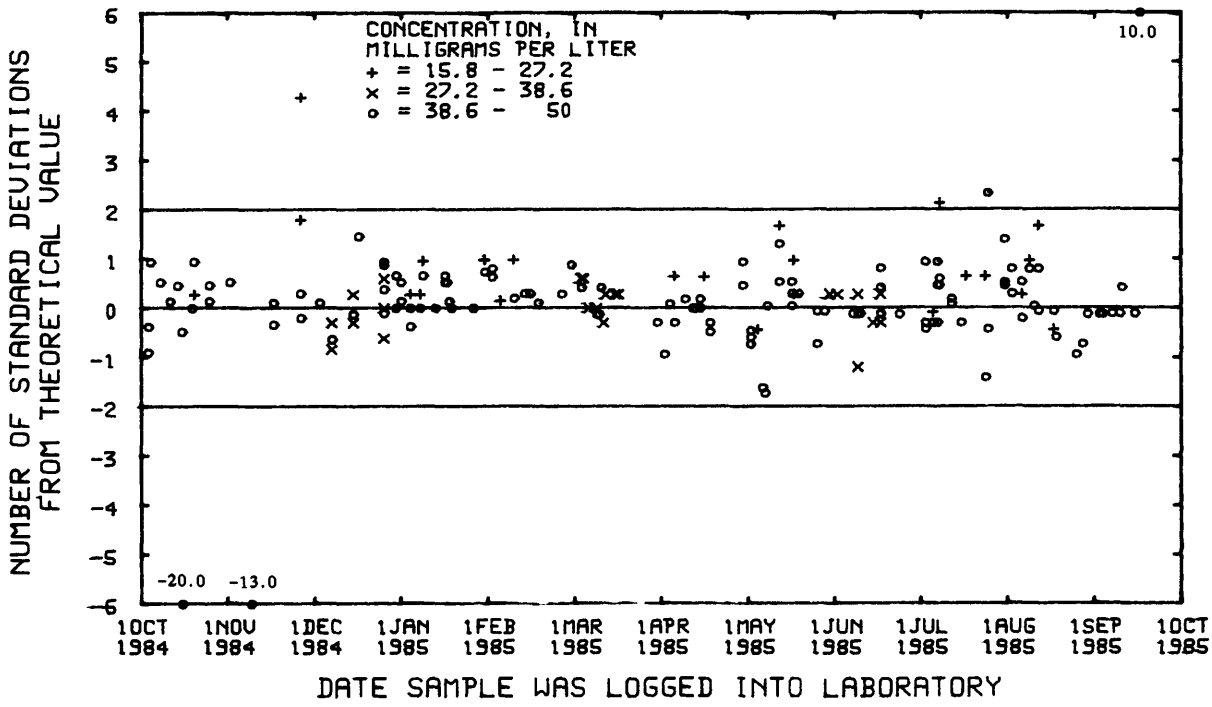

Figure 29--Chloride, dissolved, data from the Atlanta laboratory.

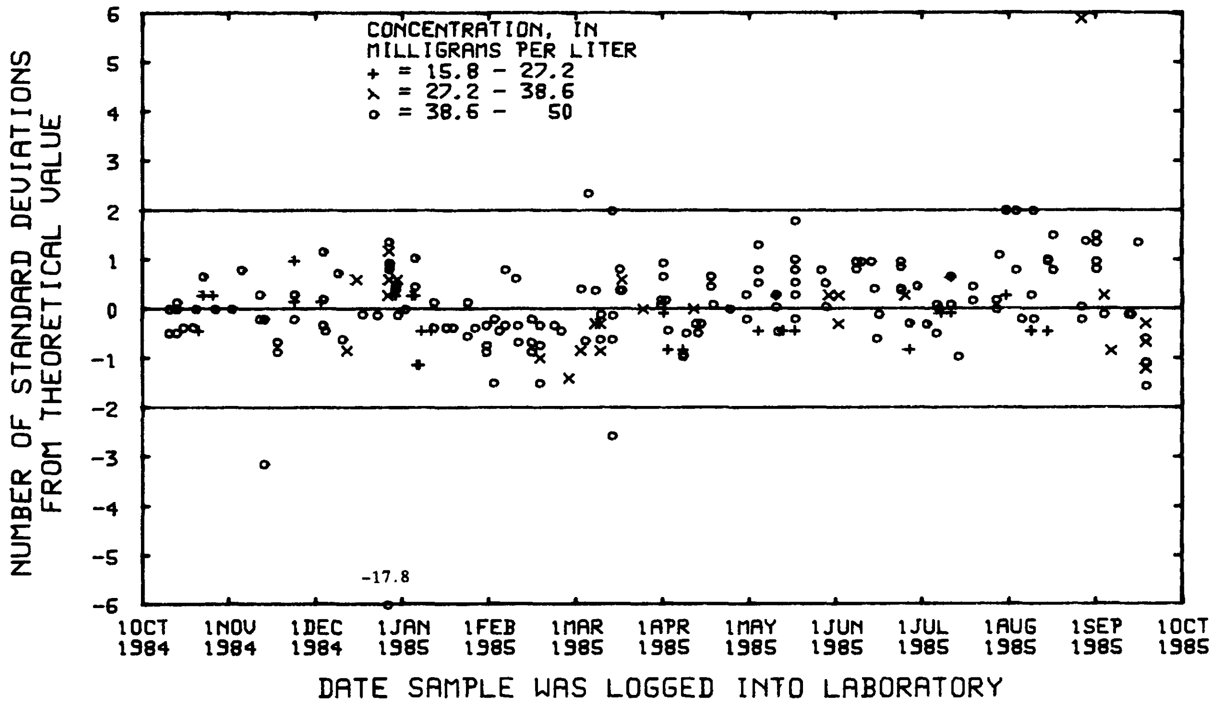

Figure 30--Chloride, dissolved, data from the Denver laboratory.

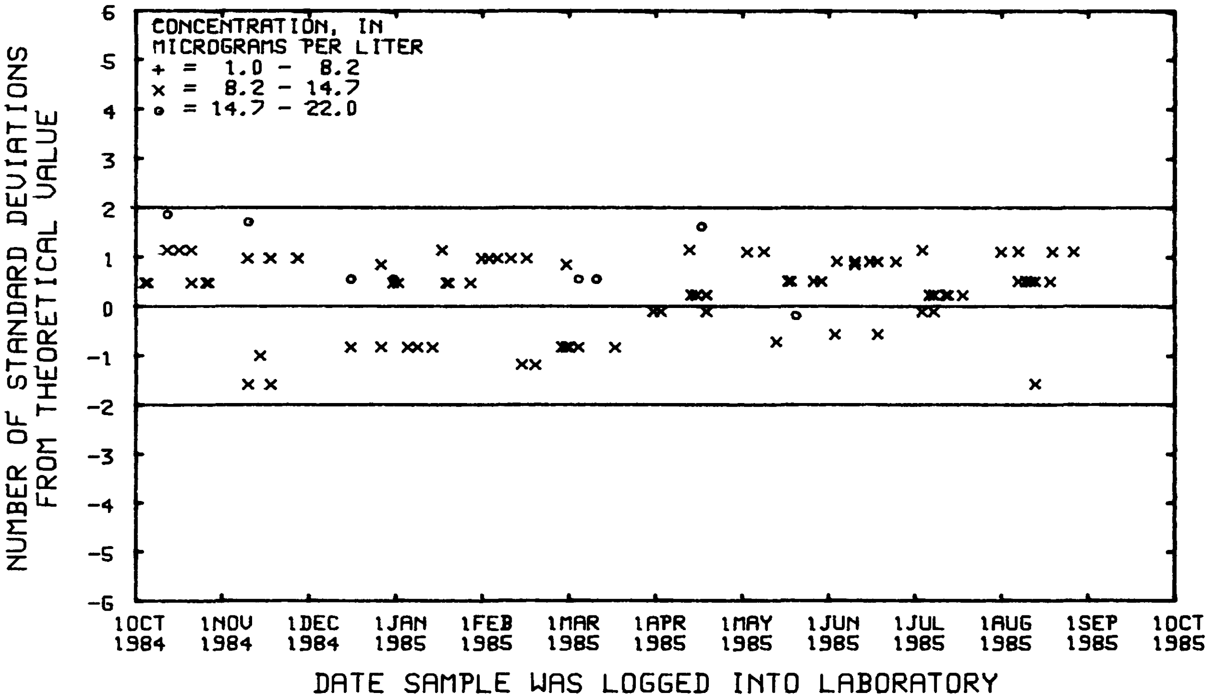

Figure 31--Chromium, dissolved, data from the Atlanta laboratory.

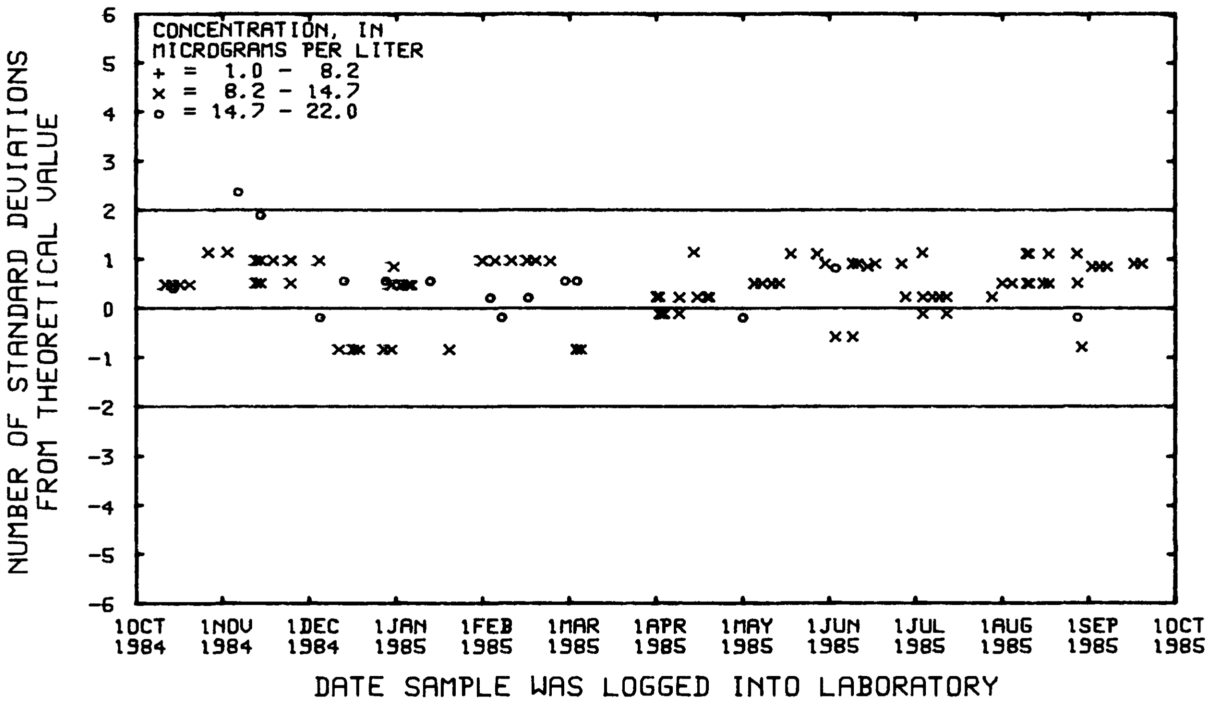

Figure 32--Chromium, dissolved, data from the Denver laboratory.

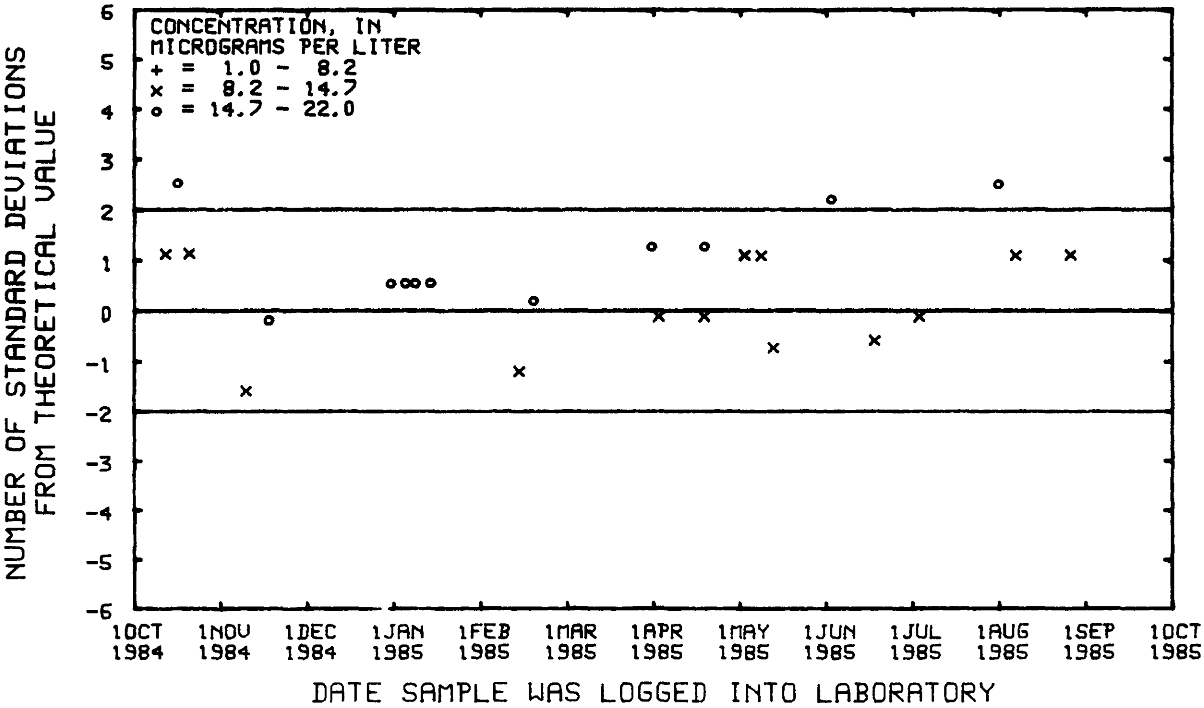

Figure 33--Chromium, total recoverable, data from the Atlanta laboratory.

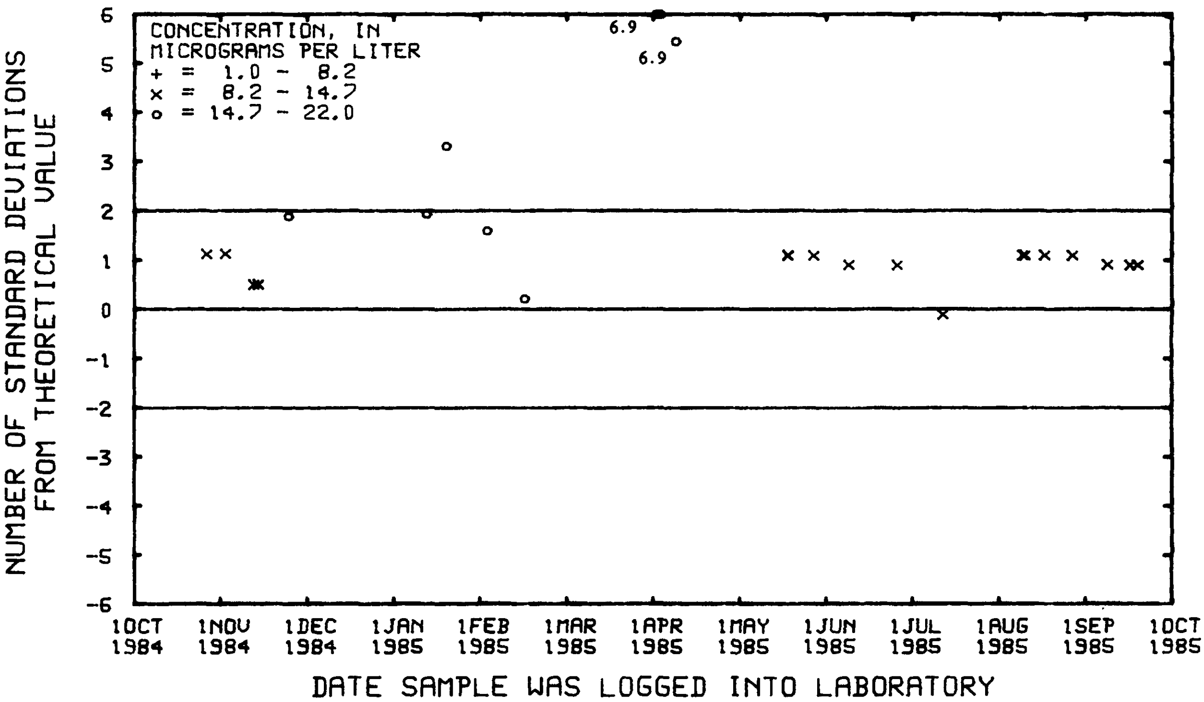

Figure 34--Chromium, total recoverable, data from the Denver laboratory.

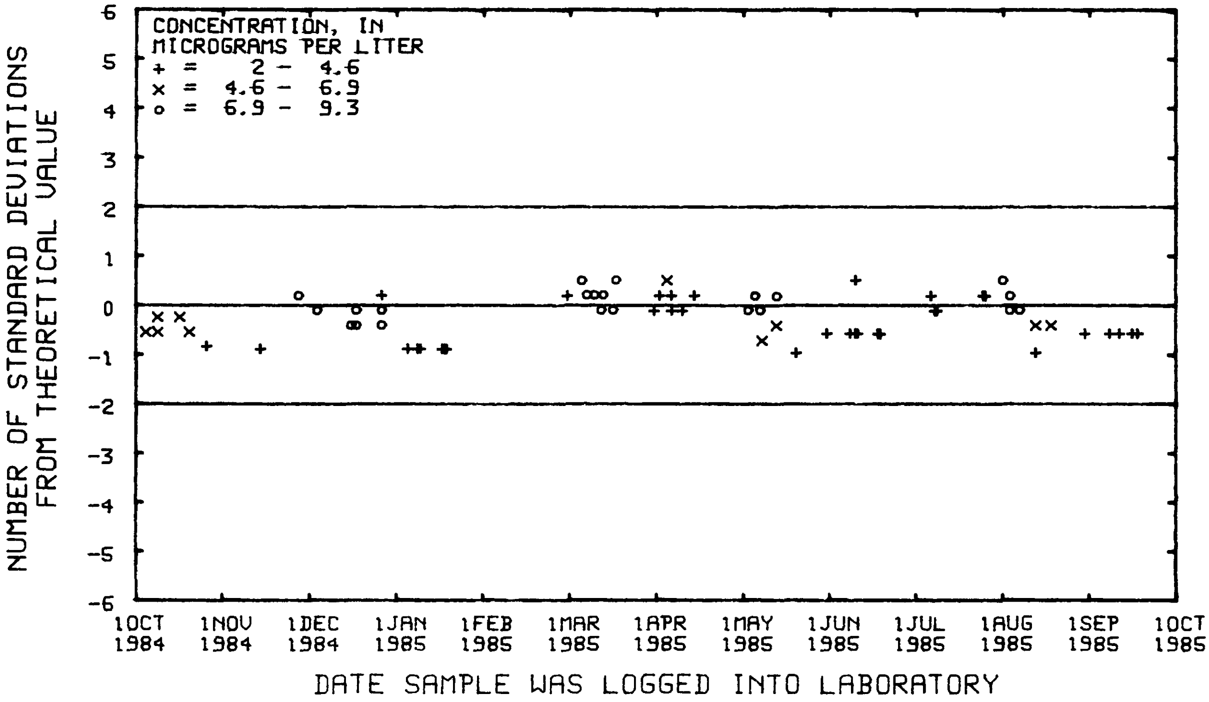

Figure 35--Cobalt, dissolved, (inductively coupled plasma emission spectrometry) data from the Atlanta laboratory.

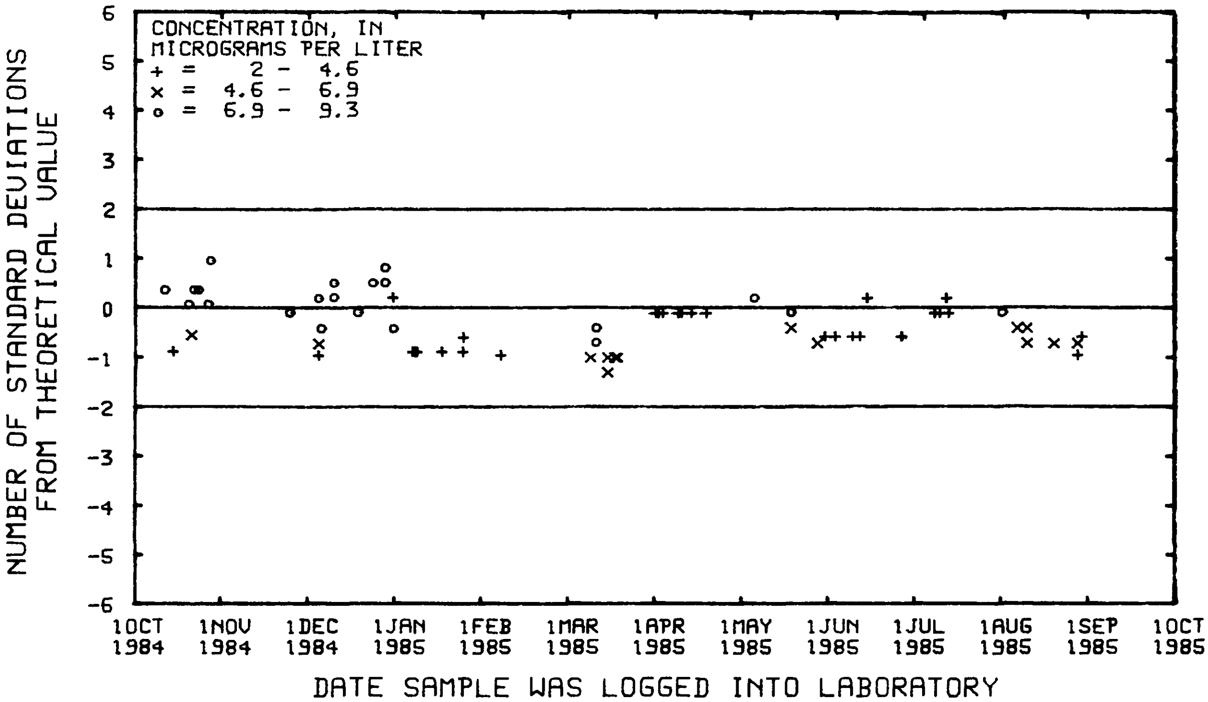

Figure 36--Cobalt, dissolved, (inductively coupled plasma emission spectrometry) data from the Denver laboratory.

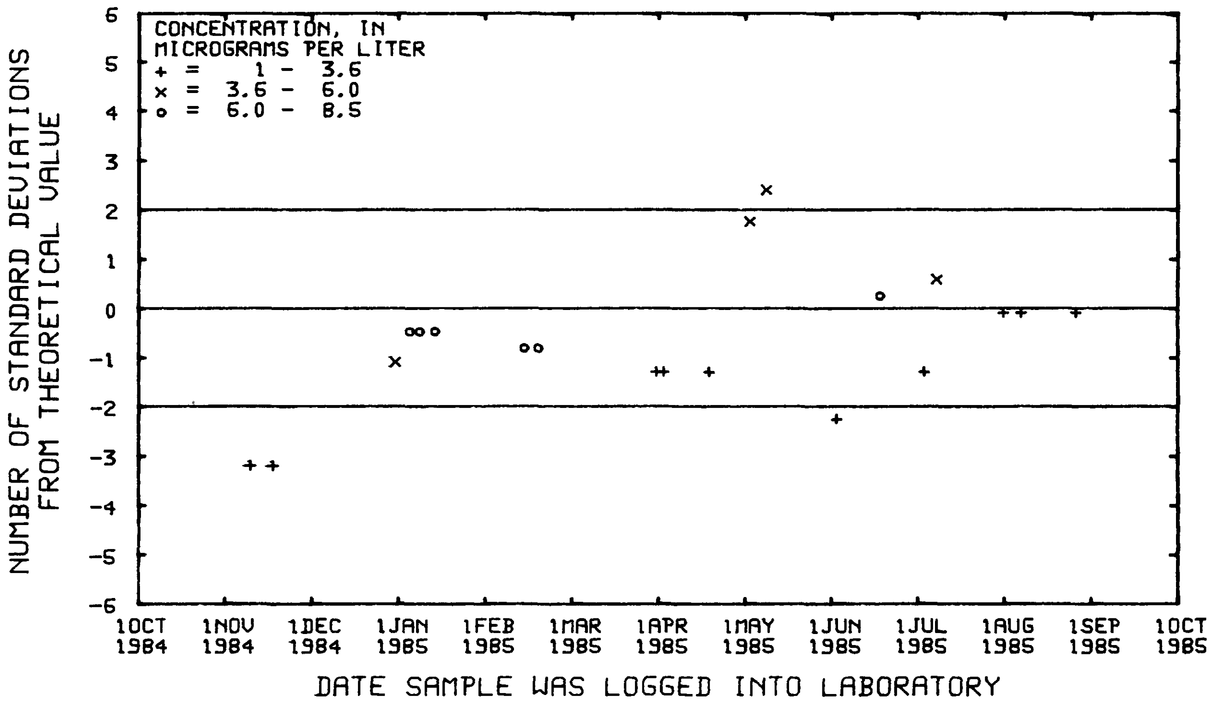

Figure 37--Cobalt, dissolved,
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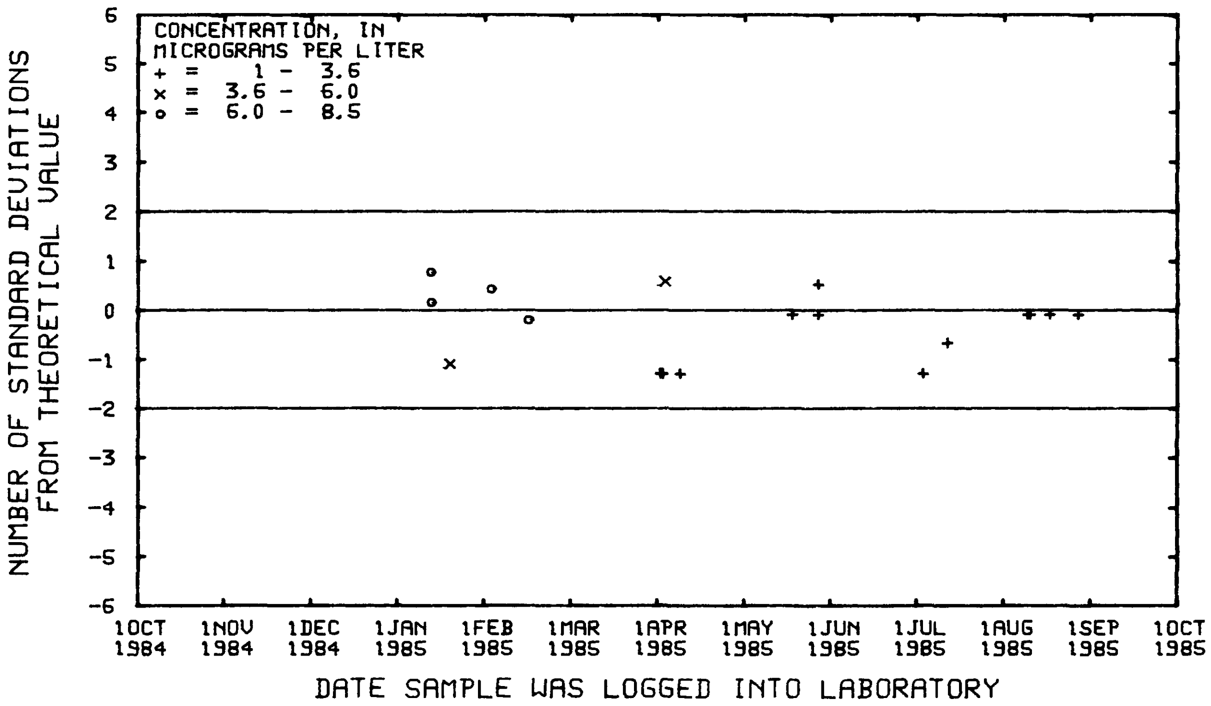

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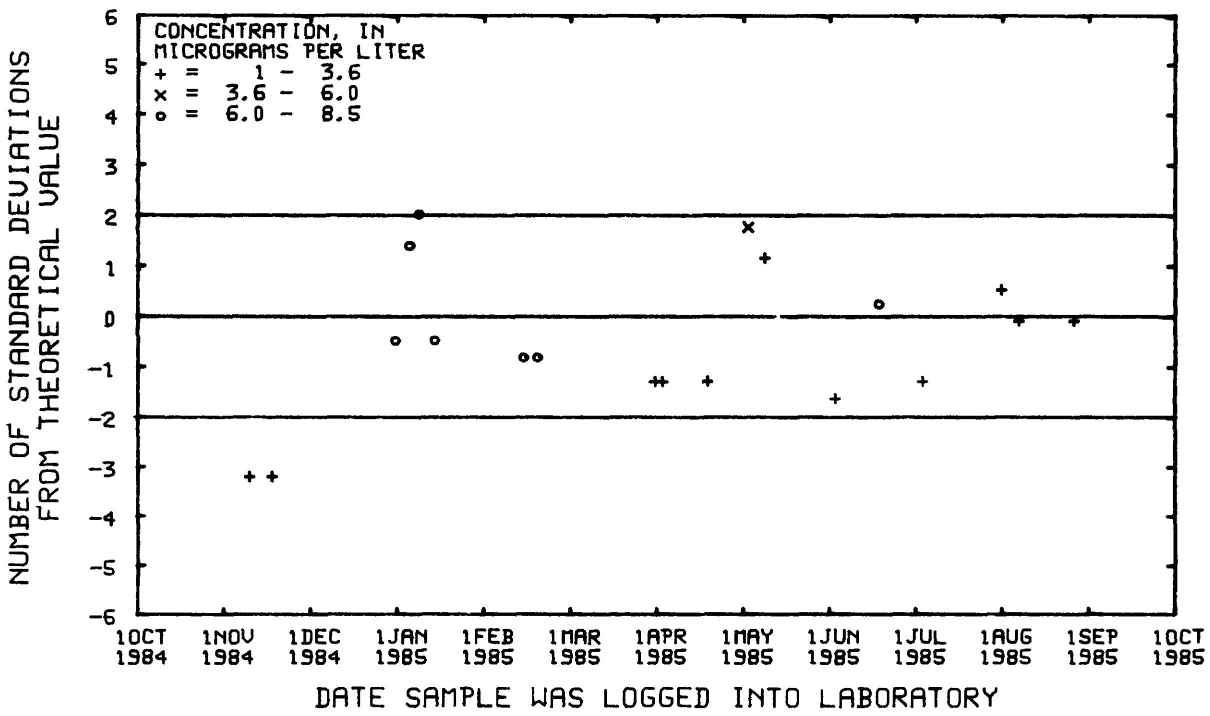


Figure 39--Cobalt, total recoverable, data from the Atlanta laboratory.

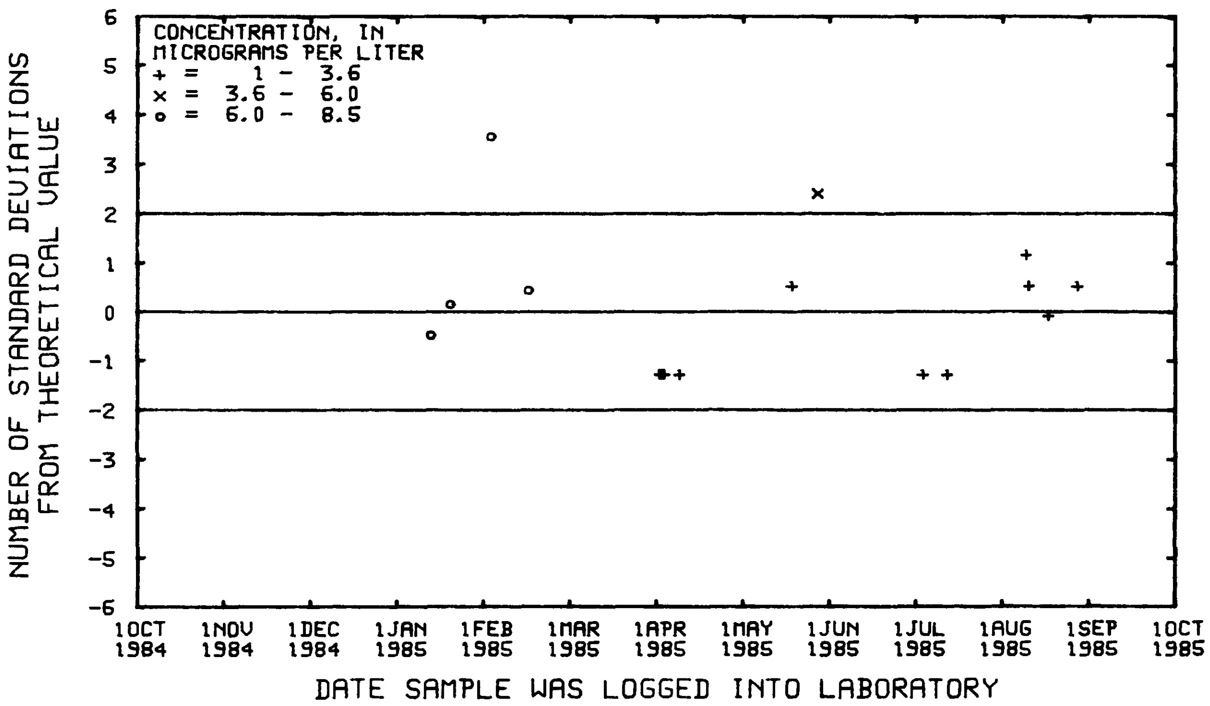


Figure 40--Cobalt, total recoverable, data from the Denver laboratory.

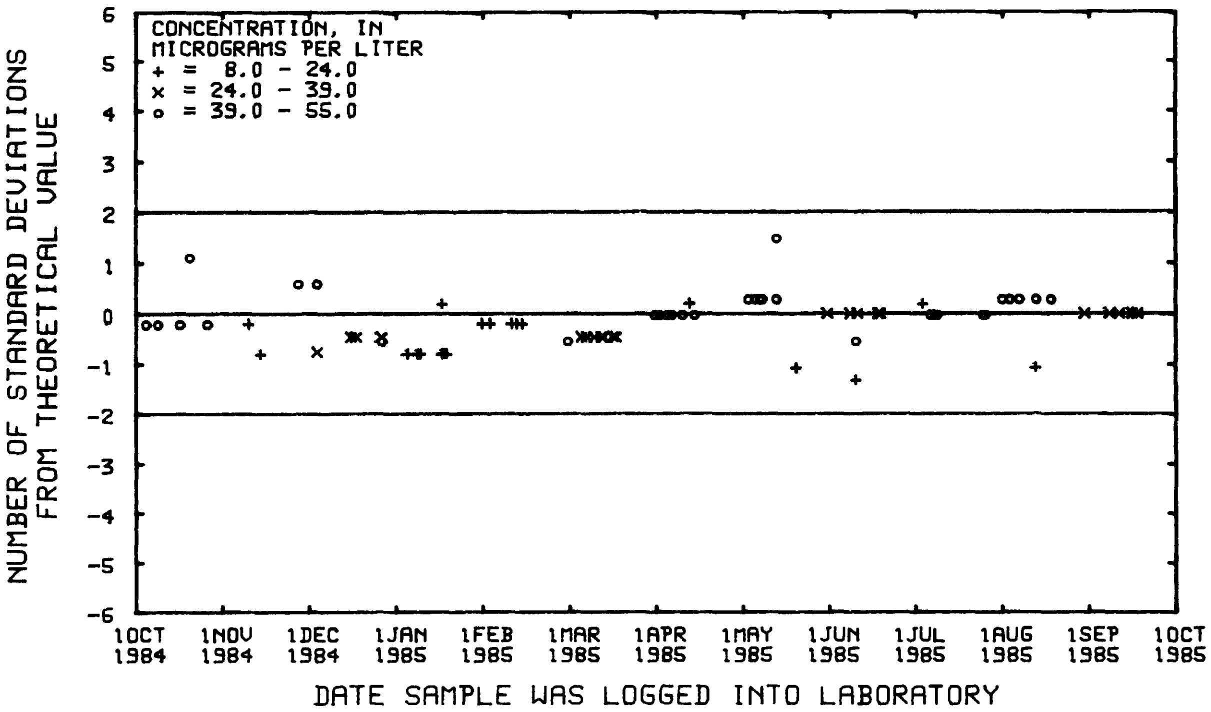
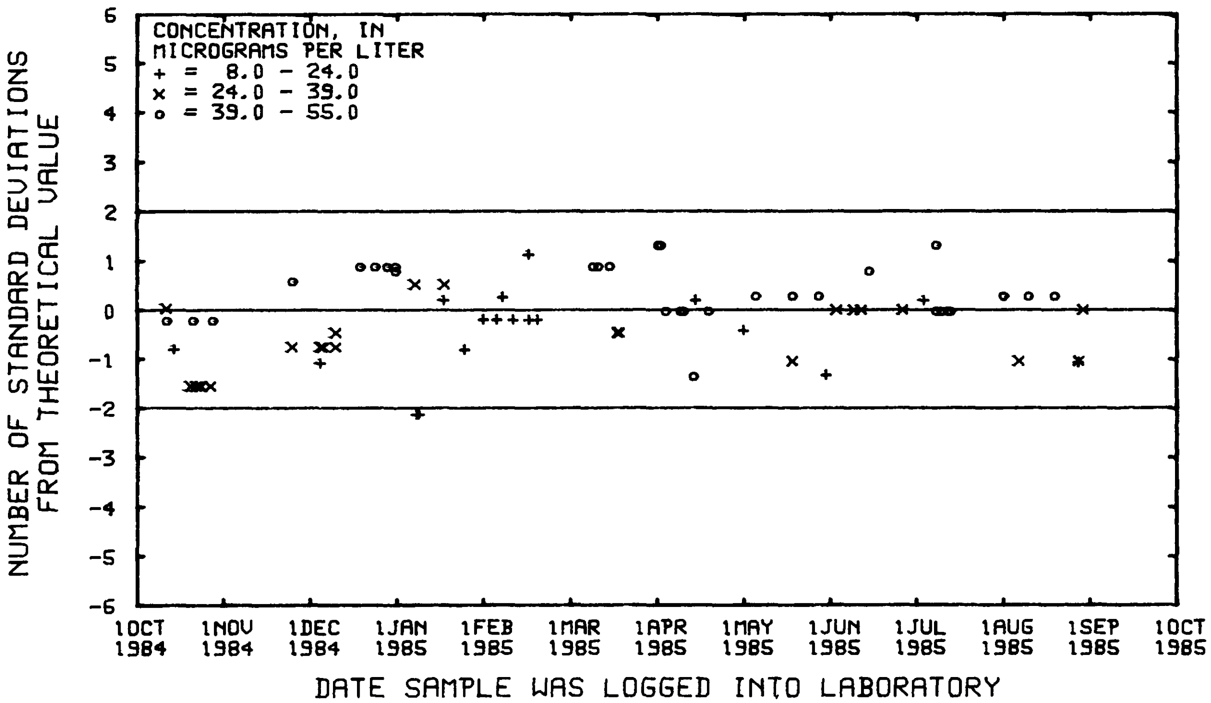


Figure 41--Copper, dissolved, (inductively coupled plasma emission spectrometry) data from the Atlanta laboratory.



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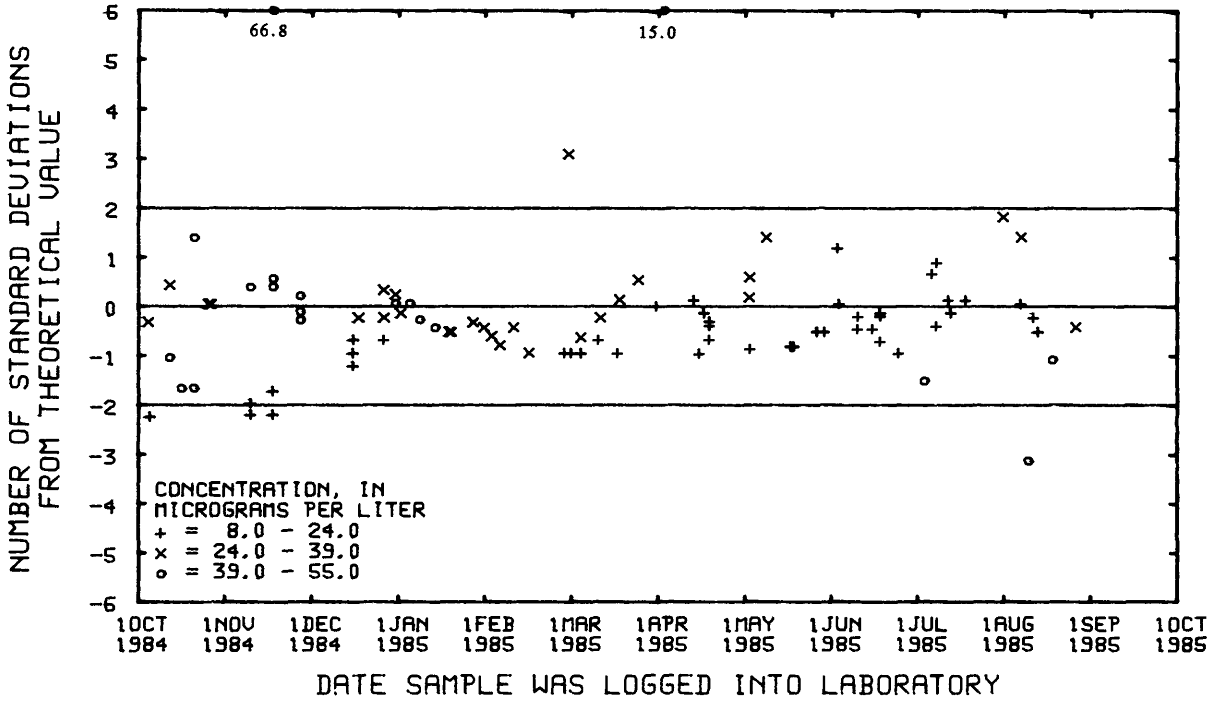

Figure 43--Copper, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

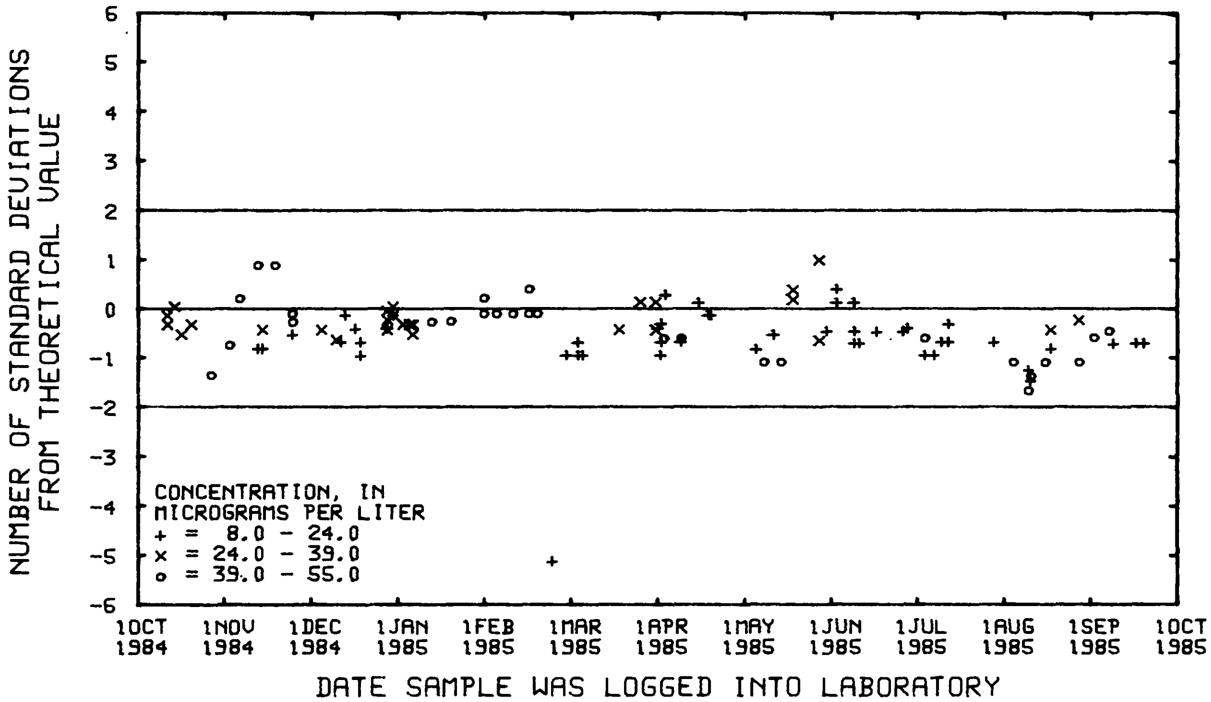

Figure 44--Copper, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

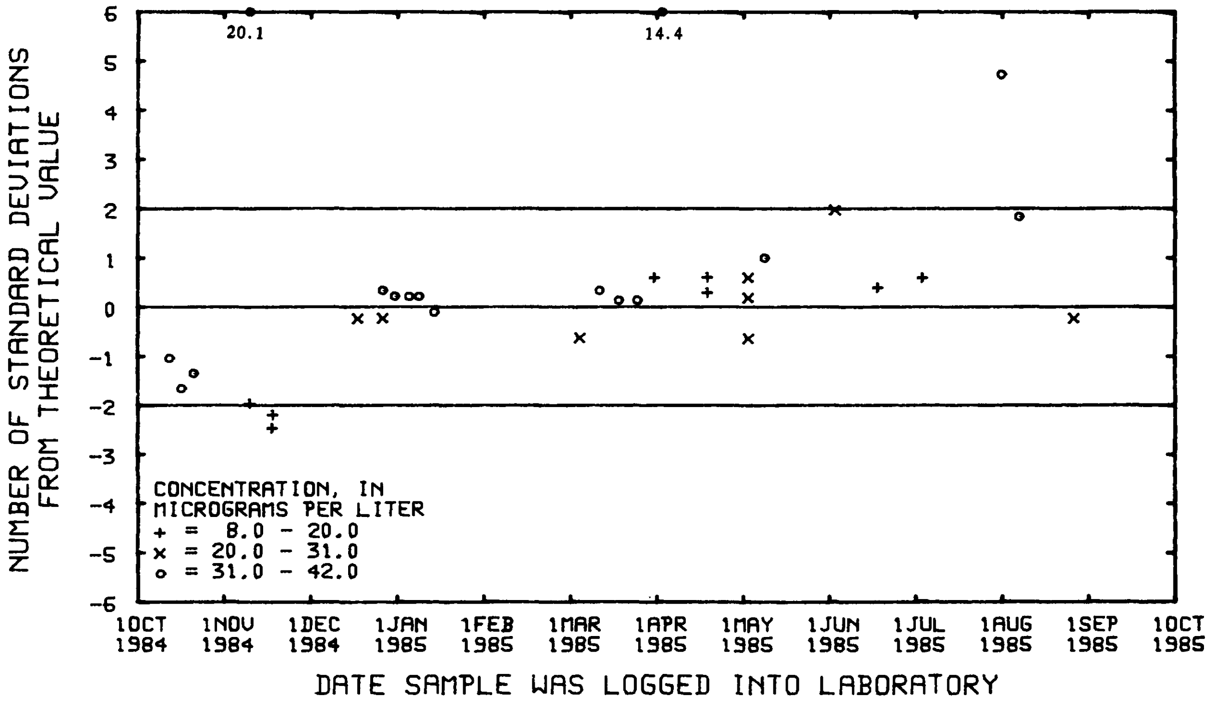

Figure 45--Copper, total recoverable, data from the Atlanta laboratory.

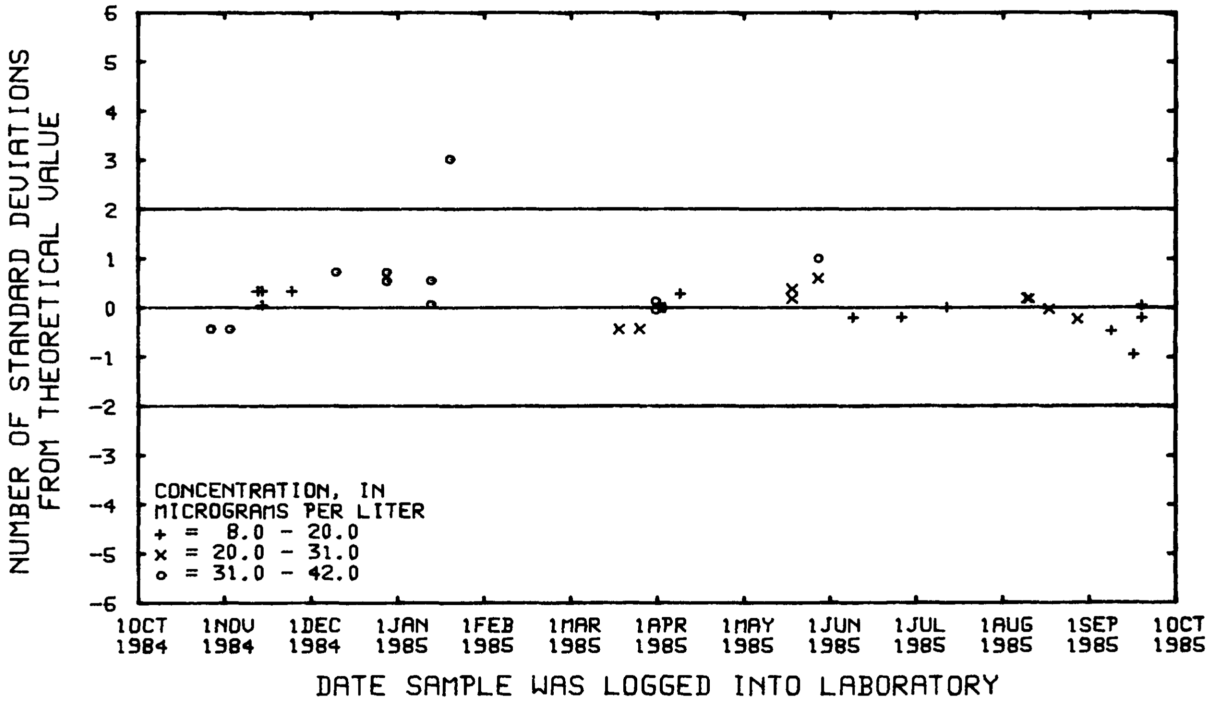

Figure 46--Copper, total recoverable, data from the Denver laboratory.

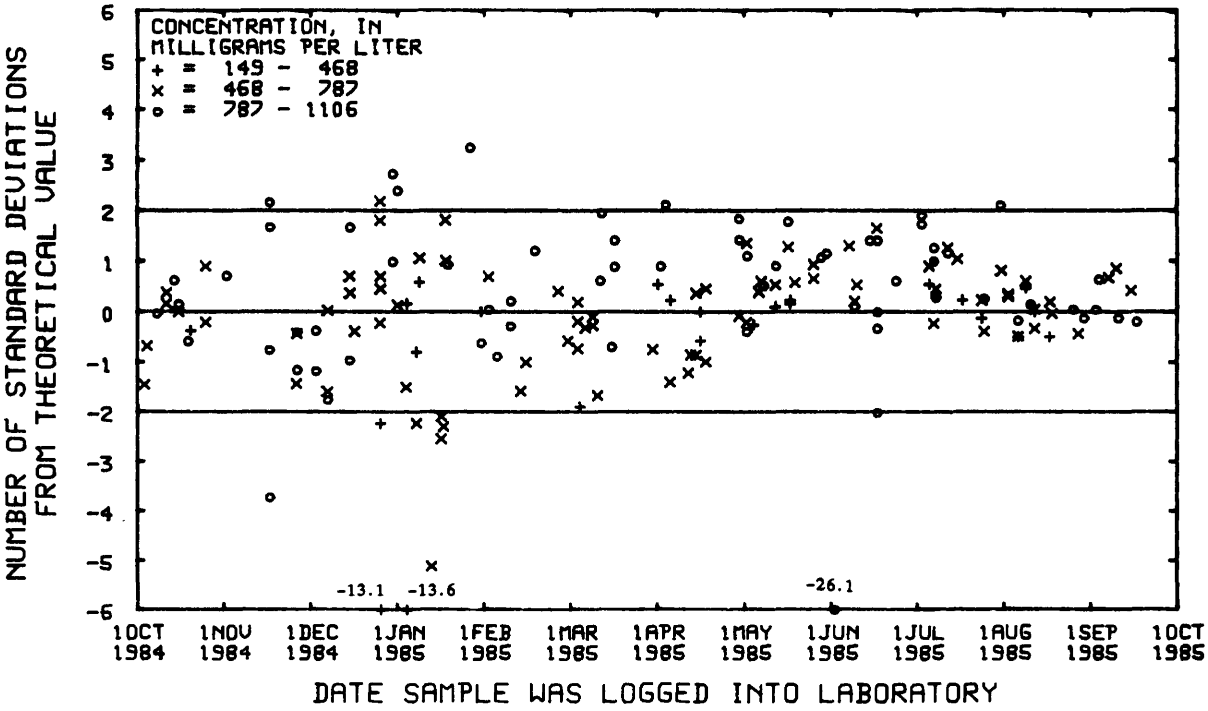

Figure 47--Dissolved solids data from the Atlanta laboratory.

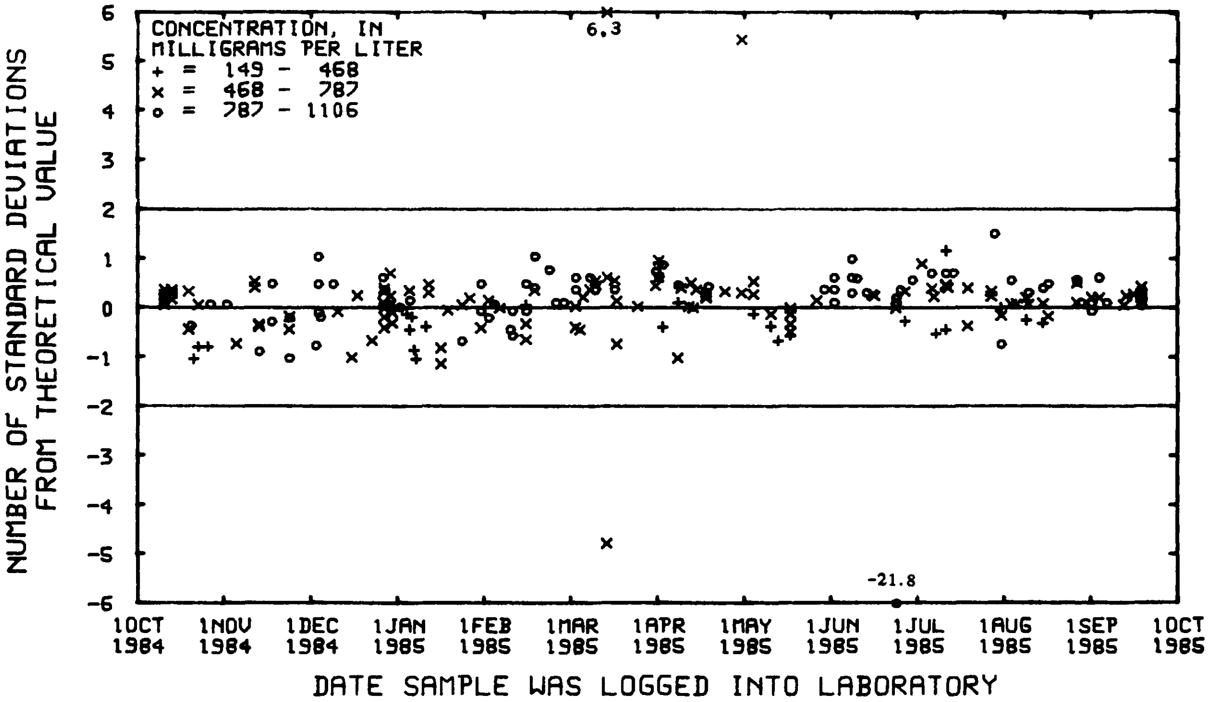

Figure 48--Dissolved solids data from the Denver laboratory.

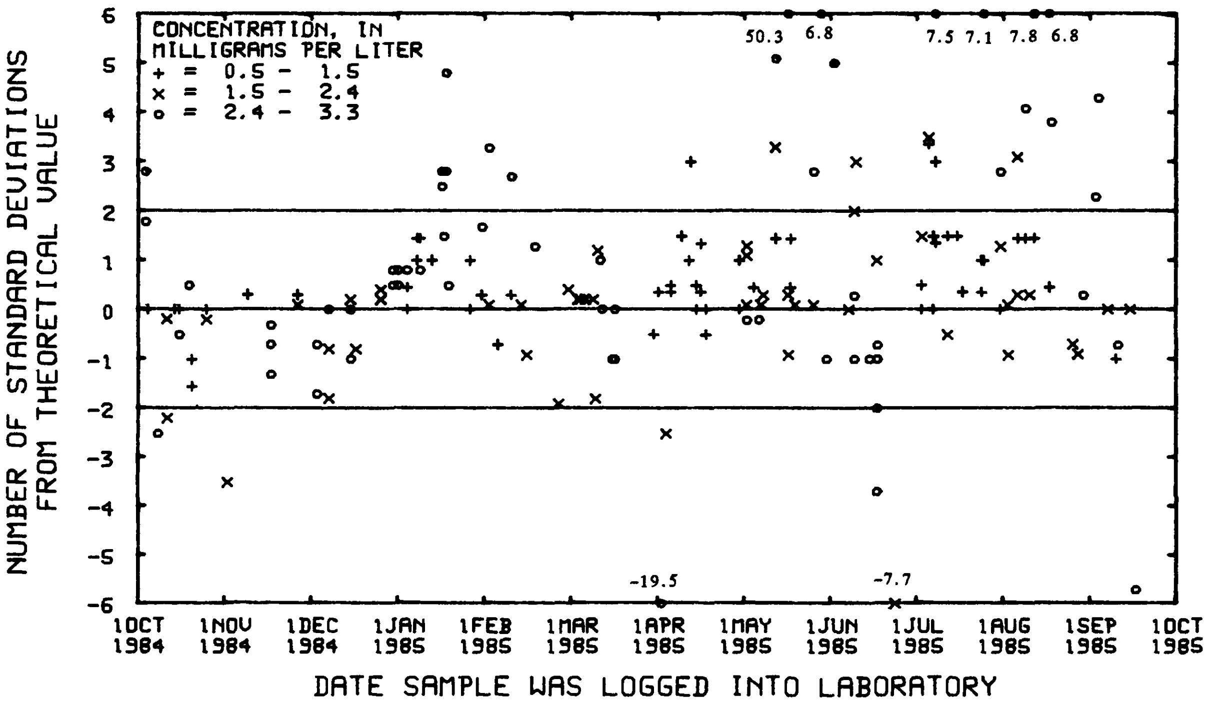

Figure 49--Flouride, dissolved, data from the Atlanta laboratory.

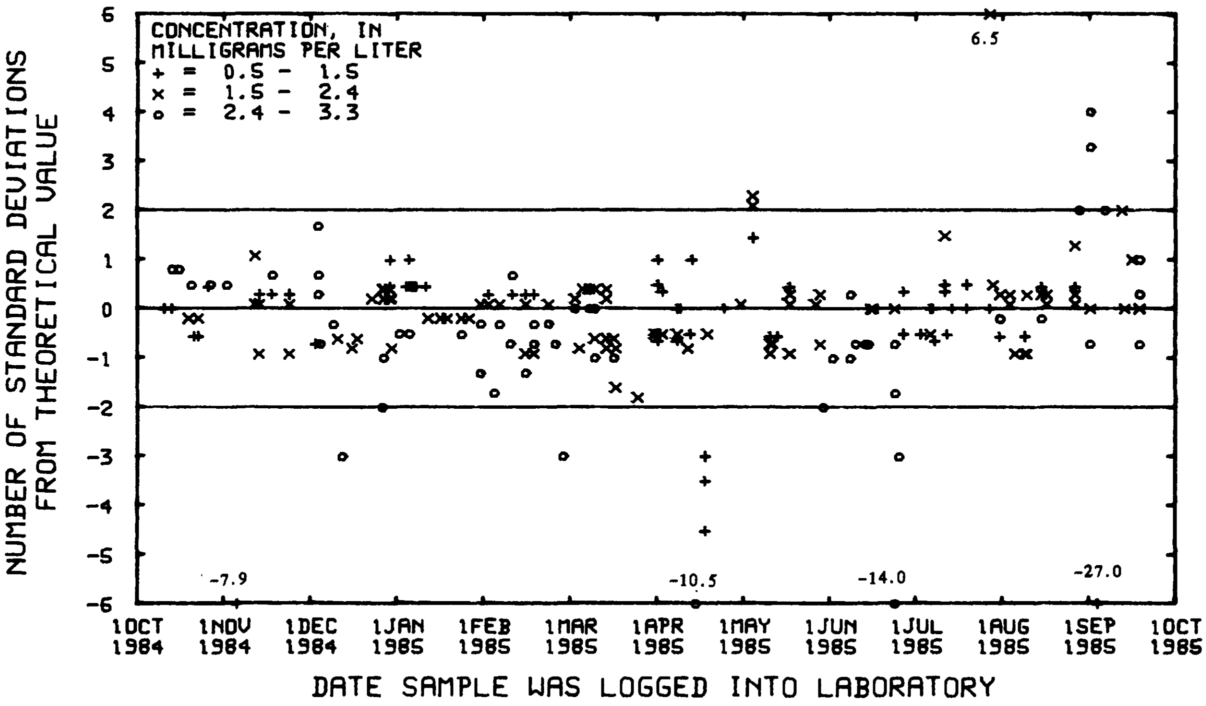

Figure 50--Flouride, dissolved, data from the Denver laboratory.

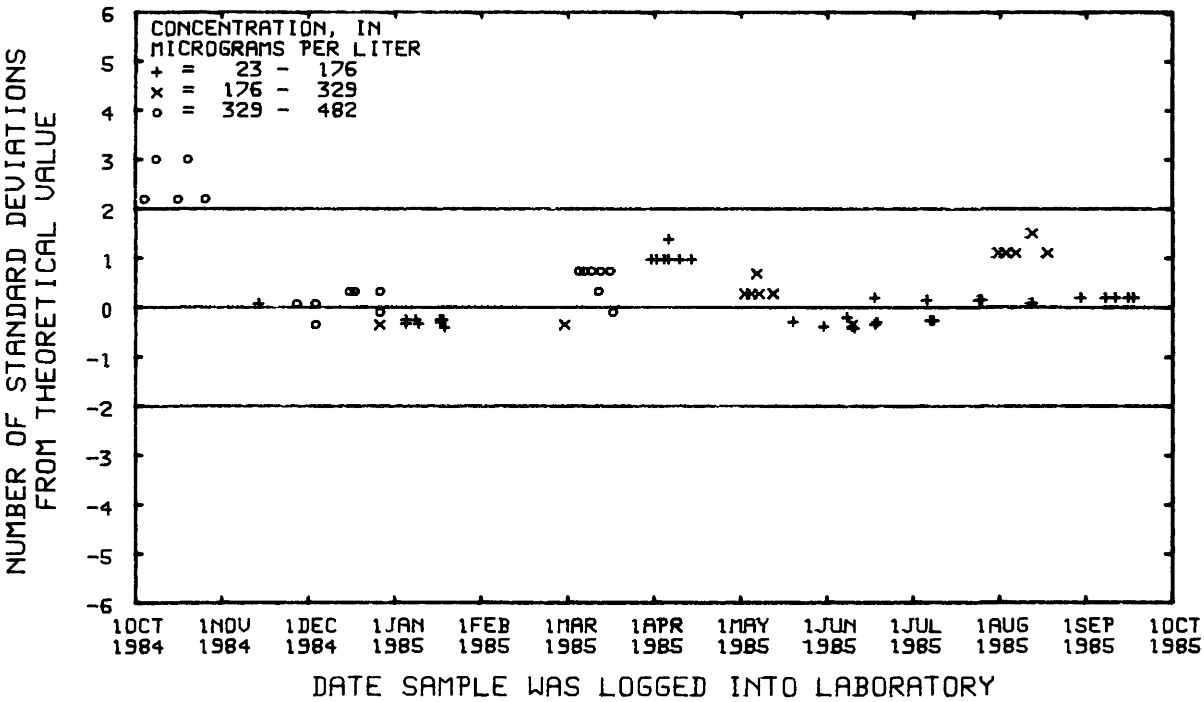

Figure 51--Iron, dissolved,
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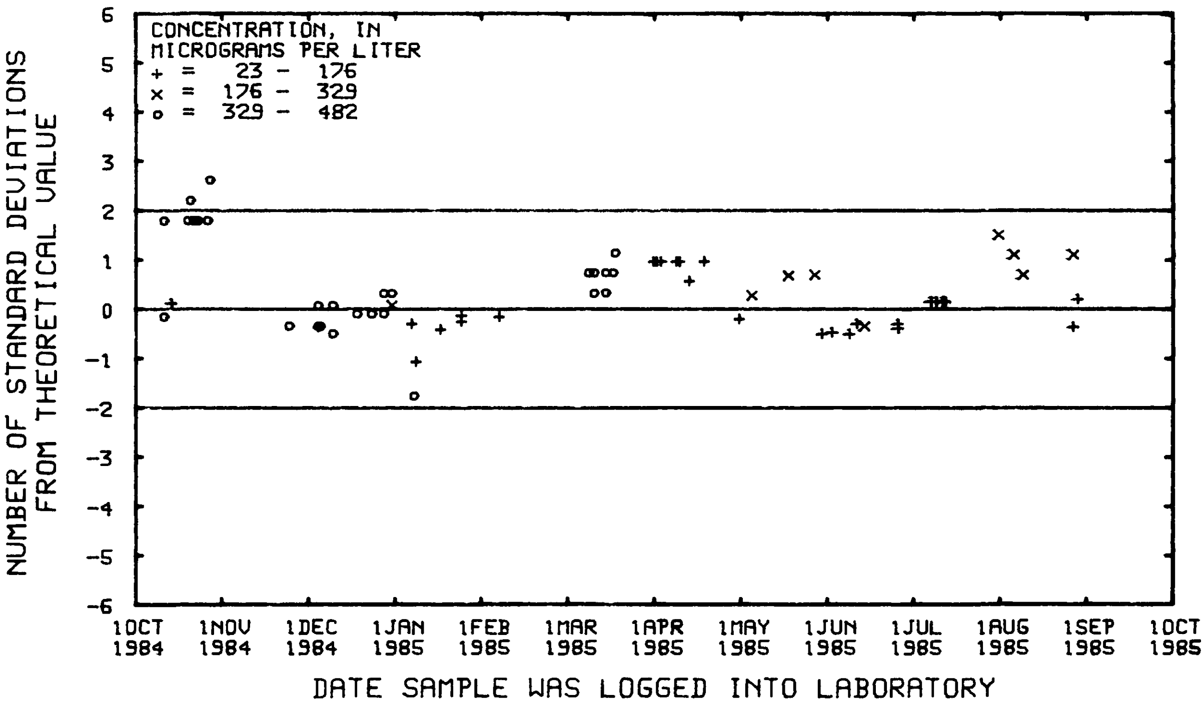

Figure 52--Iron, dissolved,
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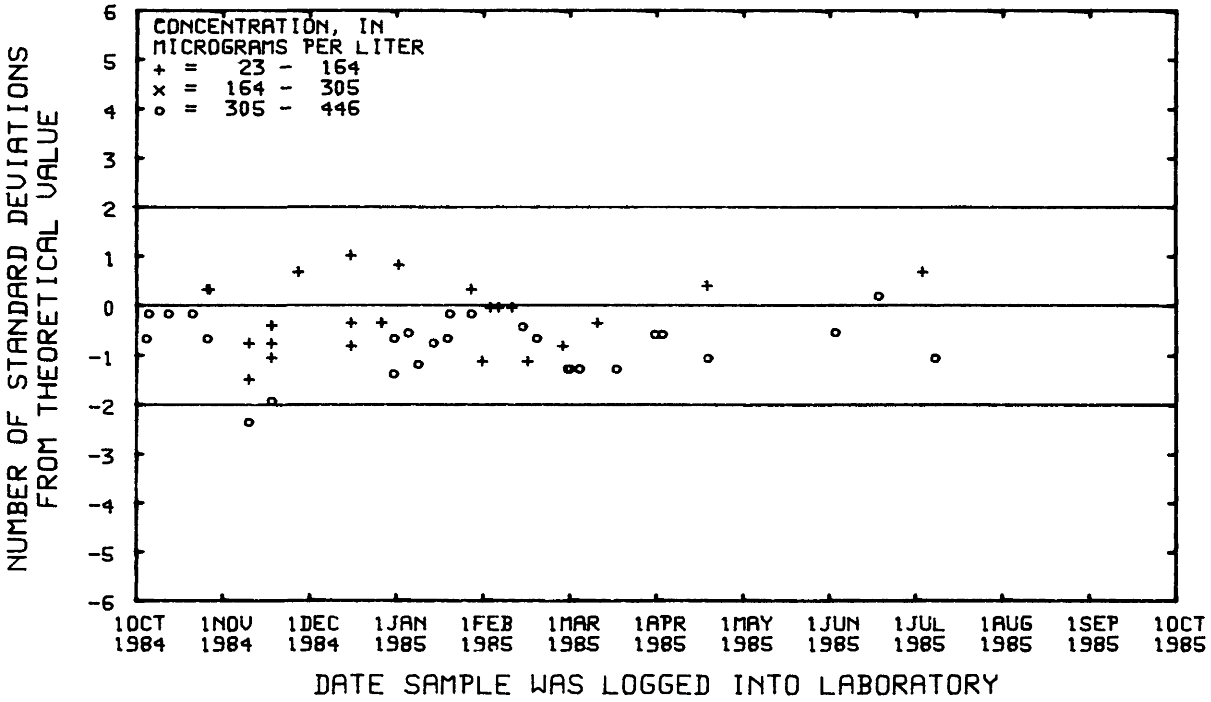

Figure 53--Iron, dissolved,
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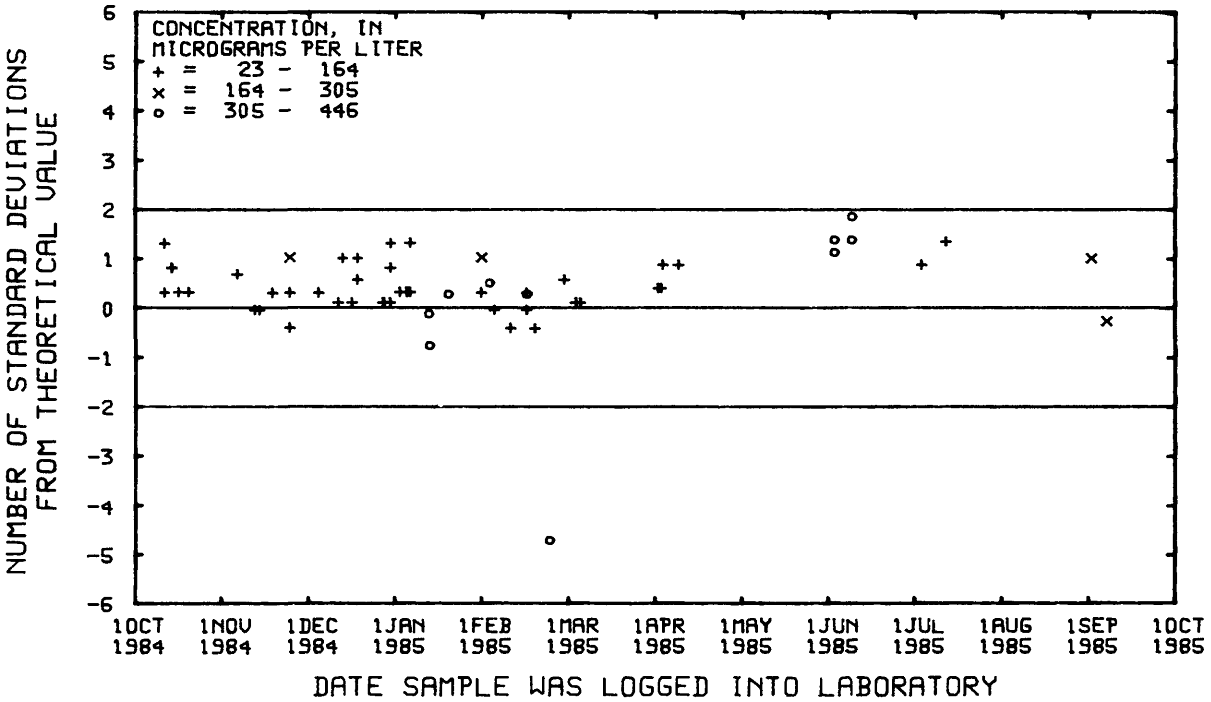

Figure 54--Iron, dissolved,
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data from the Denver laboratory.

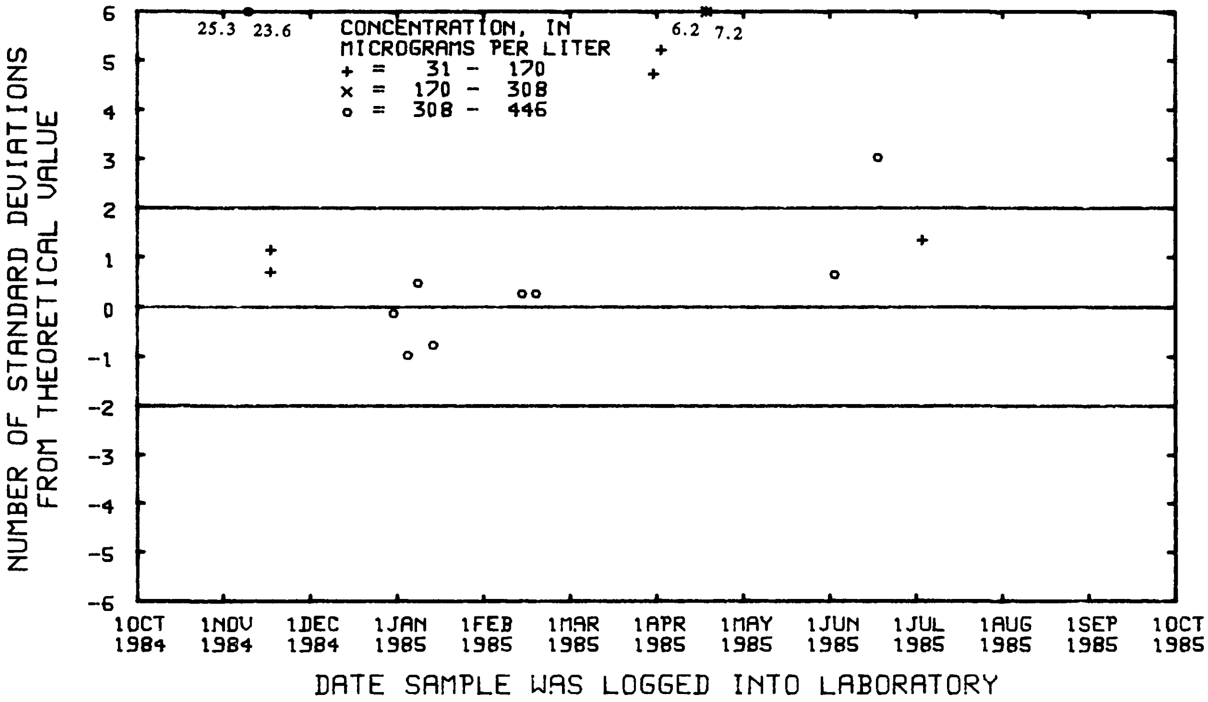

Figure 55--Iron, total recoverable, data from the Atlanta laboratory.

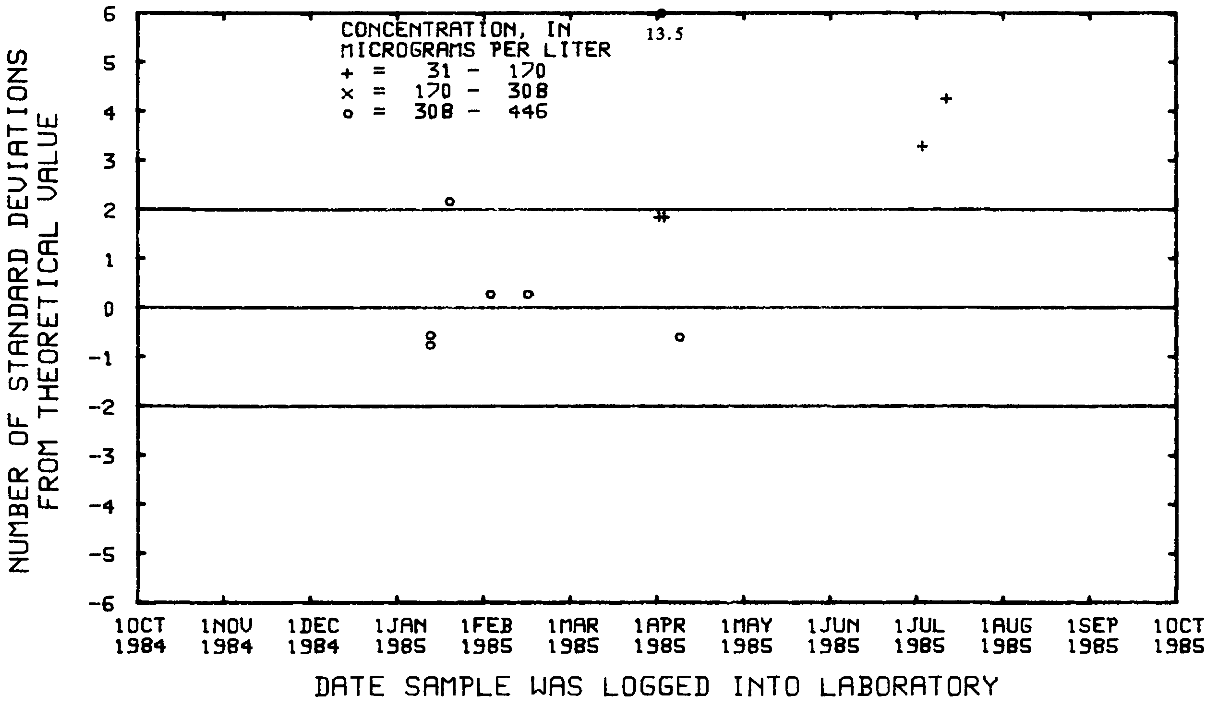

Figure 56--Iron, total recoverable, data from the Denver laboratory.

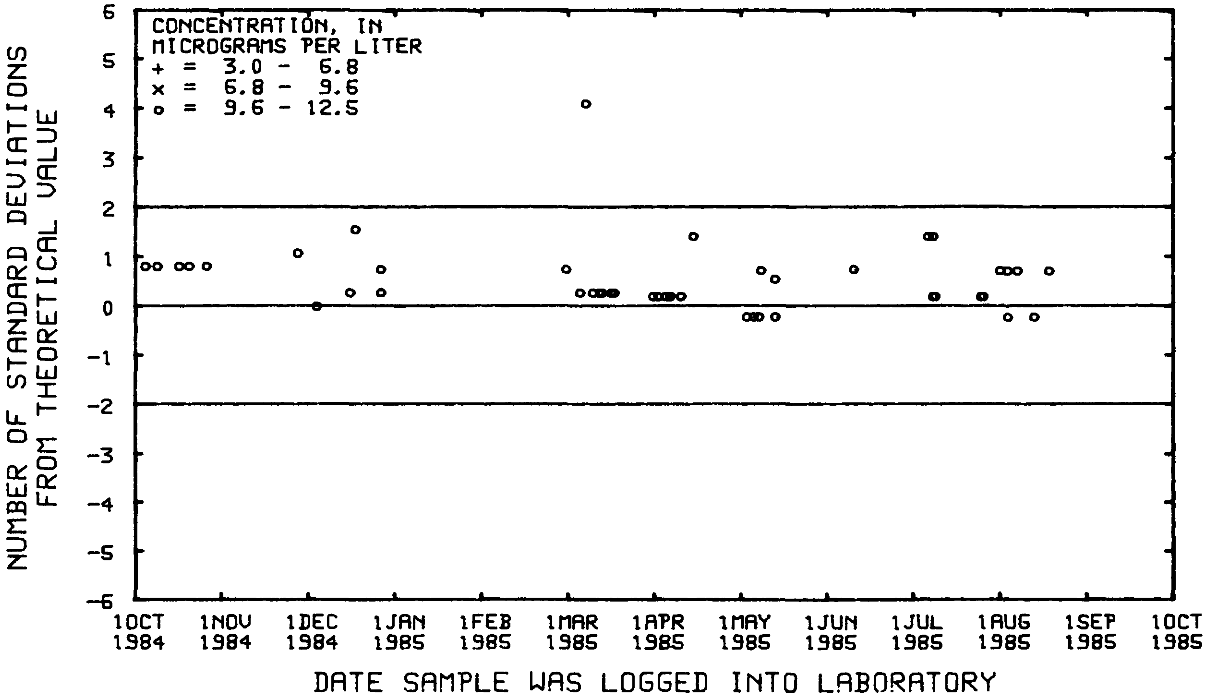

Figure 57--Lead, dissolved,
(inductively coupled plasma emission spectrometry)
data from the Atlanta laboratory.

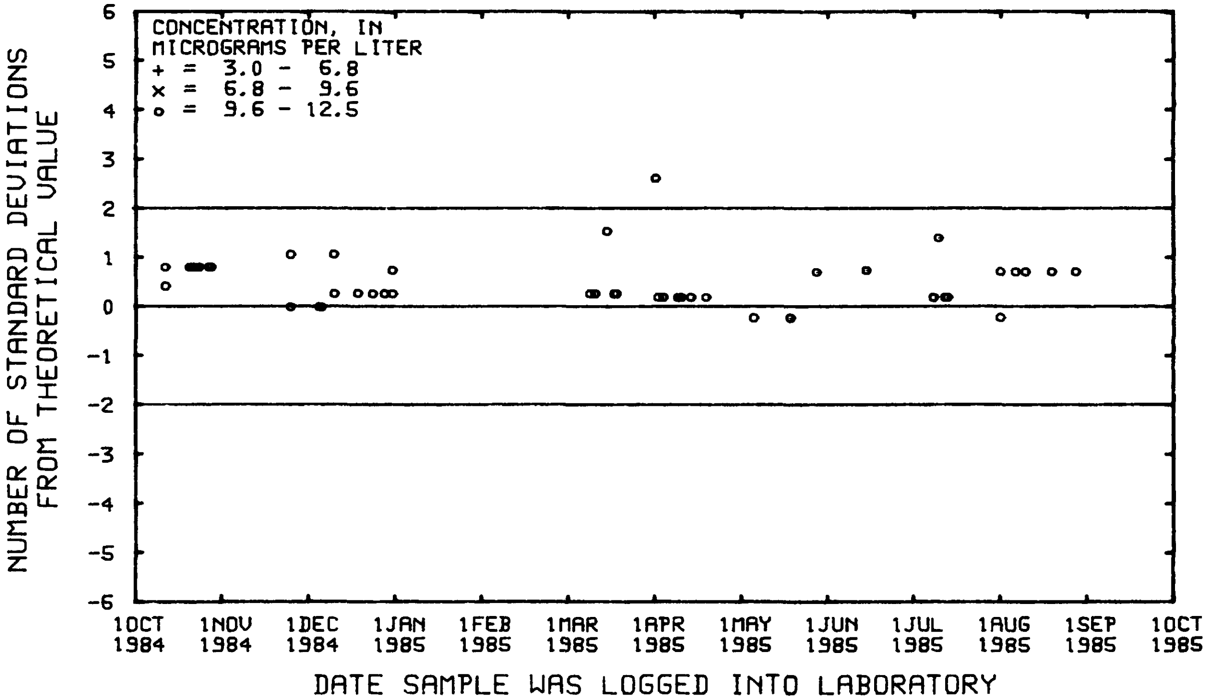

Figure 58--Lead, dissolved,
(inductively coupled plasma emission spectrometry)
data from the Denver laboratory.

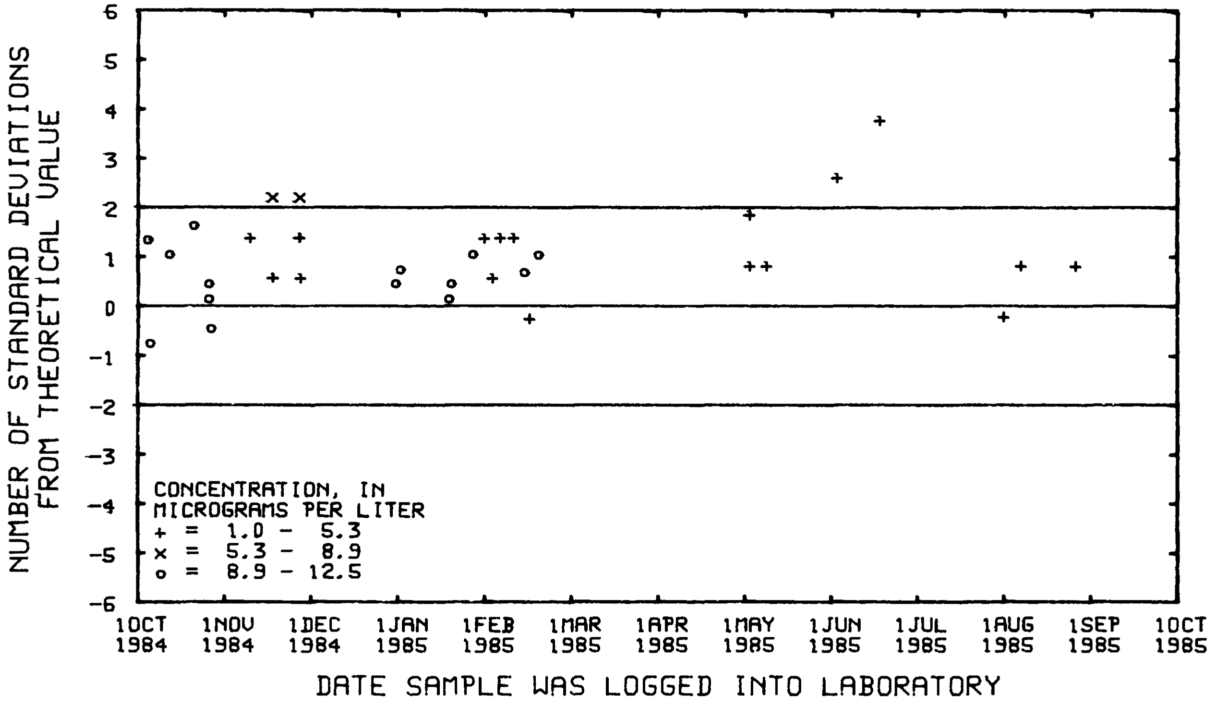

Figure 59--Lead, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

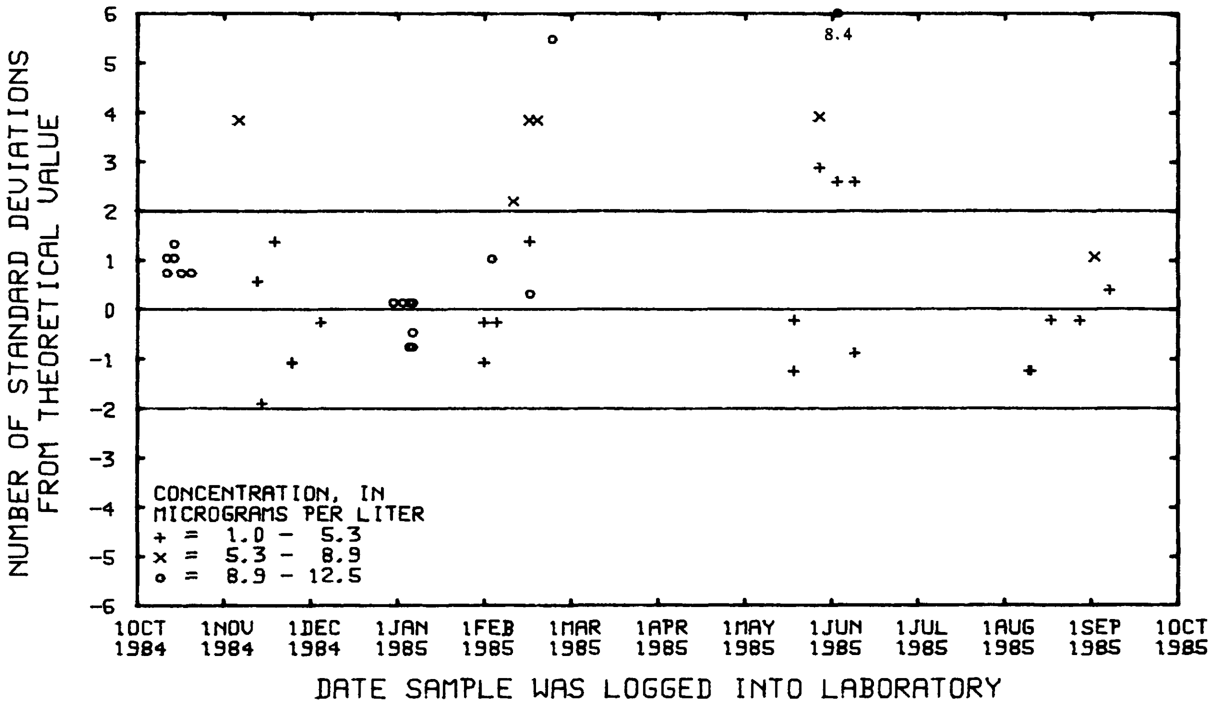

Figure 60--Lead, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

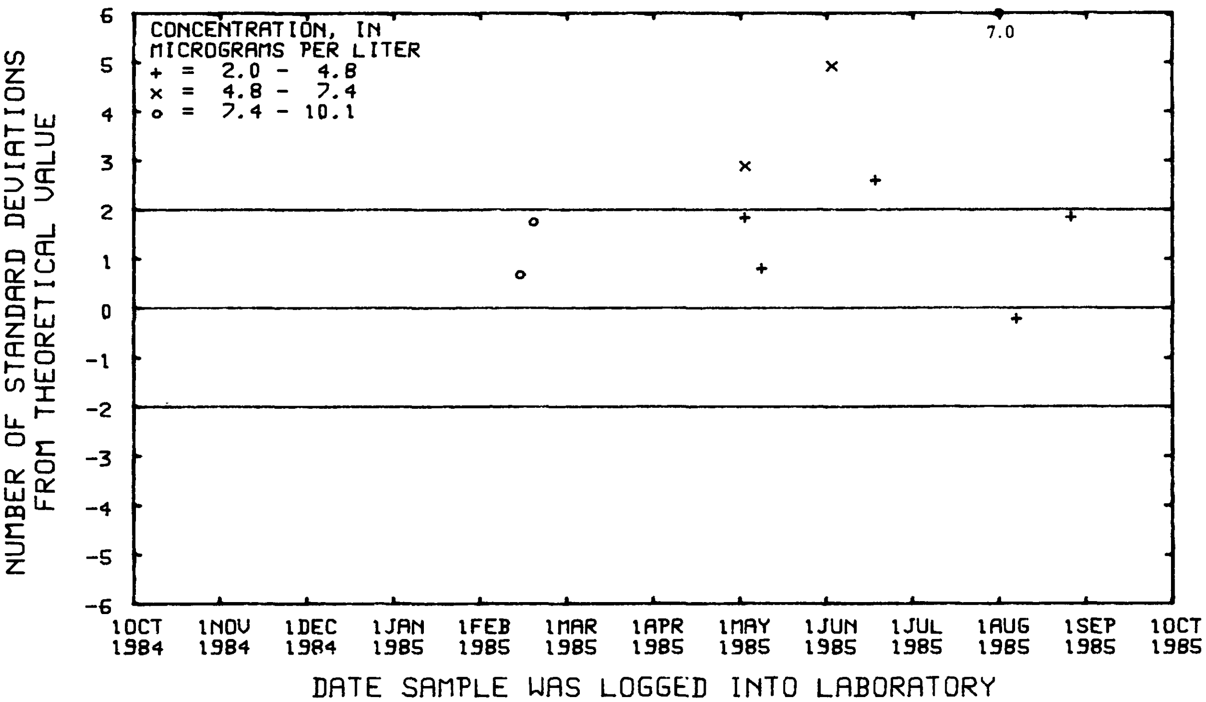

Figure 61--Lead, total recoverable,
data from the Atlanta laboratory.

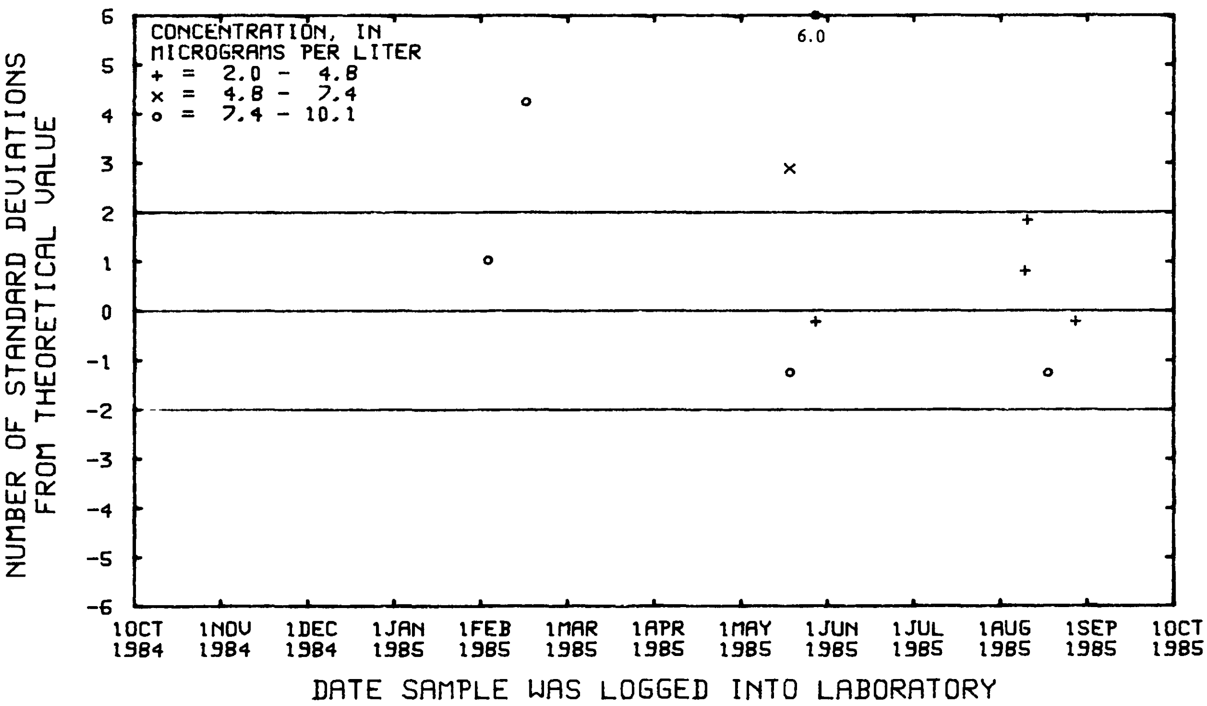

Figure 62--Lead, total recoverable,
data from the Denver laboratory.

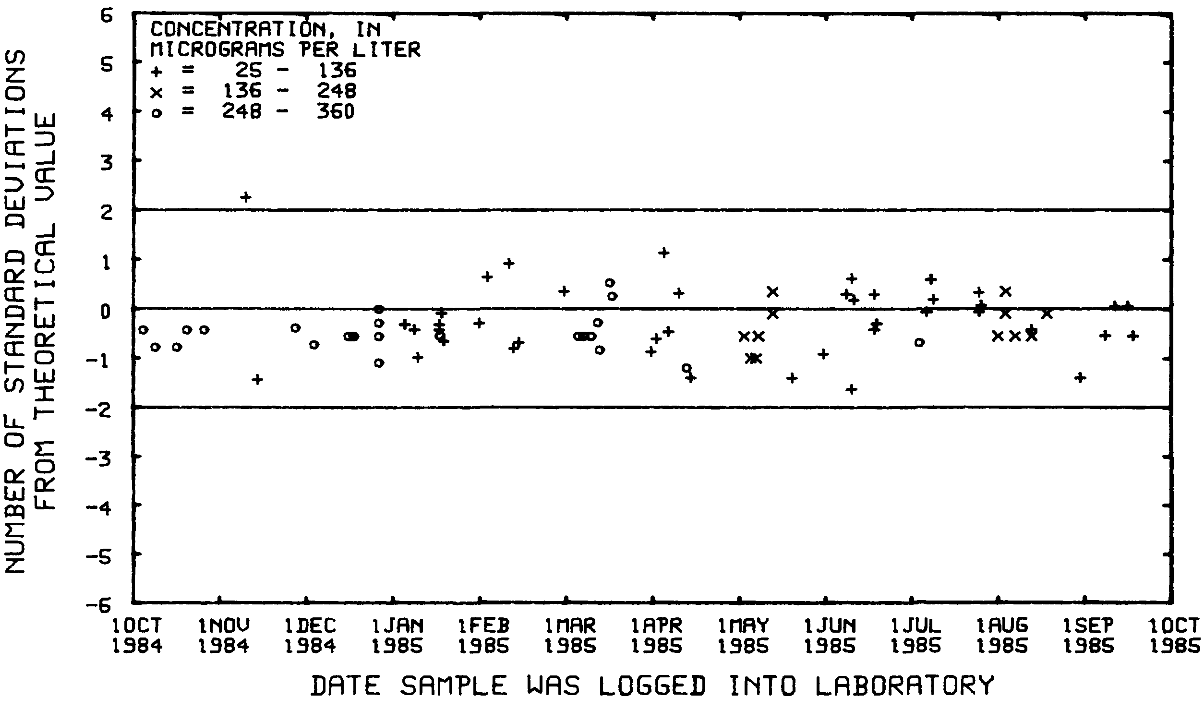

Figure 63--Lithium, dissolved, data from the Atlanta laboratory.

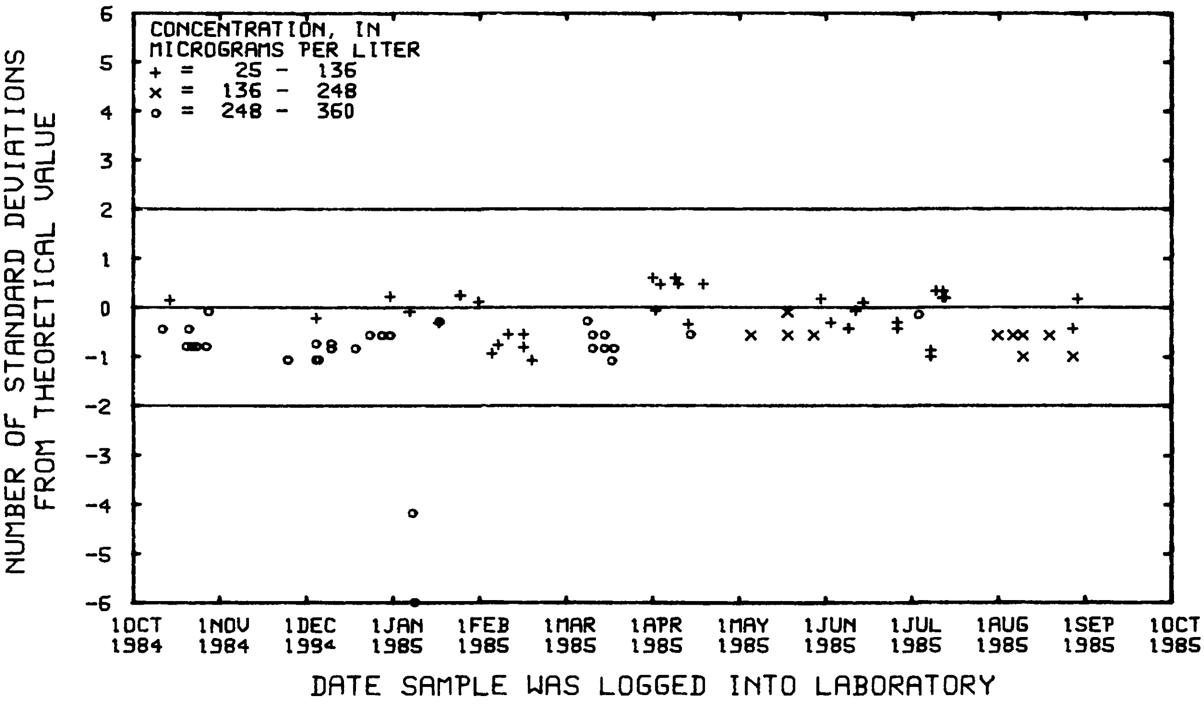

Figure 64--Lithium, dissolved, data from the Denver laboratory.

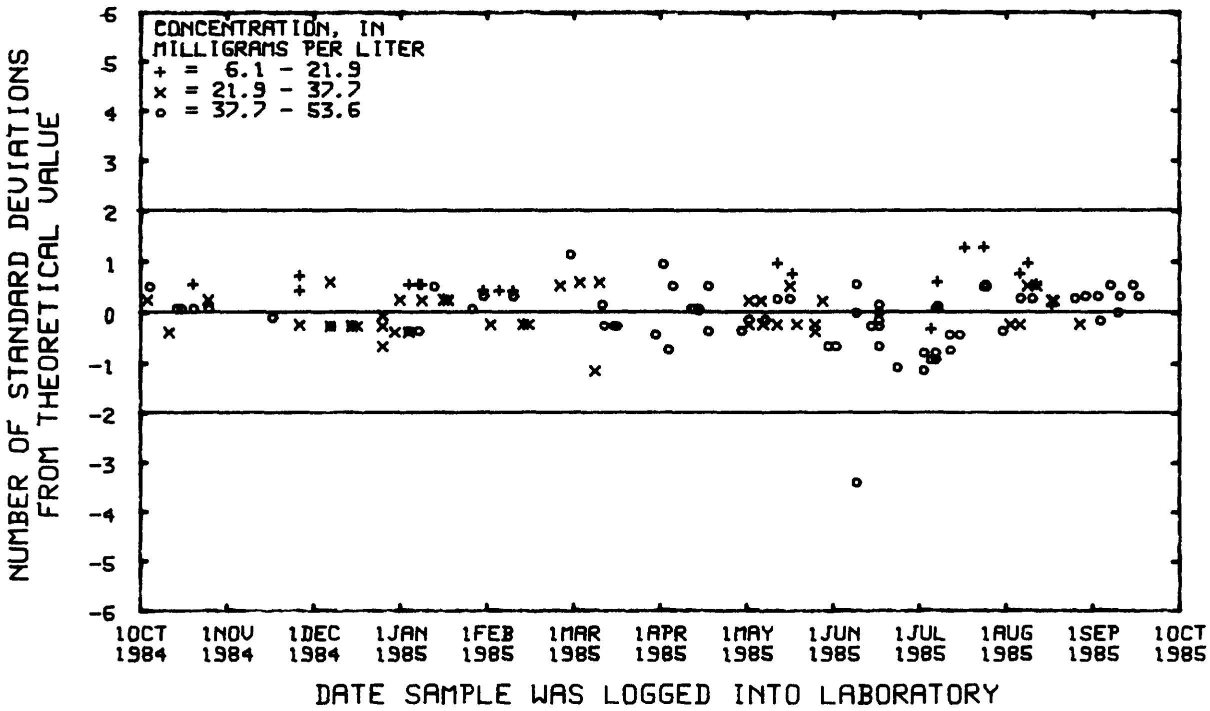

Figure 65--Magnesium, dissolved, (inductively coupled plasma emission spectrometry) data from the Atlanta laboratory.

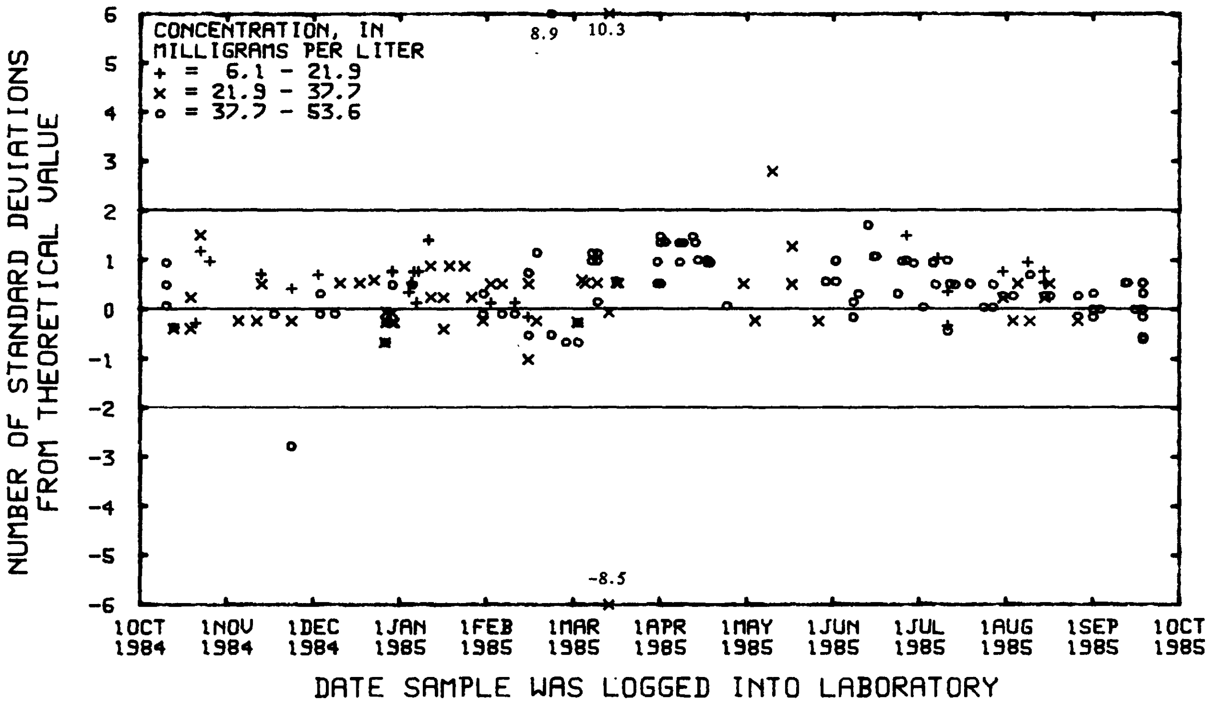

Figure 66--Magnesium, dissolved, (inductively coupled plasma emission spectrometry) data from the Denver laboratory.

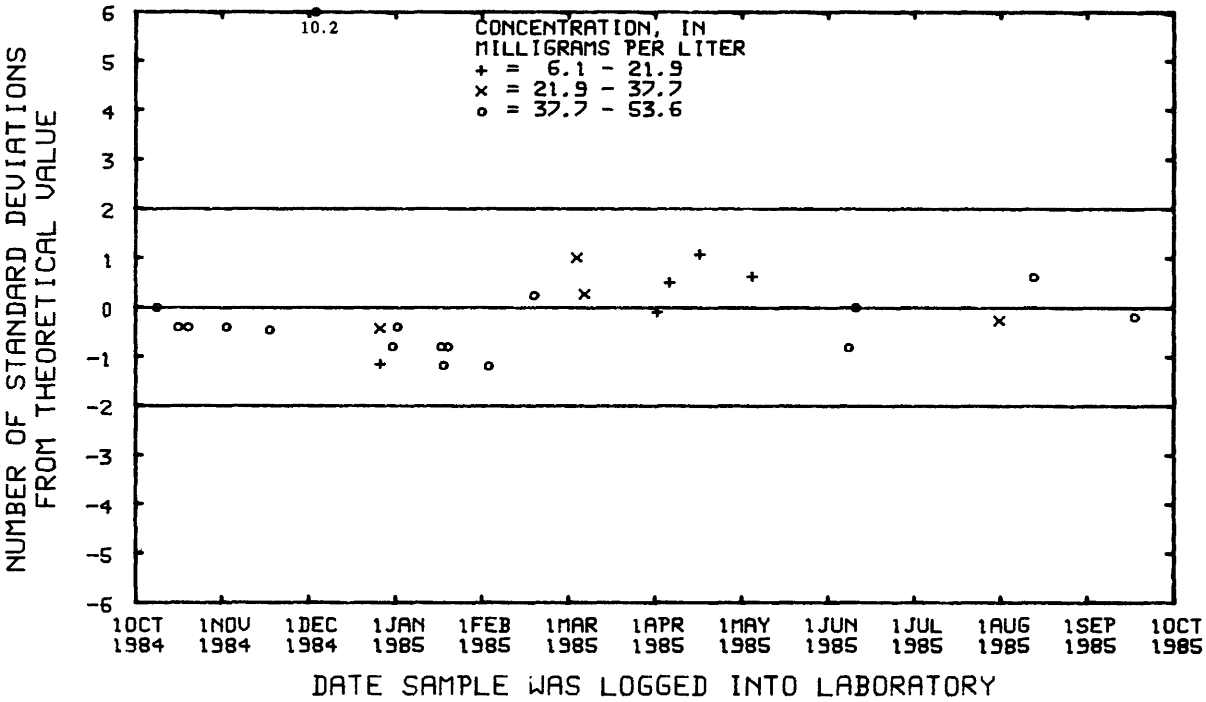

Figure 67--Magnesium, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

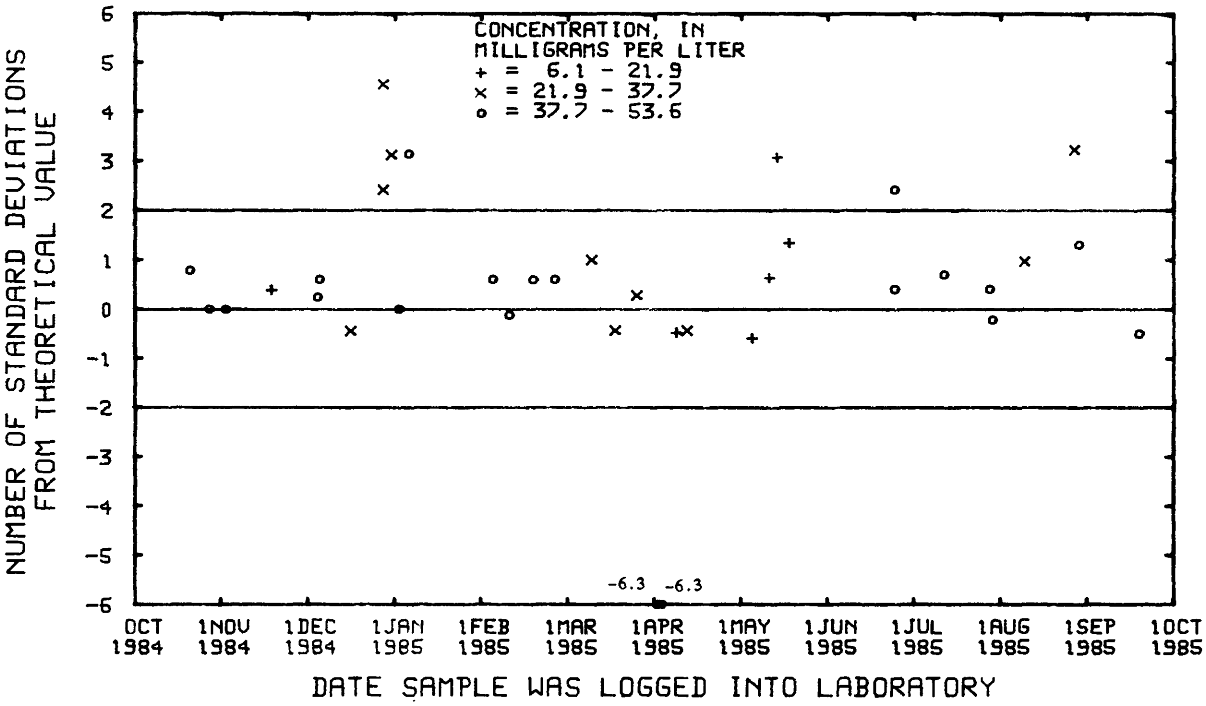

Figure 68--Magnesium, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

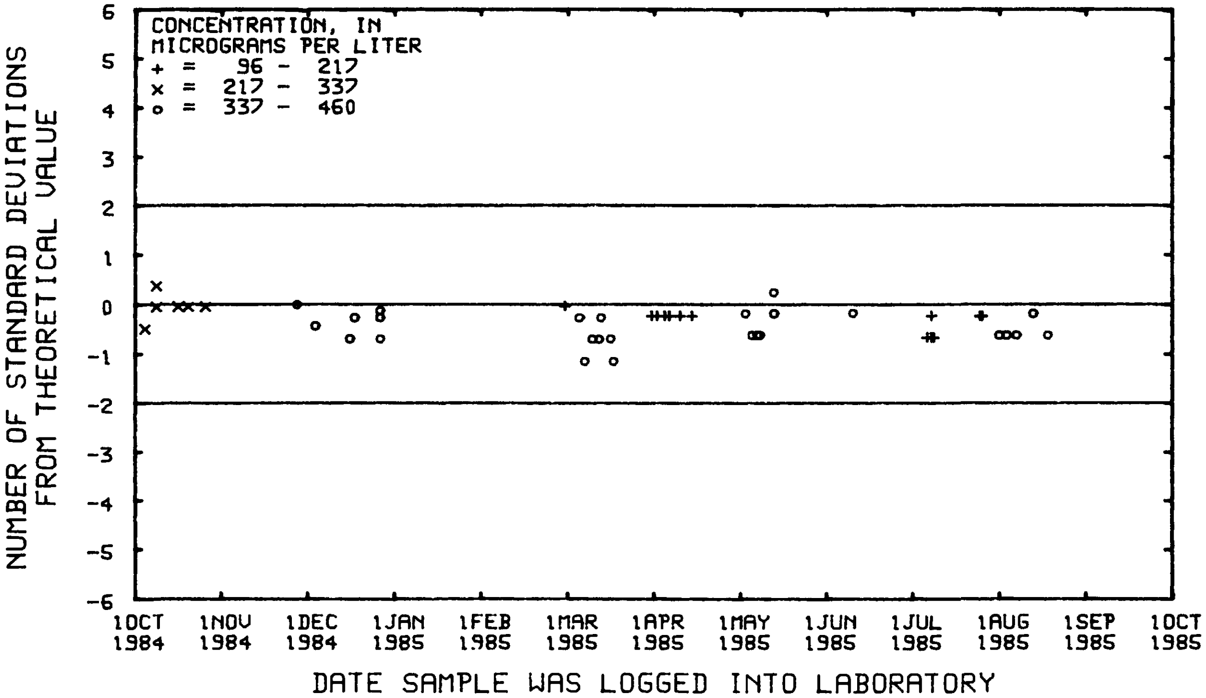

Figure 69--Manganese, dissolved,
(inductively coupled plasma emission spectrometry)
data from the Atlanta laboratory.

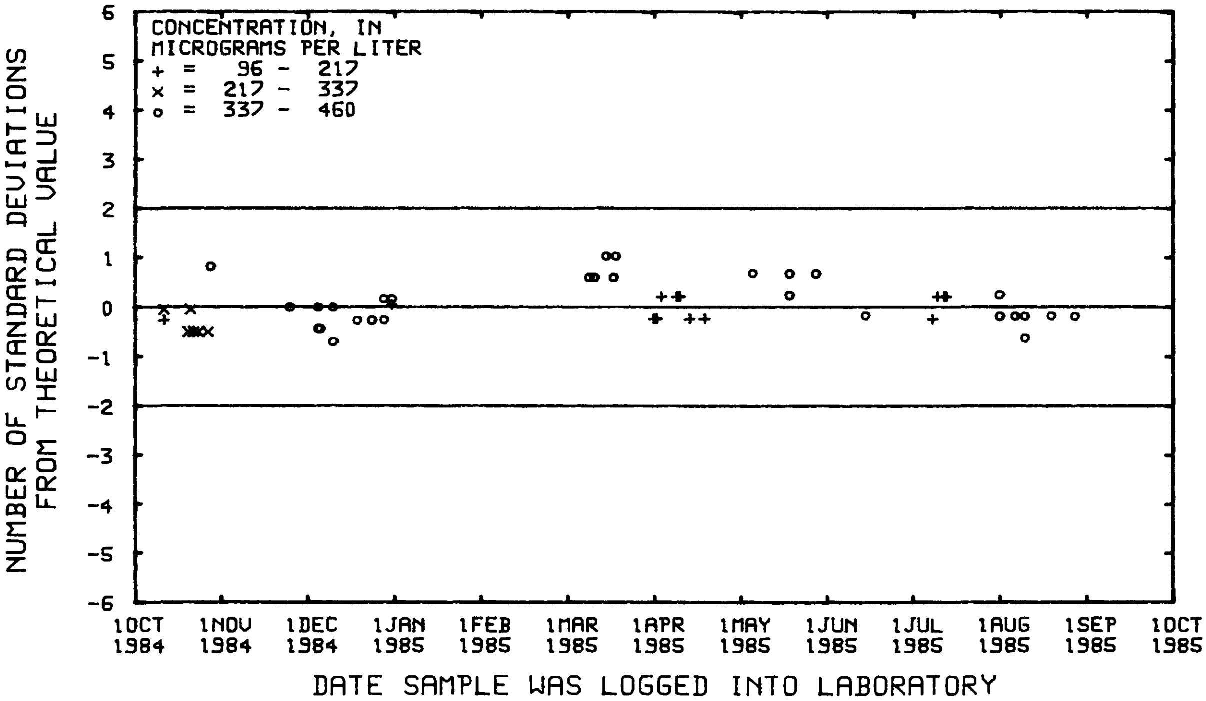

Figure 70--Manganese, dissolved,
(inductively coupled plasma emission spectrometry)
data from the Denver laboratory.

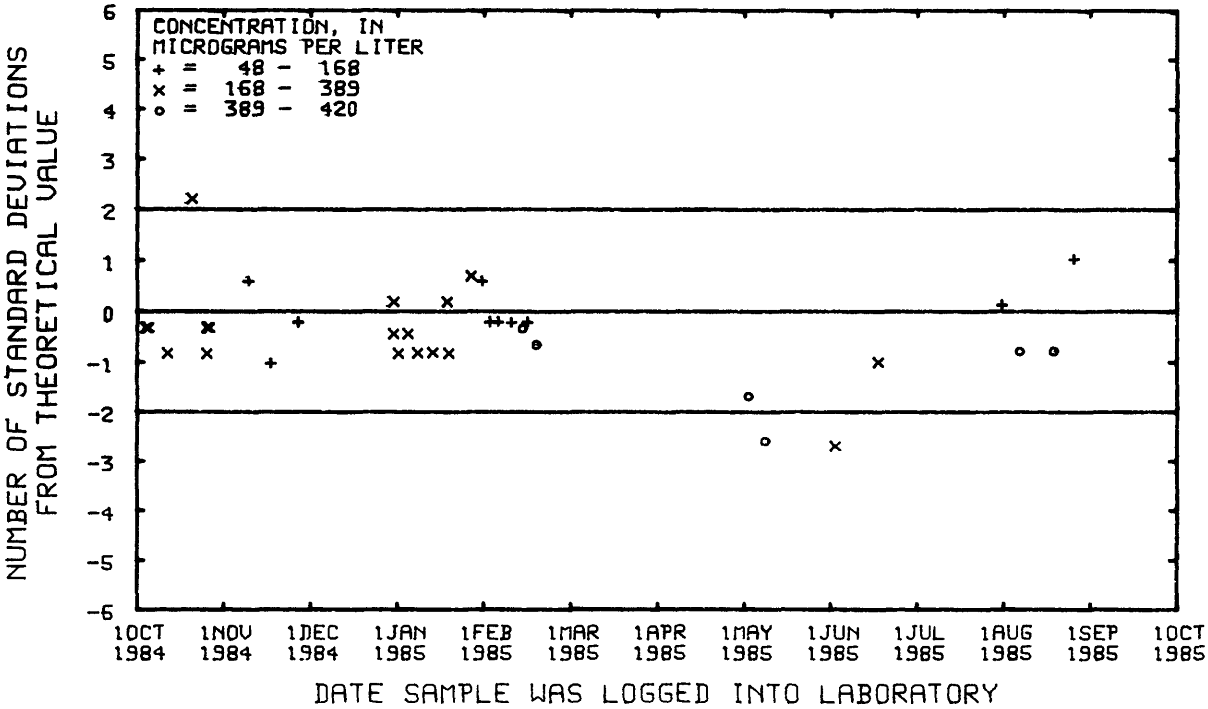

Figure 71--Manganese, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

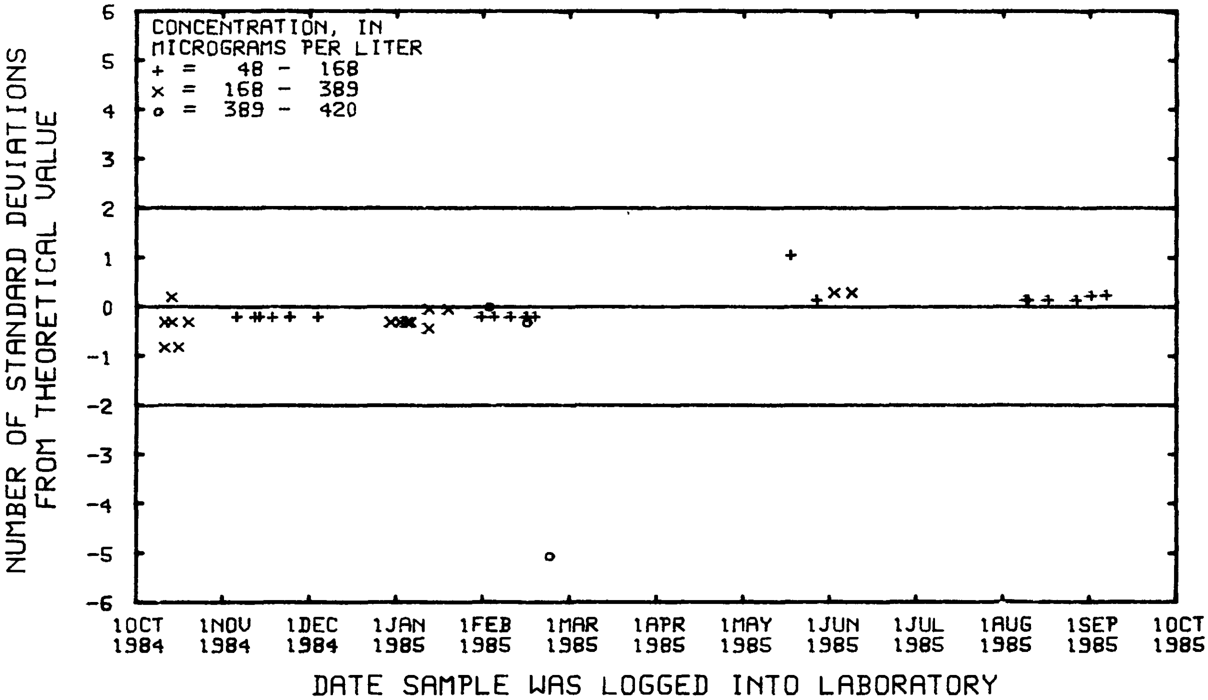

Figure 72--Manganese, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

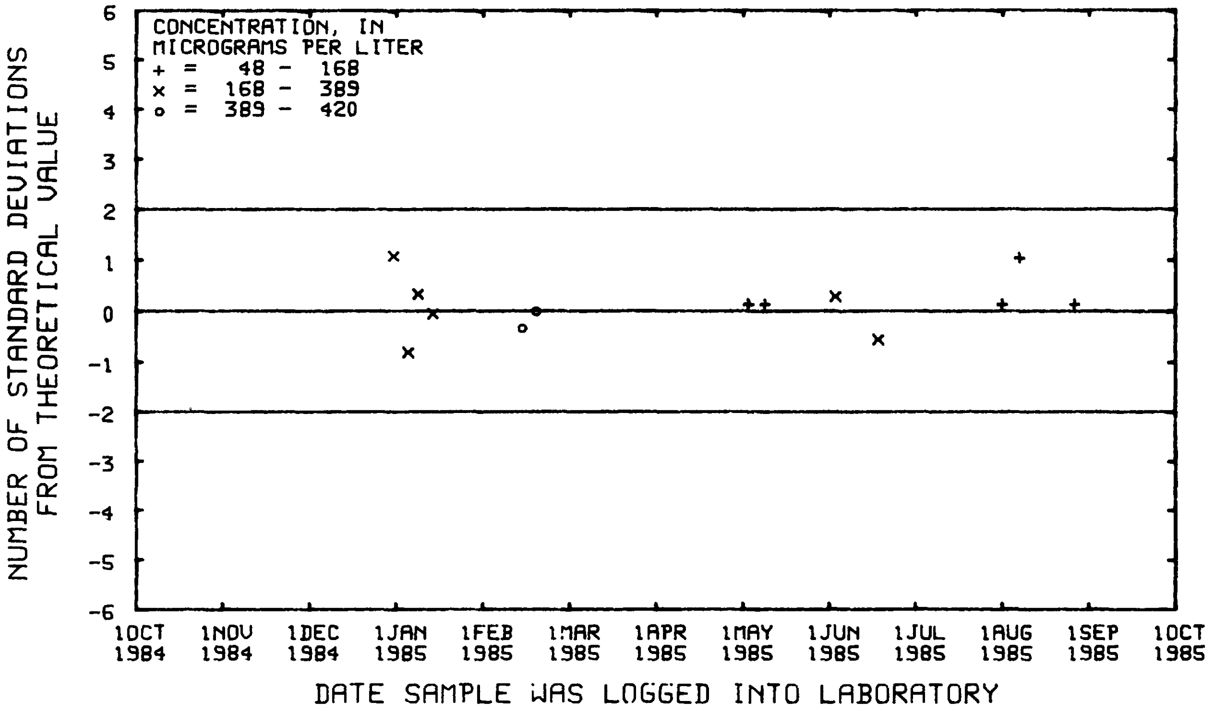

Figure 73--Manganese, total recoverable, data from the Atlanta laboratory.

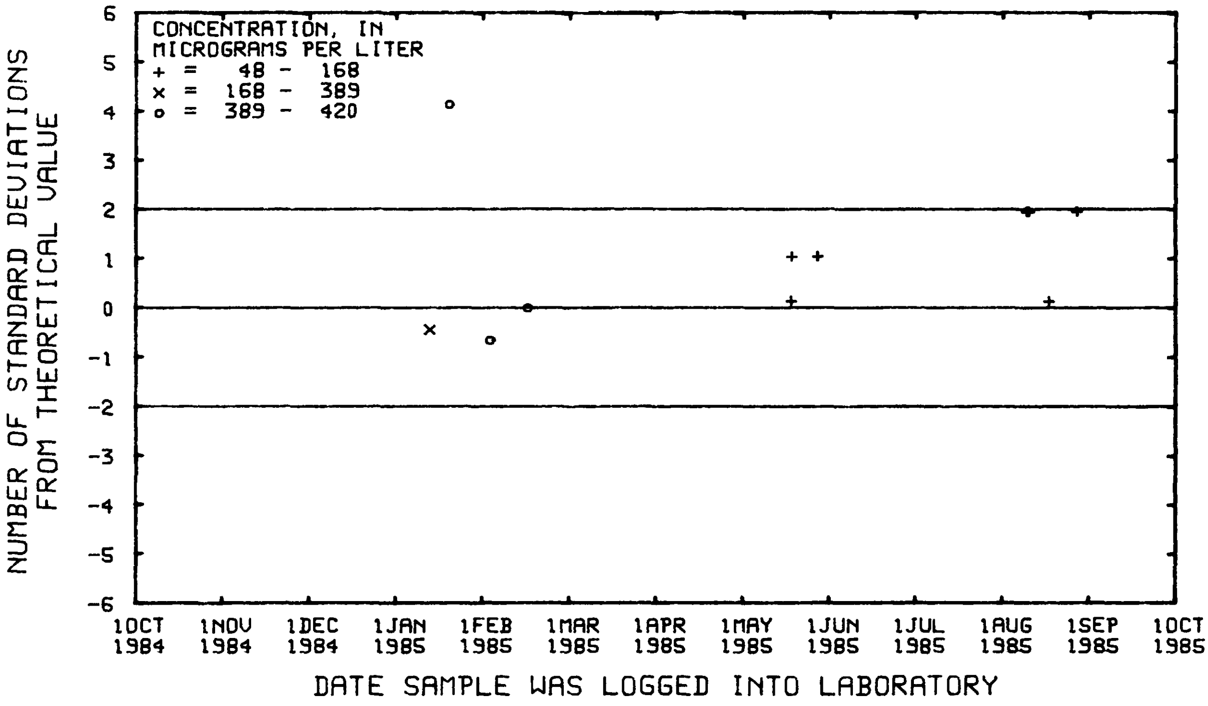

Figure 74--Manganese, total recoverable, data from the Denver laboratory.

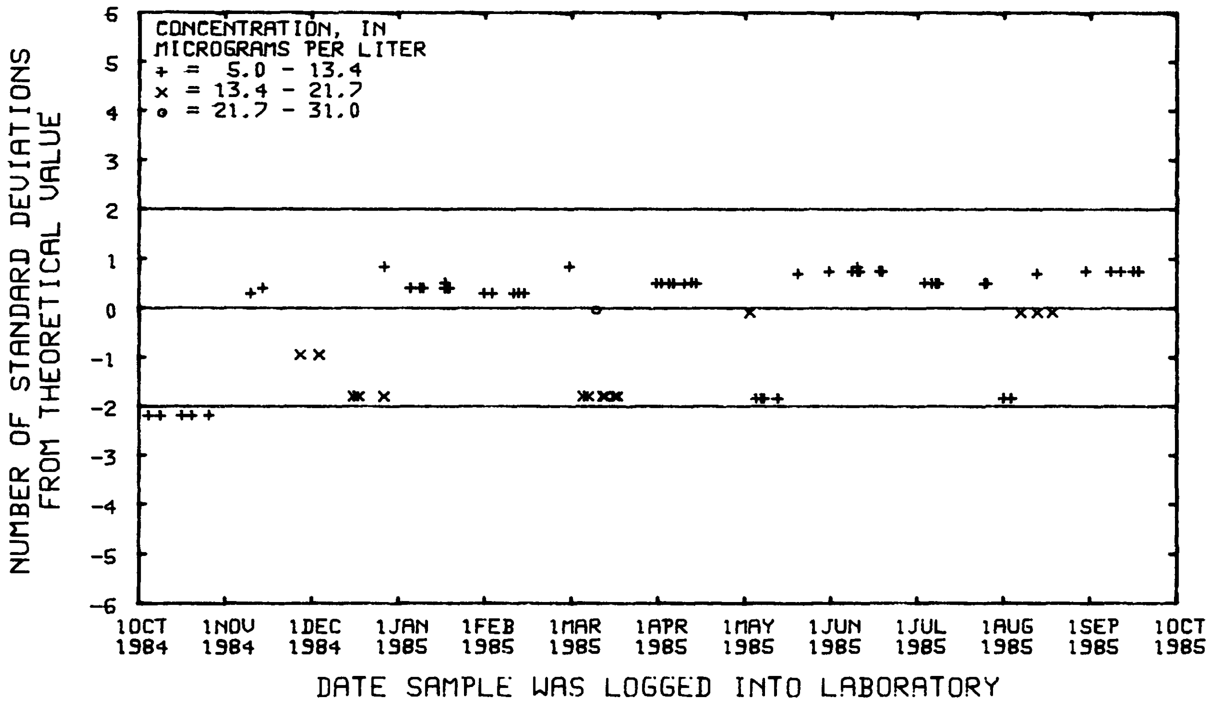

Figure 75--Molybdenum, dissolved, (inductively coupled plasma emission spectrometry) data from the Atlanta laboratory.

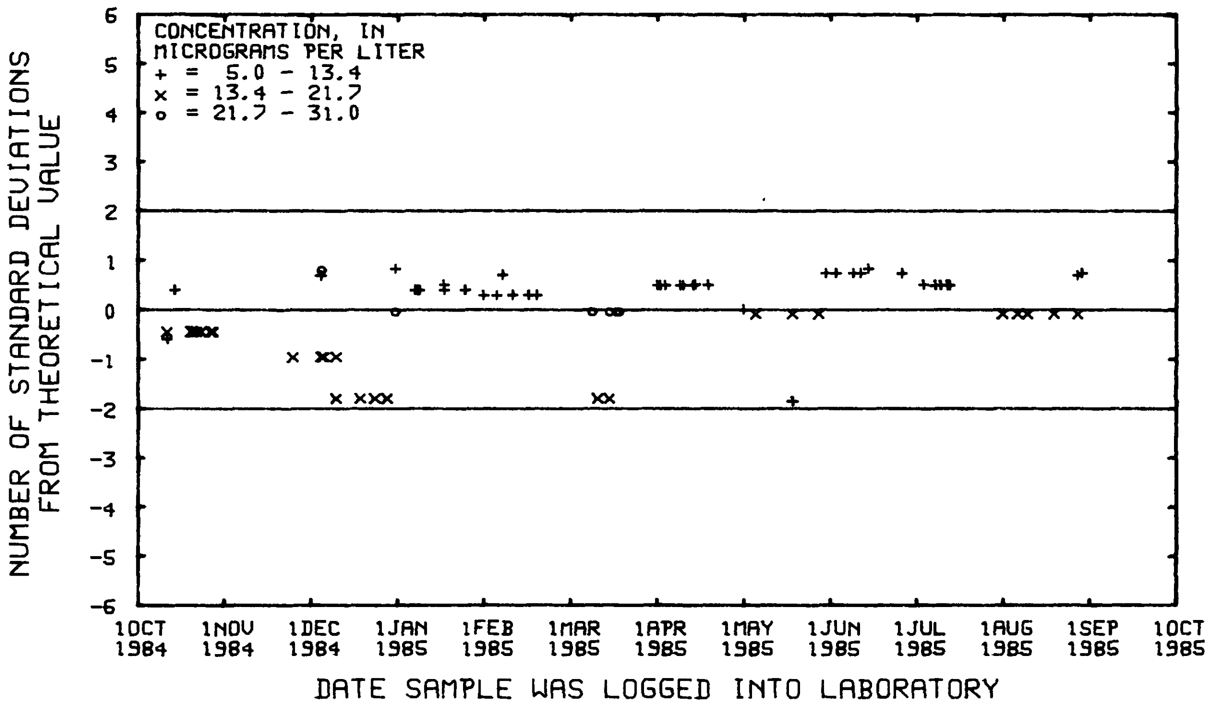

Figure 76--Molybdenum, dissolved, (inductively coupled plasma emission spectrometry) data from the Denver laboratory.

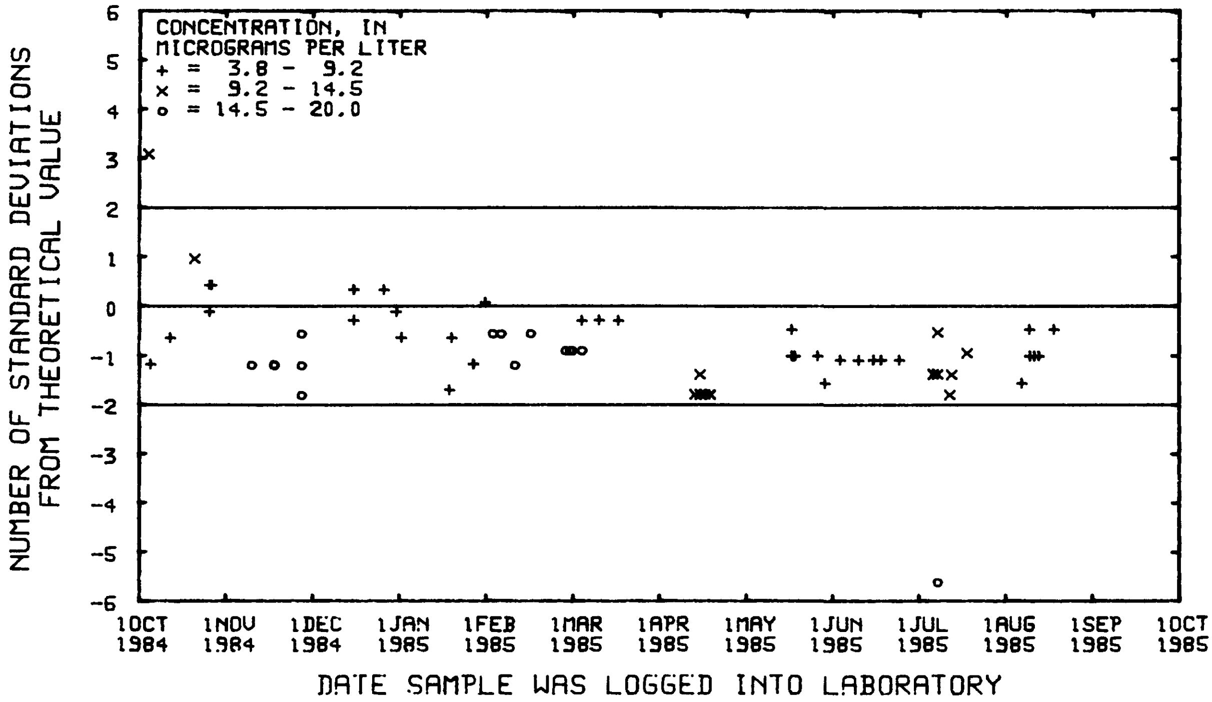

Figure 77--Molybdenum, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

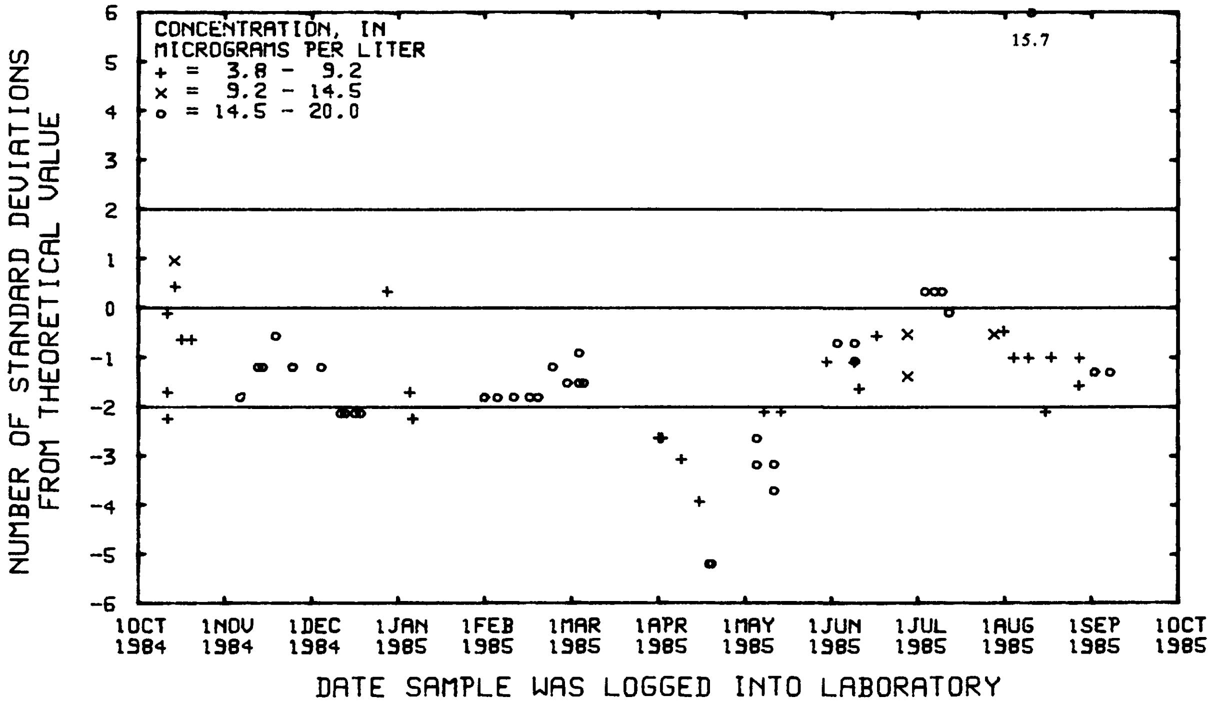

Figure 78--Molybdenum, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

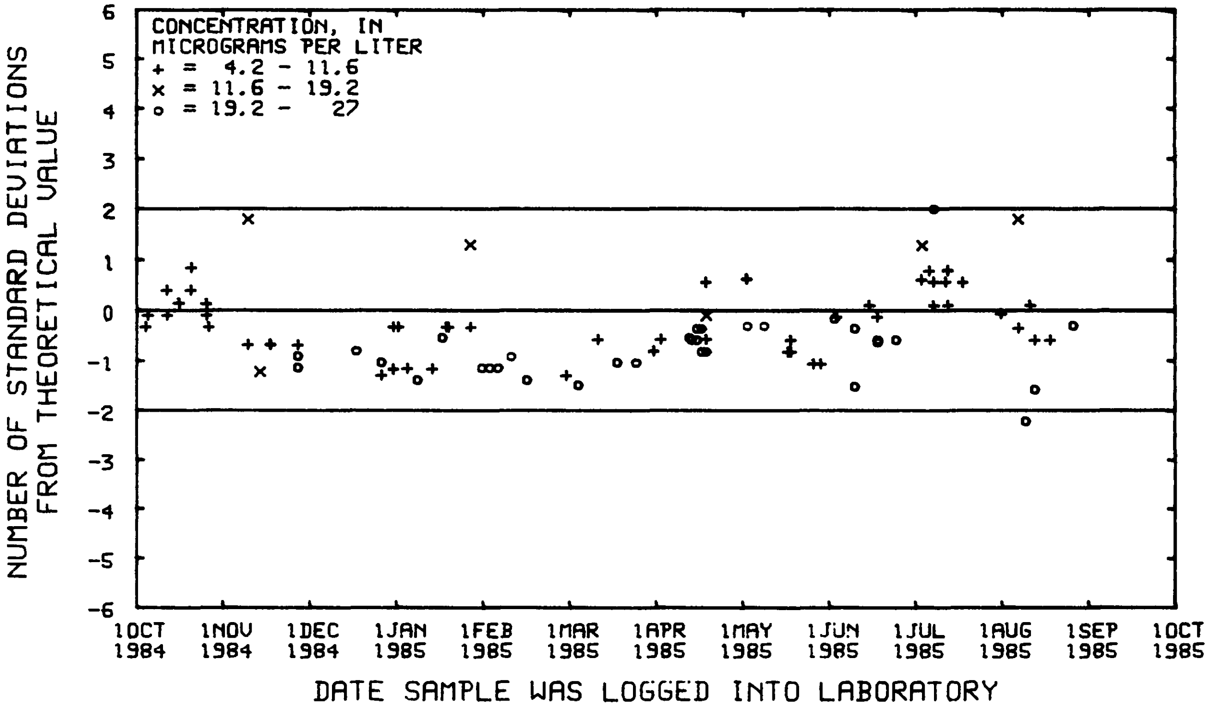

Figure 79--Nickel, dissolved, data from the Atlanta laboratory.

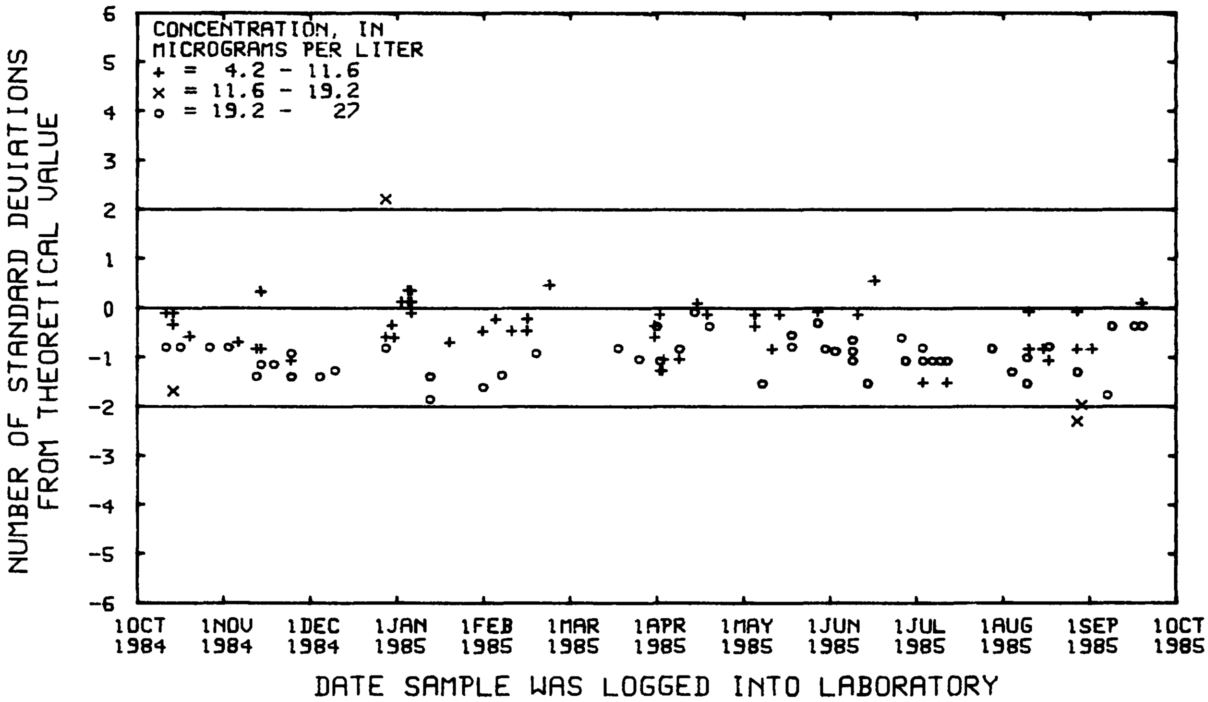

Figure 80--Nickel, dissolved, data from the Denver laboratory.

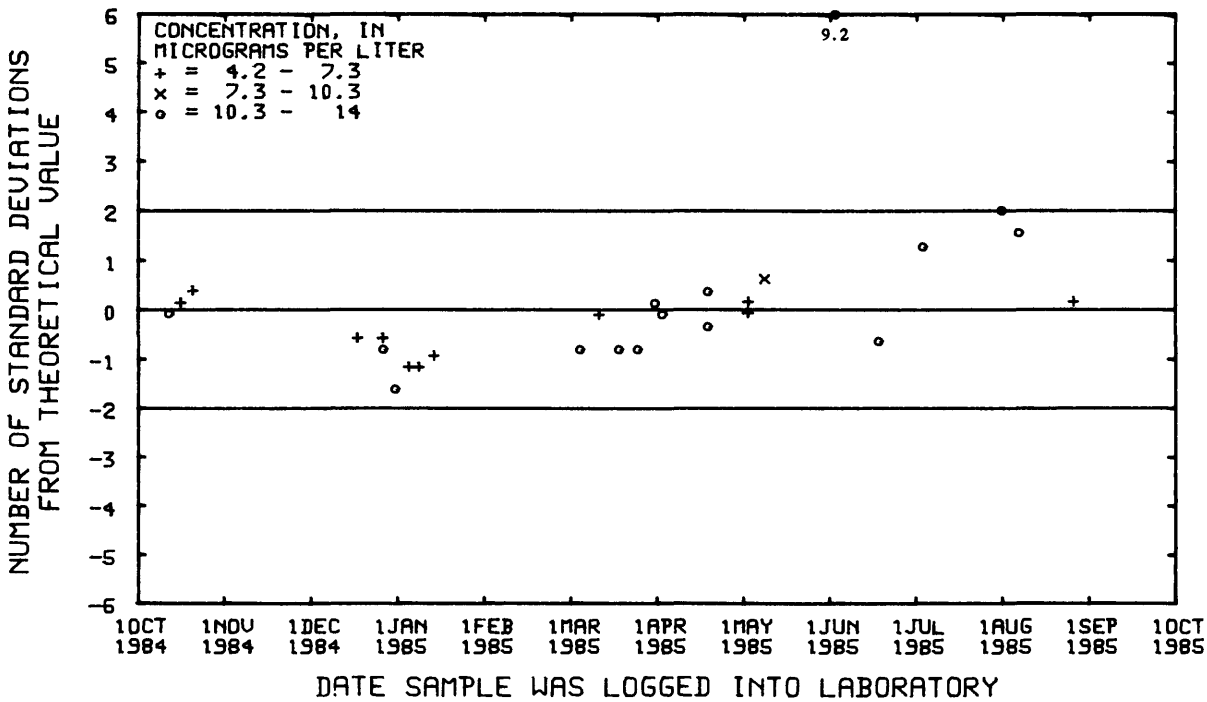

Figure 81--Nickel, total recoverable,
data from the Atlanta laboratory.

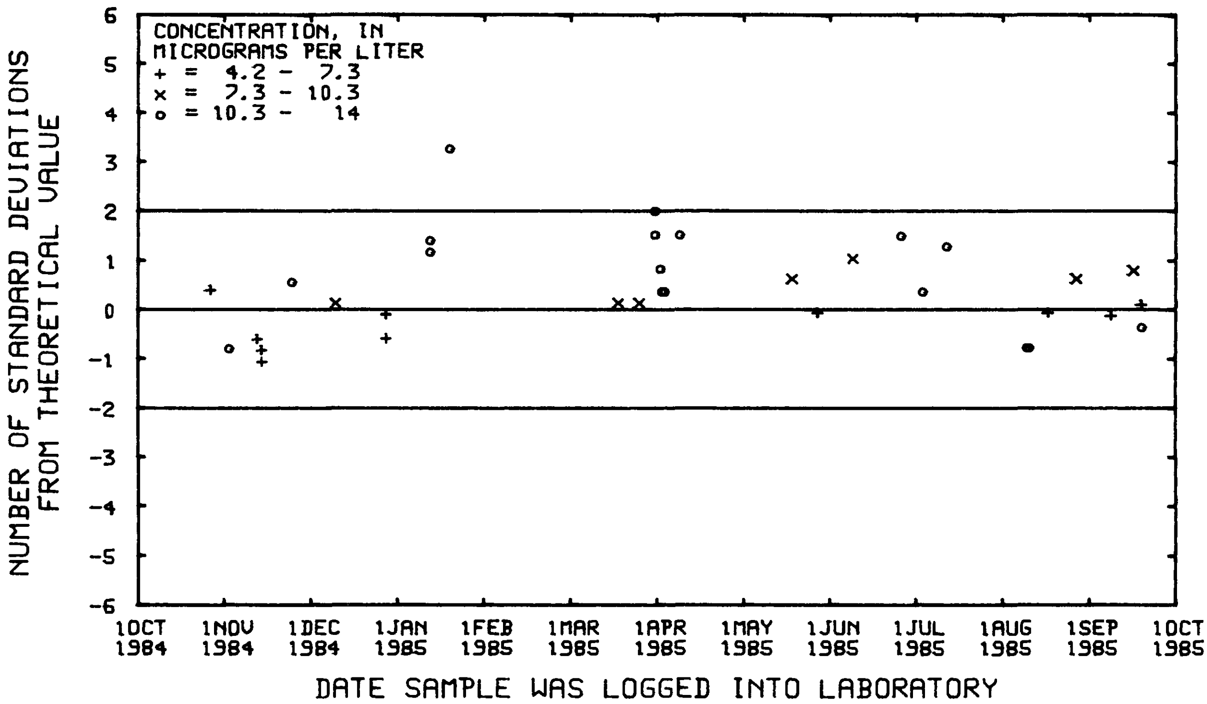

Figure 82--Nickel, total recoverable,
data from the Denver laboratory.

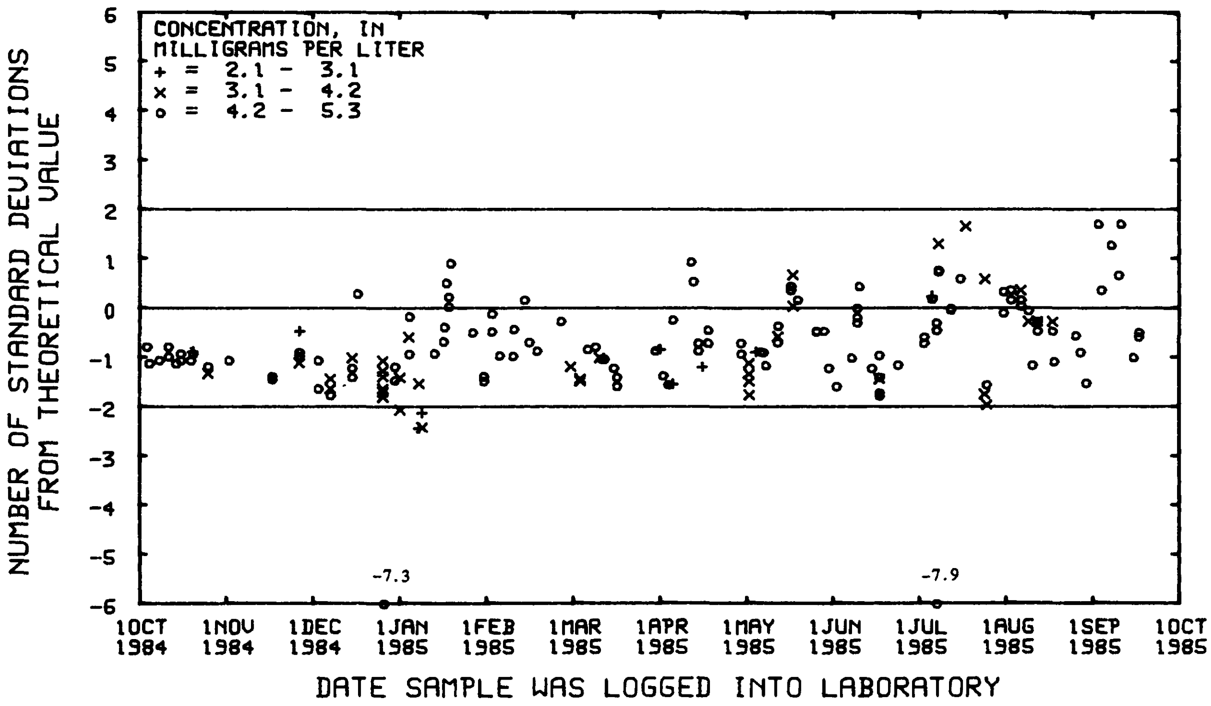

Figure 83--Potassium, dissolved, data from the Atlanta laboratory.

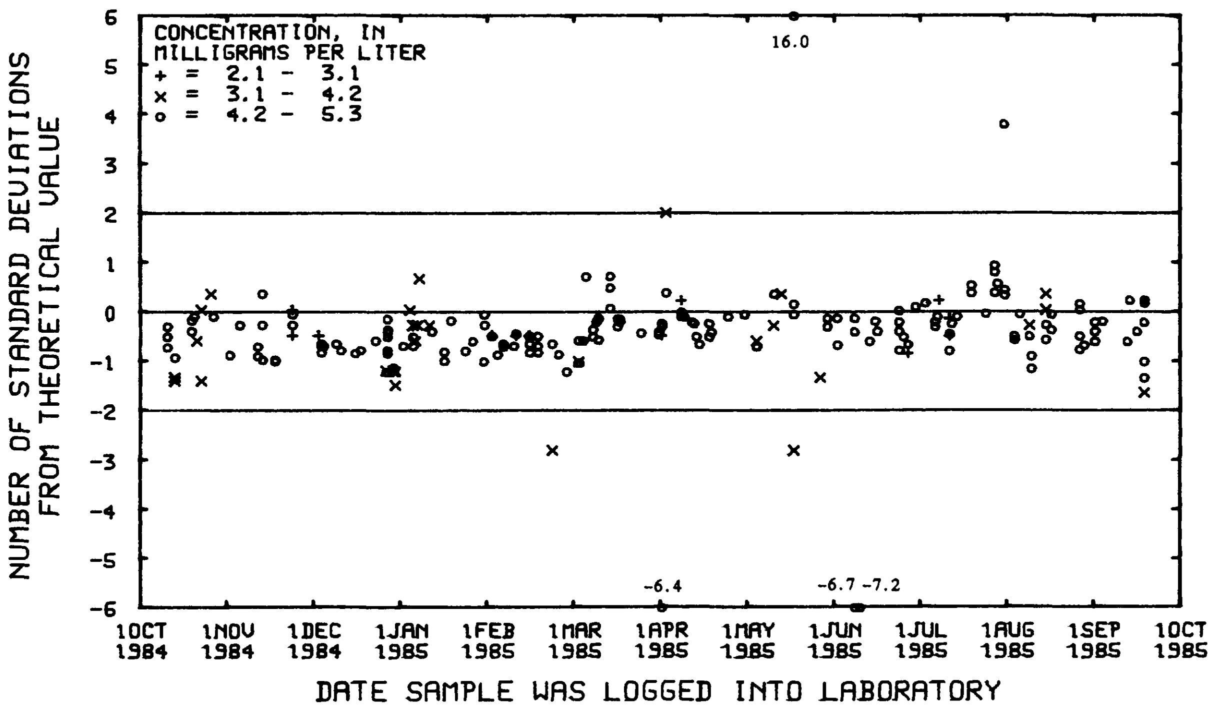

Figure 84--Potassium, dissolved, data from the Denver laboratory.

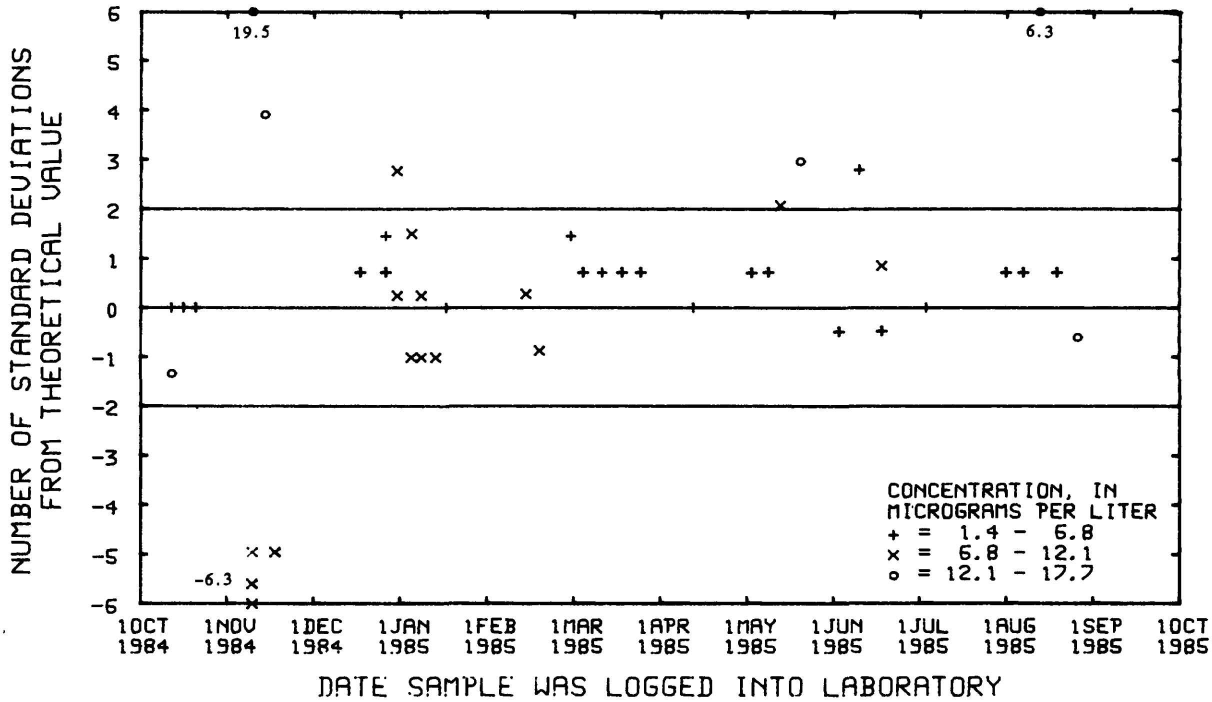

Figure 85--Selenium, dissolved, data from the Atlanta laboratory.

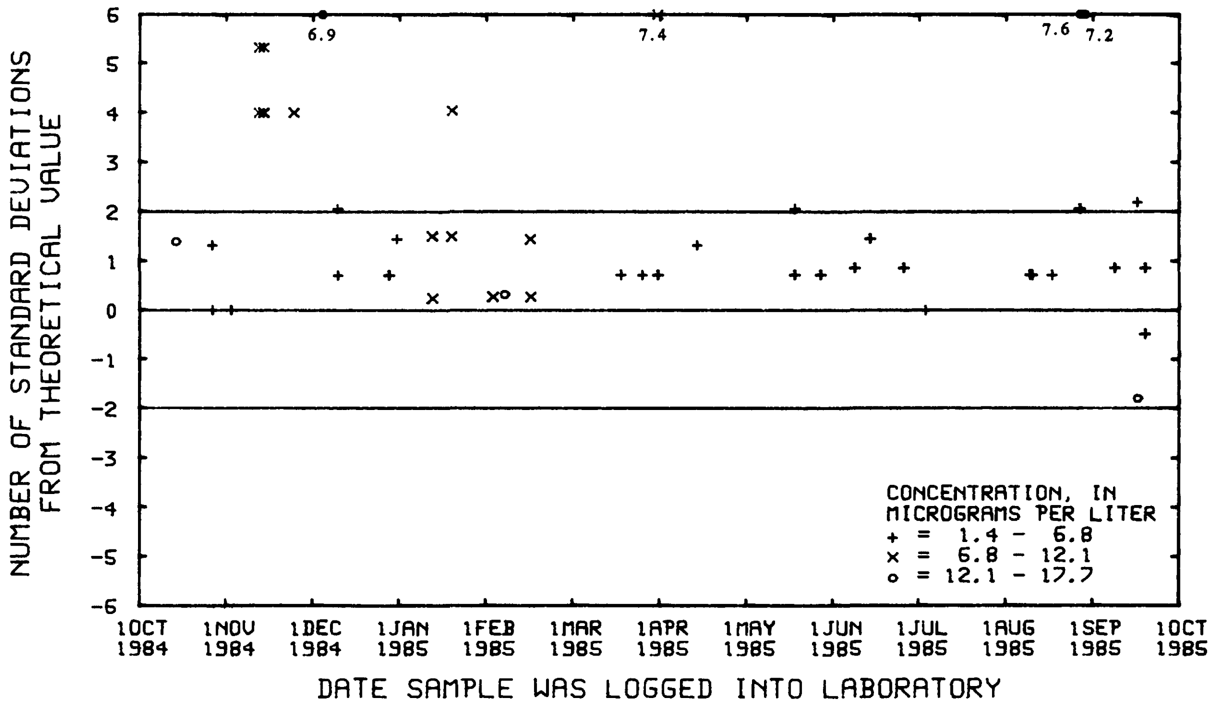

Figure 86--Selenium, dissolved, data from the Denver laboratory.

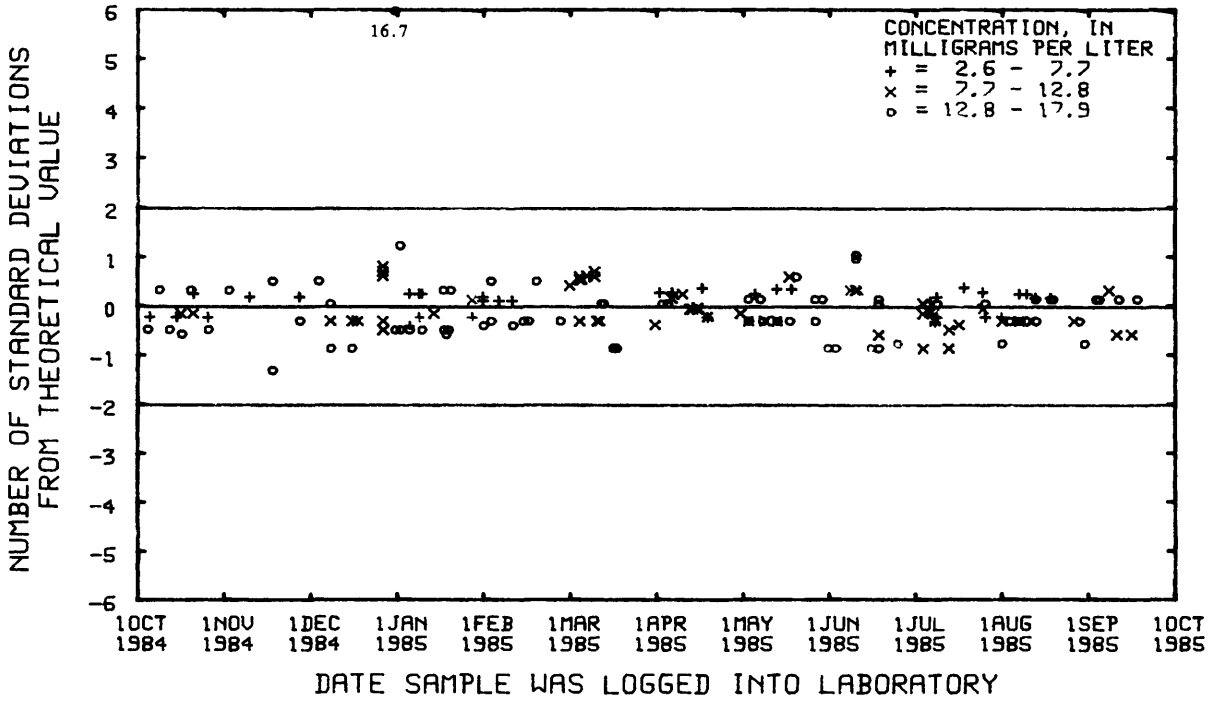

Figure 87--Silica, dissolved, data from the Atlanta laboratory.

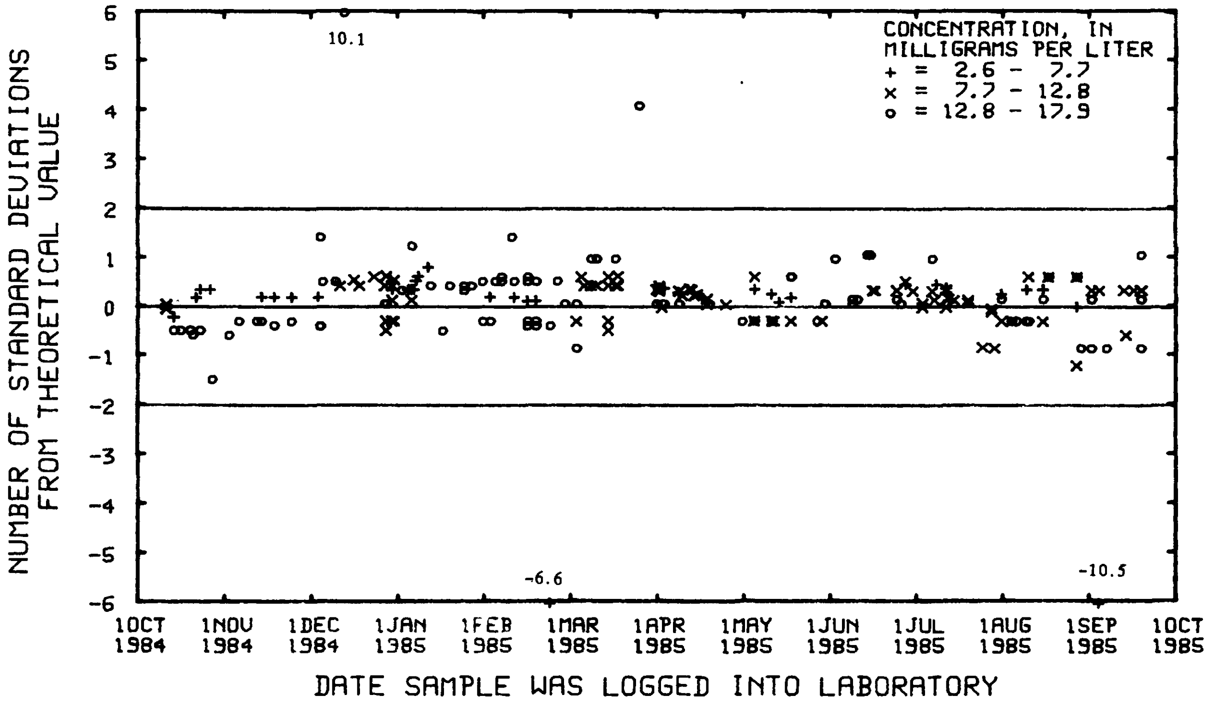

Figure 88--Silica, dissolved, data from the Denver laboratory.

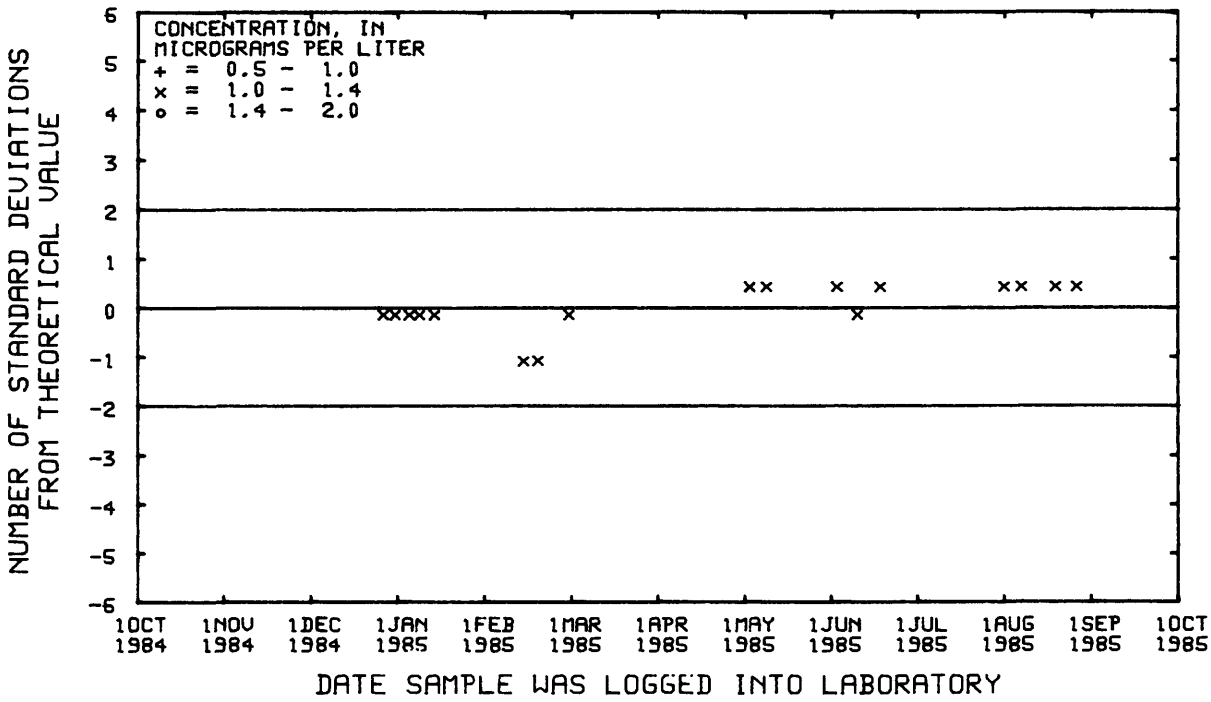

Figure 89--Silver, dissolved, data from the Atlanta laboratory.

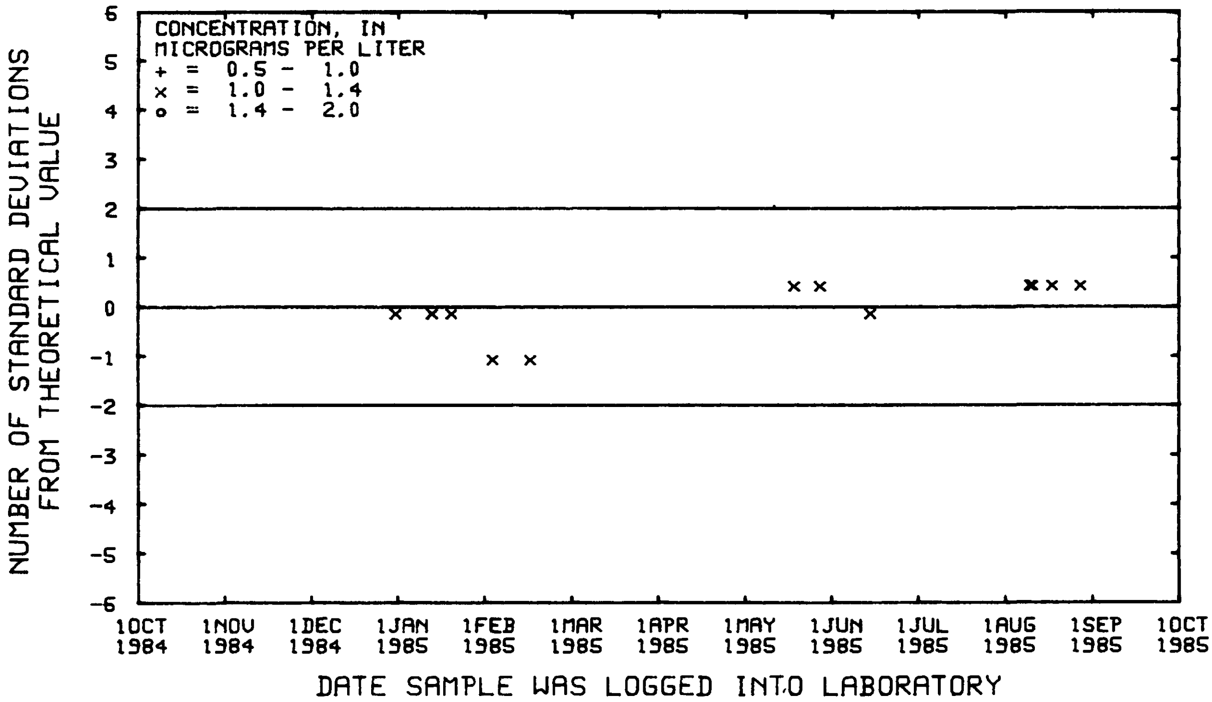

Figure 90--Silver, dissolved, data from the Denver laboratory.

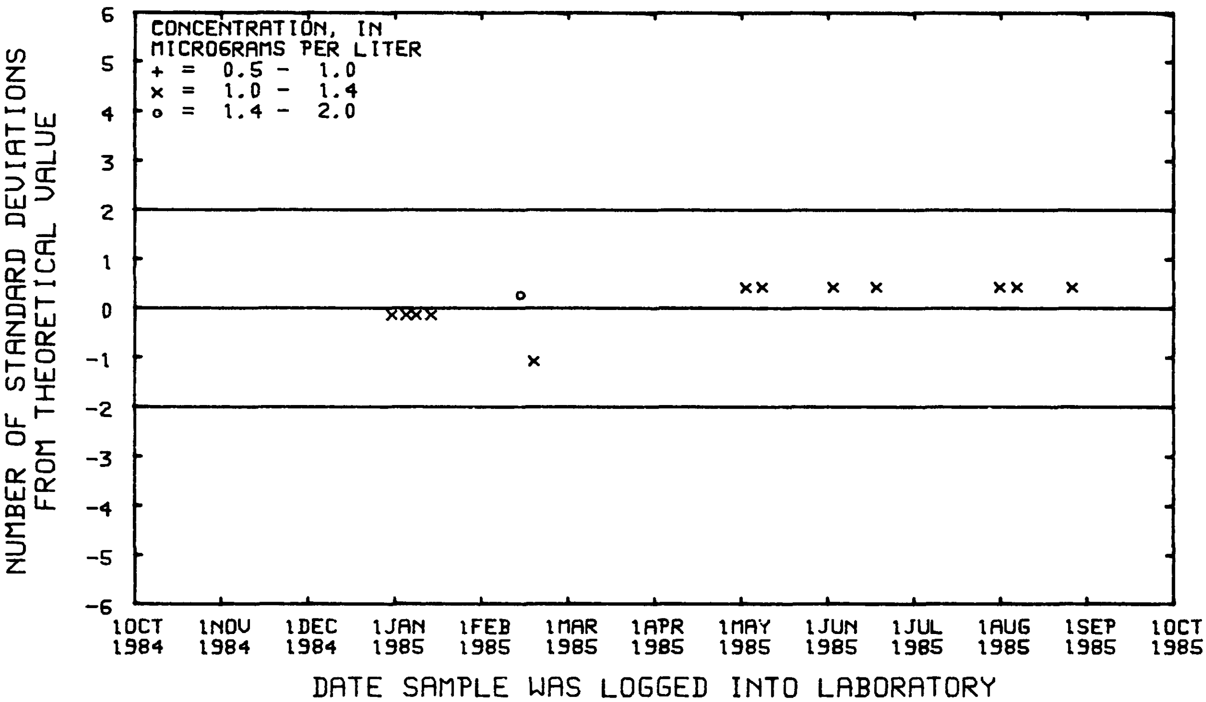

Figure 91--Silver, total recoverable, data from the Atlanta laboratory.

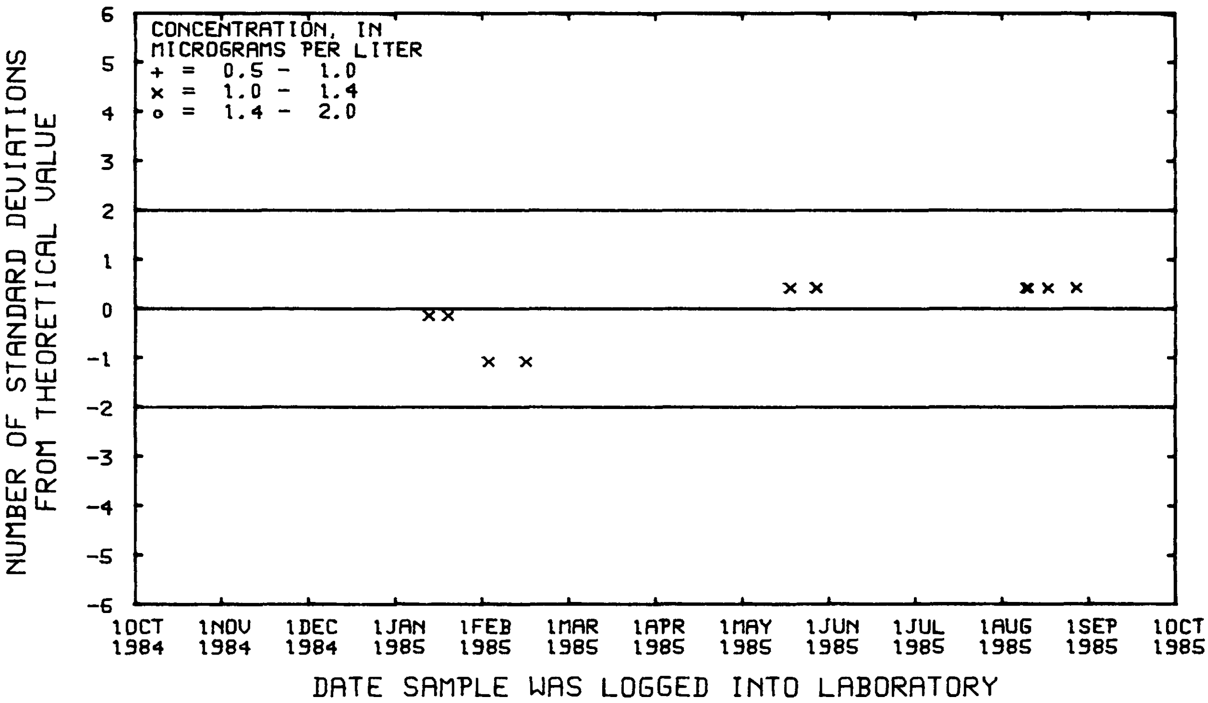

Figure 92--Silver, total recoverable, data from the Denver laboratory.

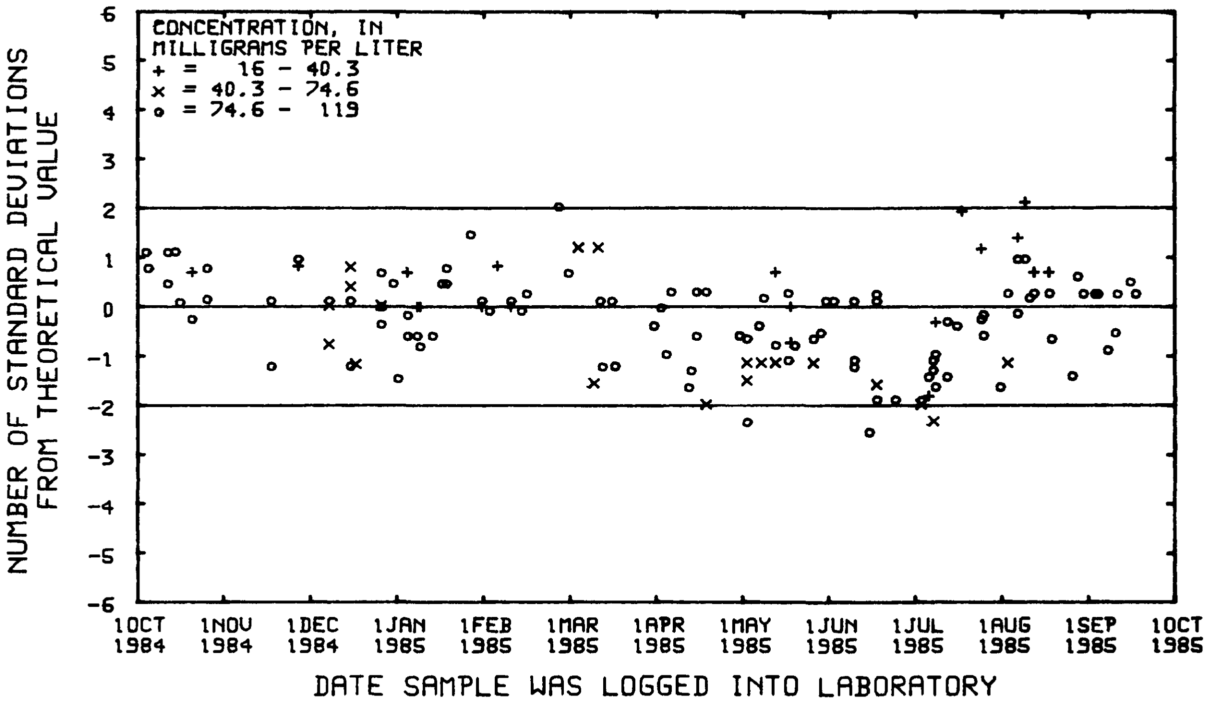

Figure 93--Sodium, dissolved,
(inductively coupled plasma emission spectrometry)
data from the Atlanta laboratory.

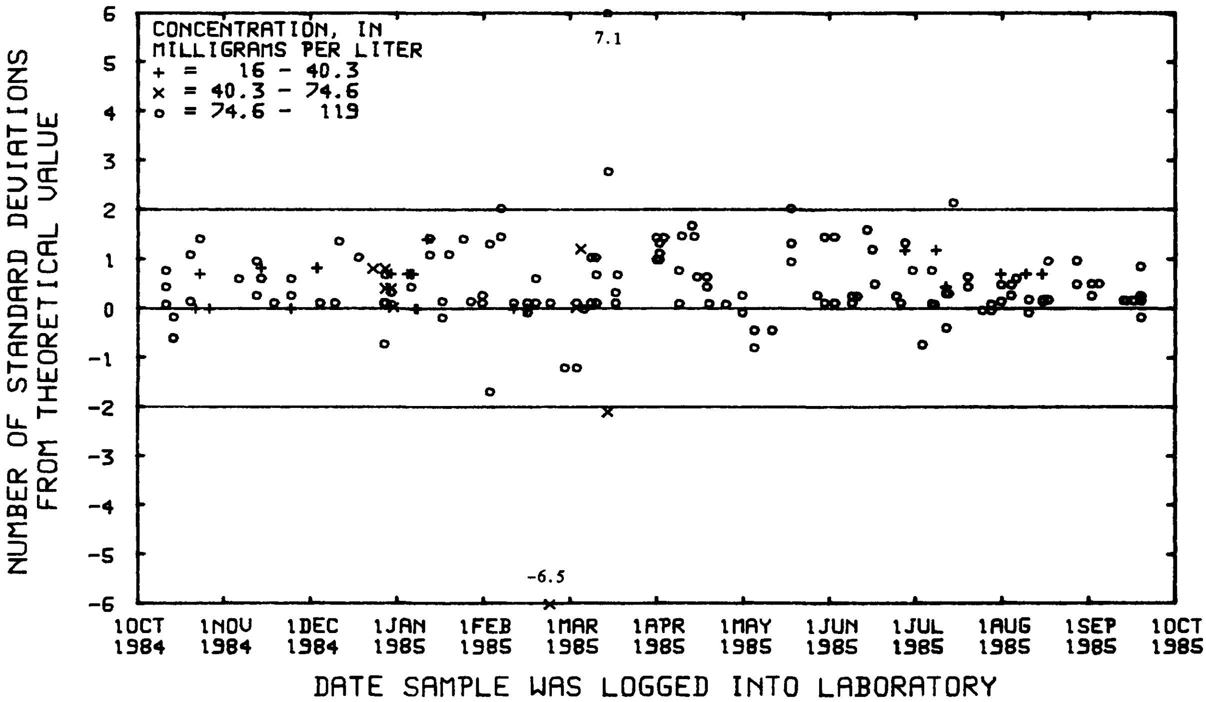

Figure 94--Sodium, dissolved,
(inductively coupled plasma emission spectrometry)
data from the Denver laboratory.

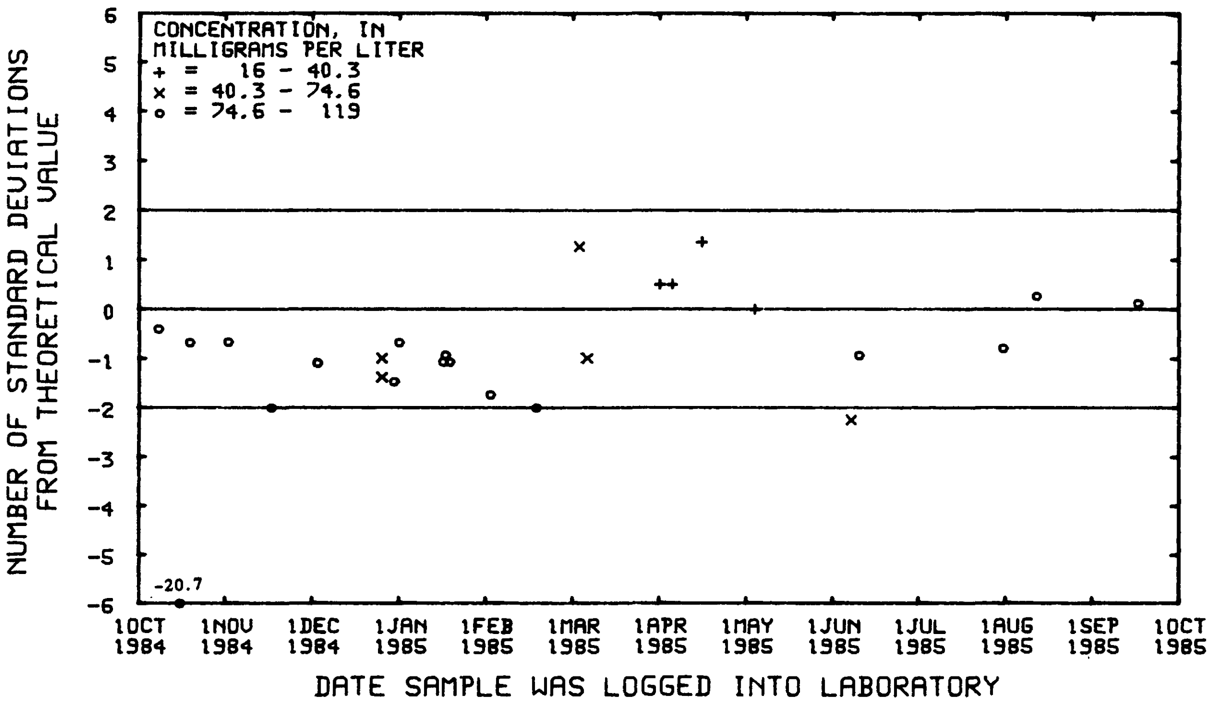

Figure 95--Sodium, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

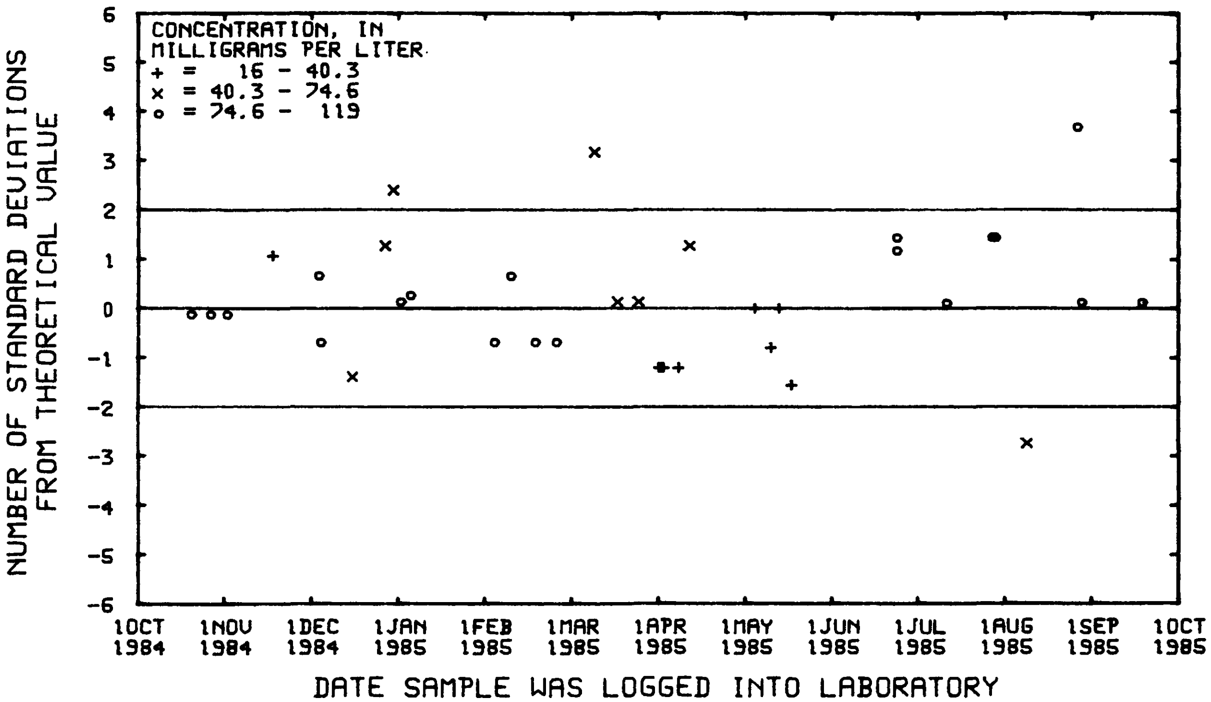

Figure 96--Sodium, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

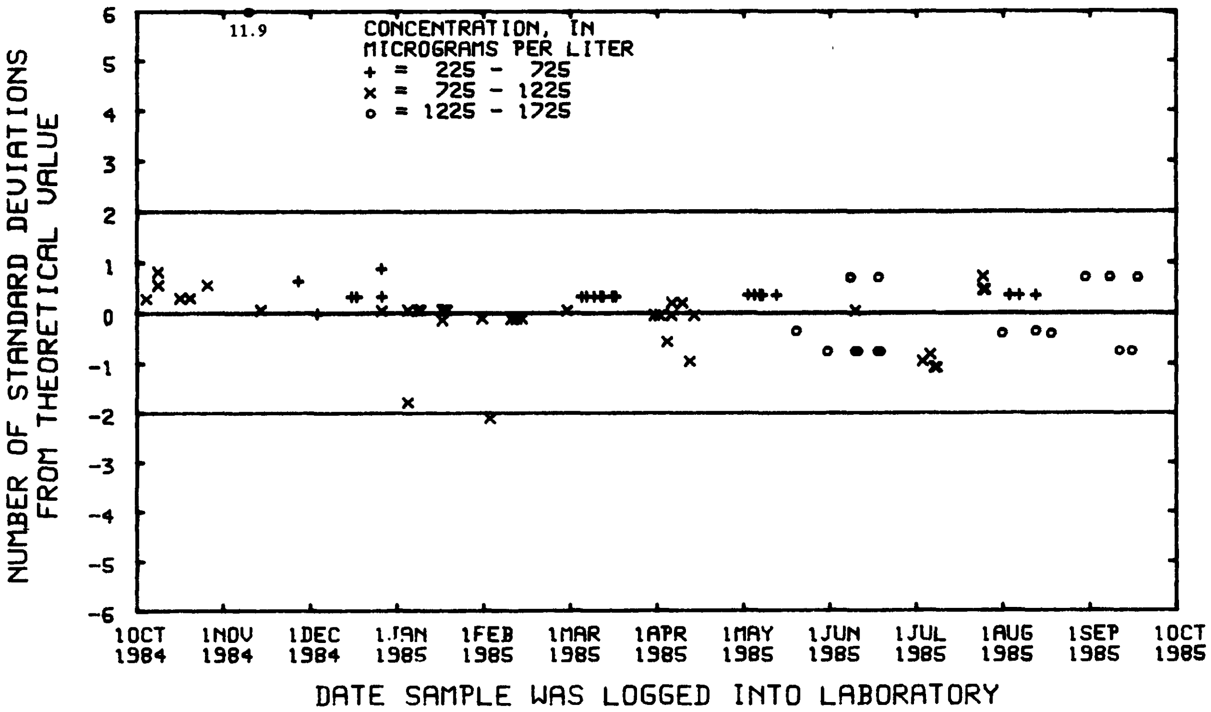

Figure 97--Strontium, dissolved, data from the Atlanta laboratory.

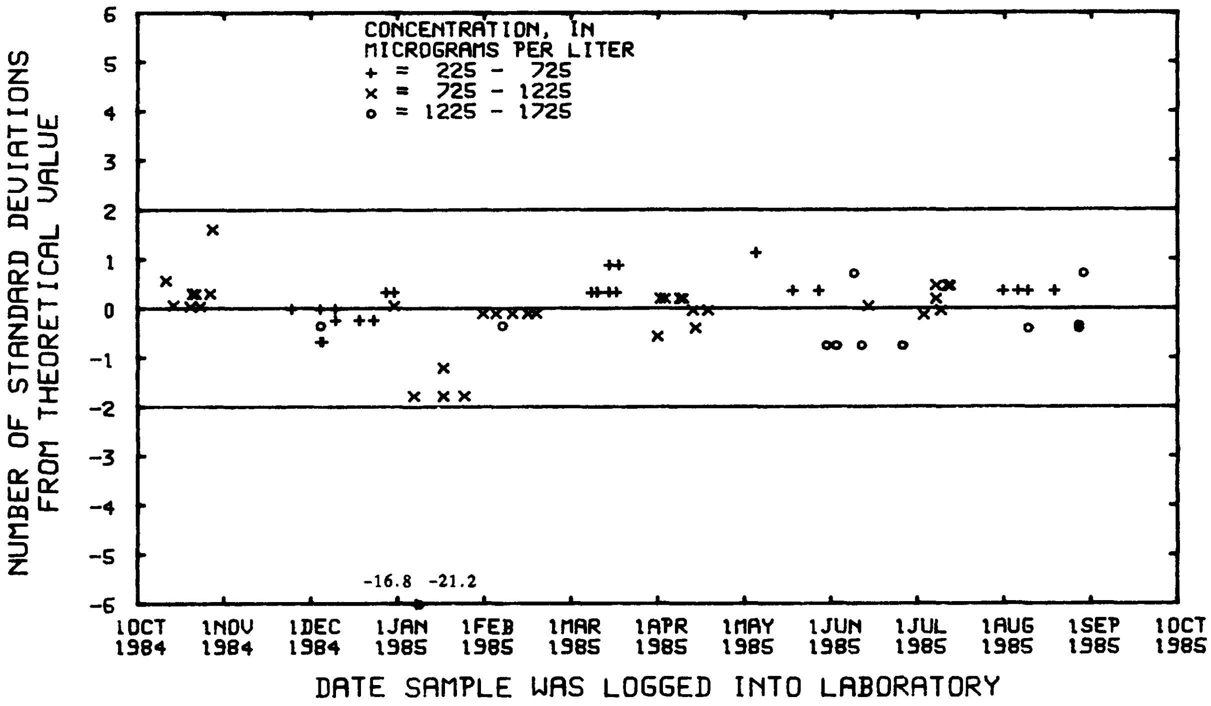

Figure 98--Strontium, dissolved, data from the Denver laboratory.

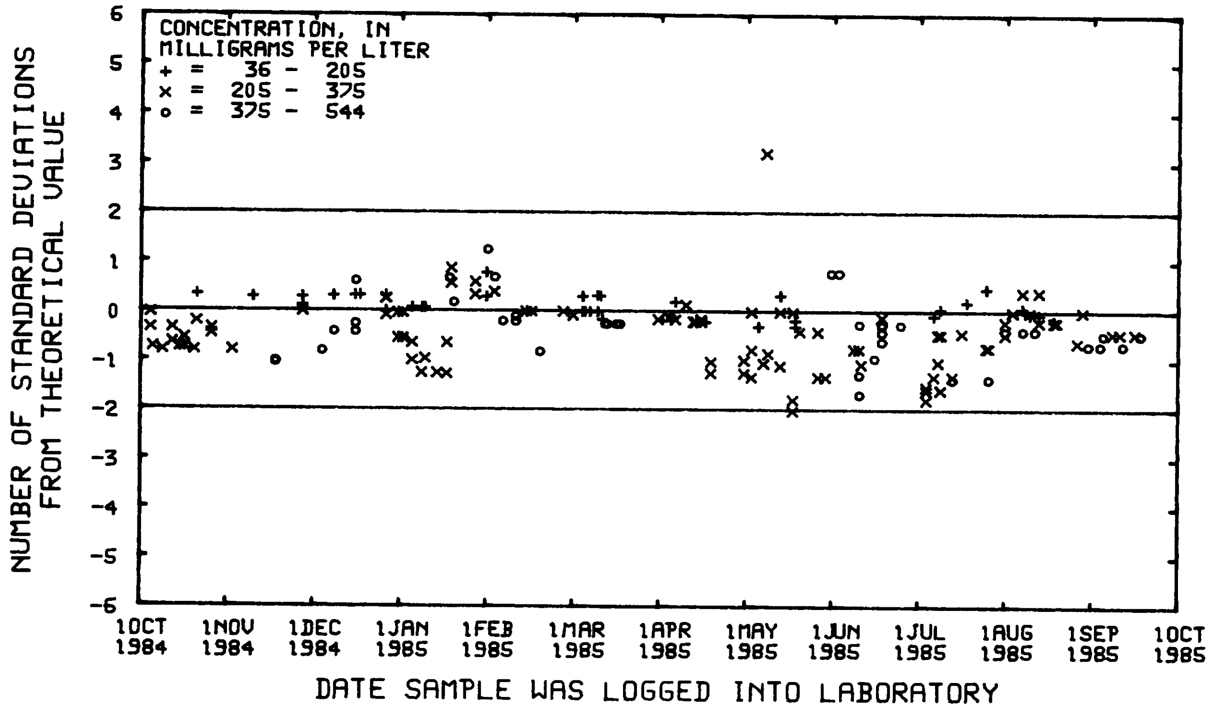

Figure 99--Sulfate, dissolved, data from the Atlanta laboratory.

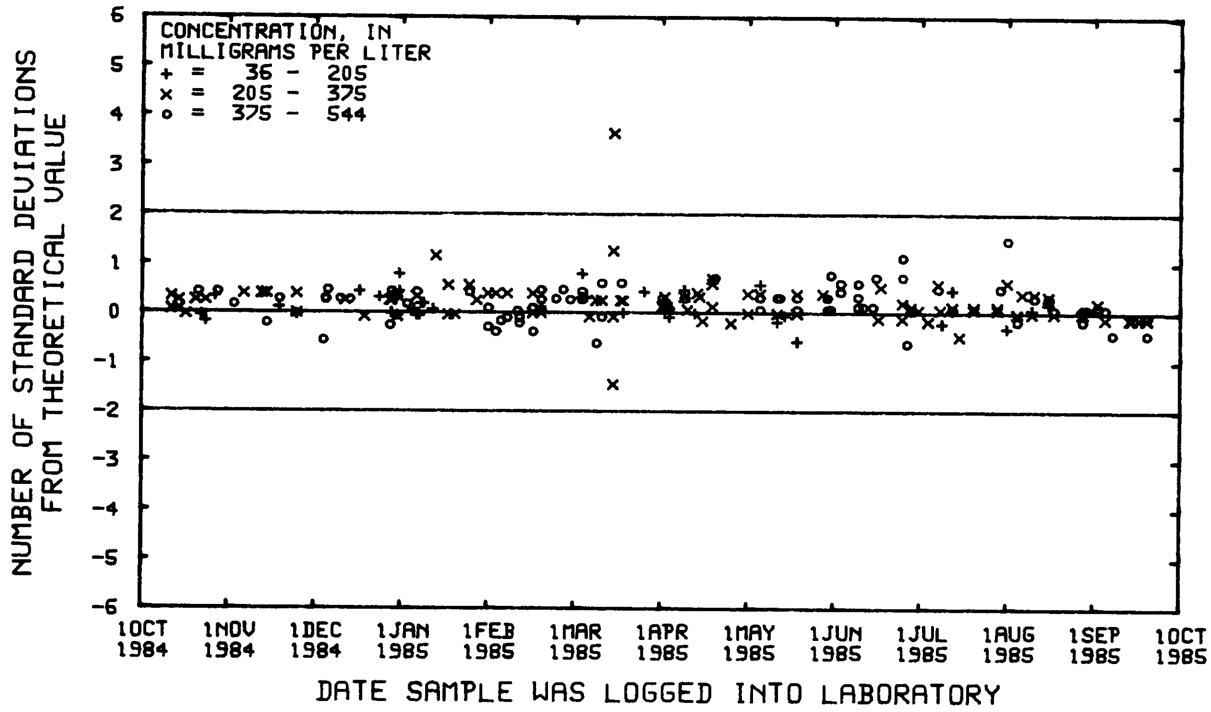

Figure 100--Sulfate, dissolved, data from the Denver laboratory.

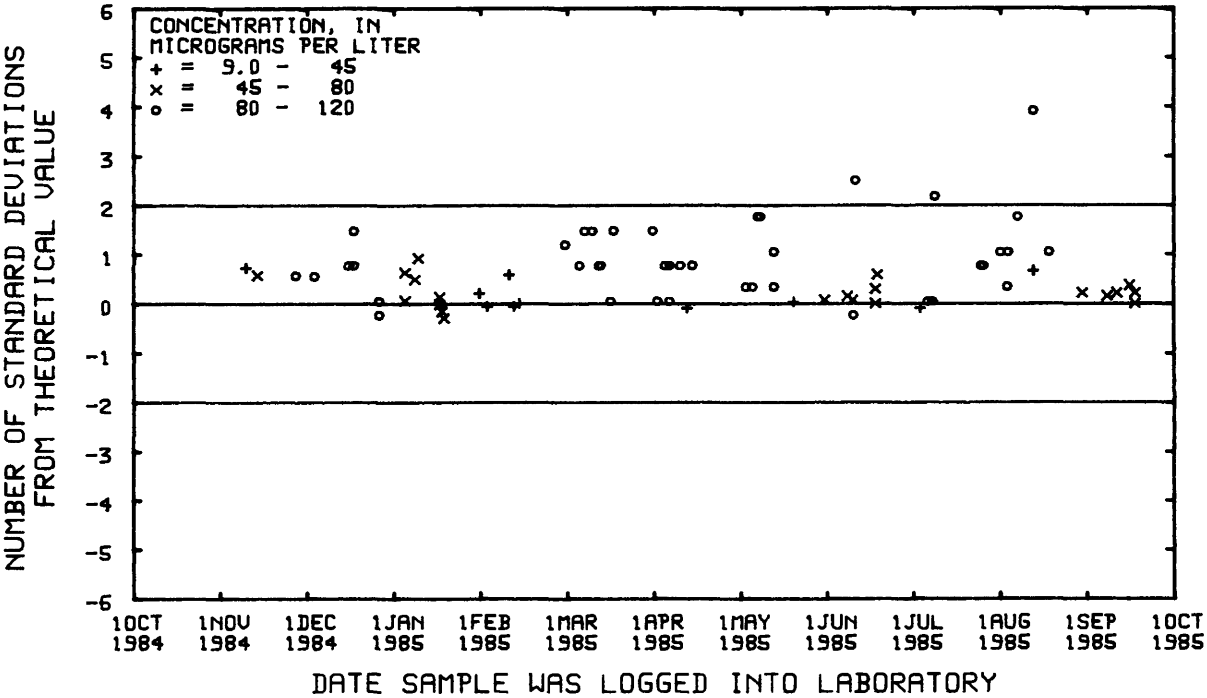

Figure 101--Zinc, dissolved, (inductively coupled plasma emission spectrometry) data from the Atlanta laboratory.

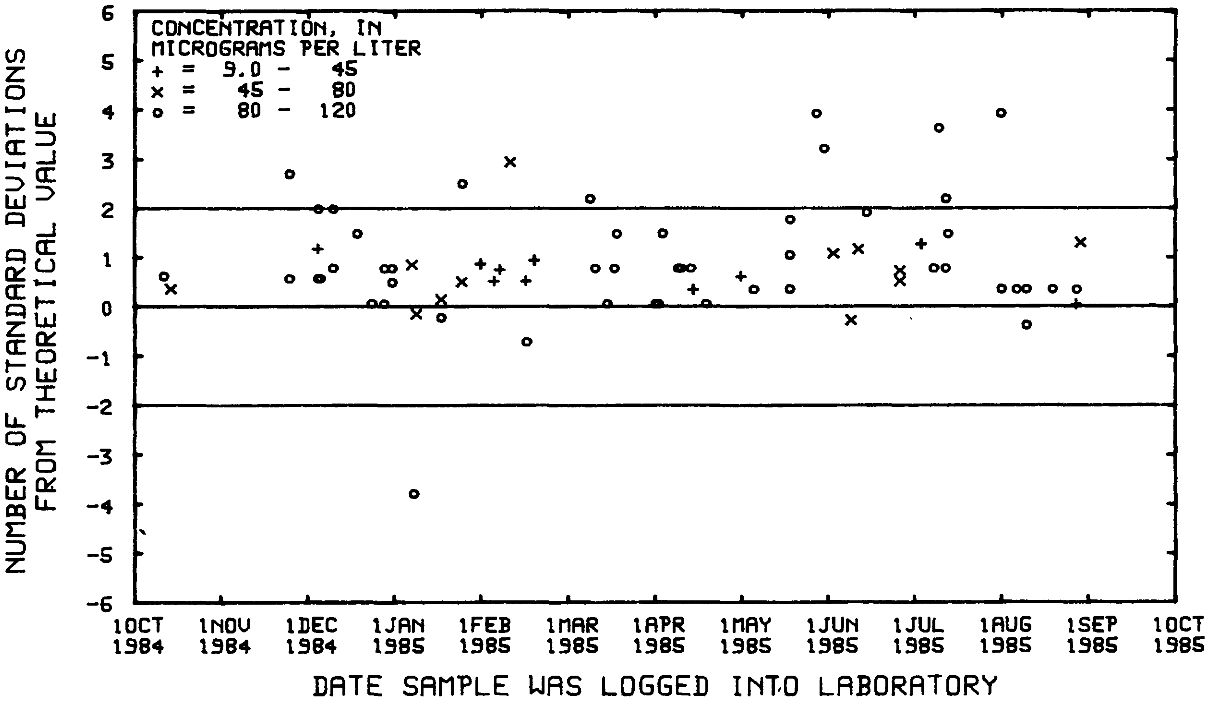

Figure 102--Zinc, dissolved, (inductively coupled plasma emission spectrometry) data from the Denver laboratory.

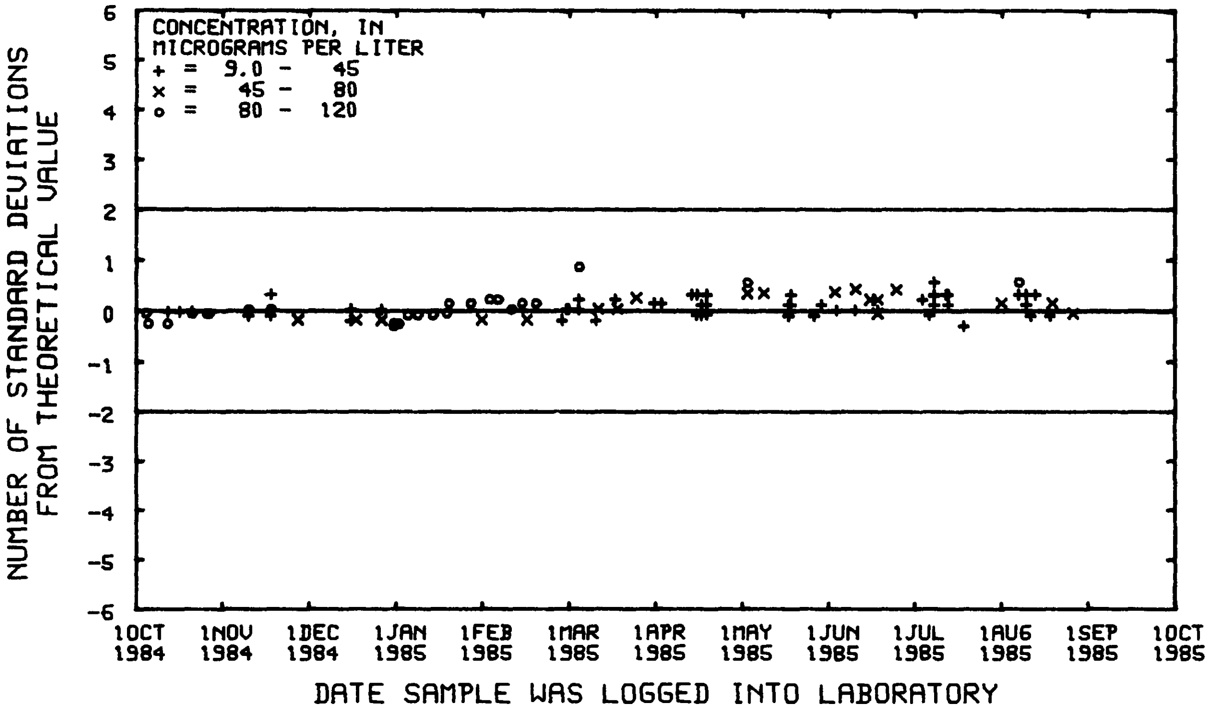

Figure 103--Zinc, dissolved, (atomic absorption spectrometry) data from the Atlanta laboratory.

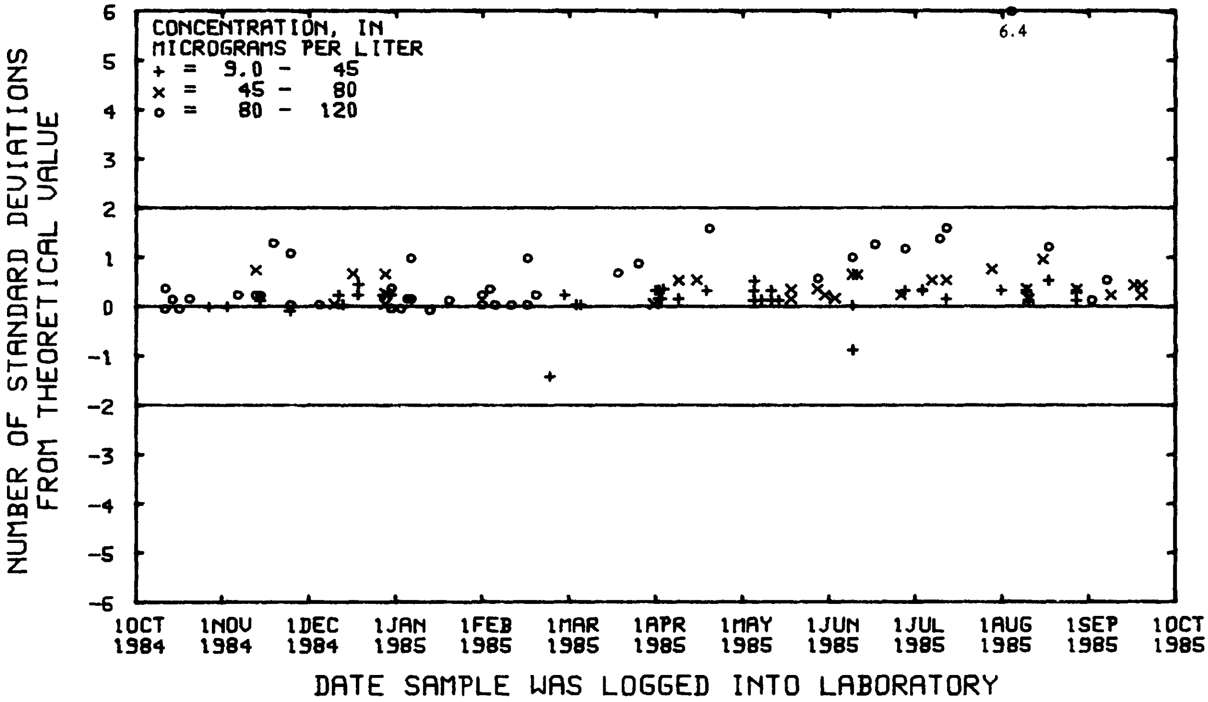

Figure 104--Zinc, dissolved, (atomic absorption spectrometry) data from the Denver laboratory.

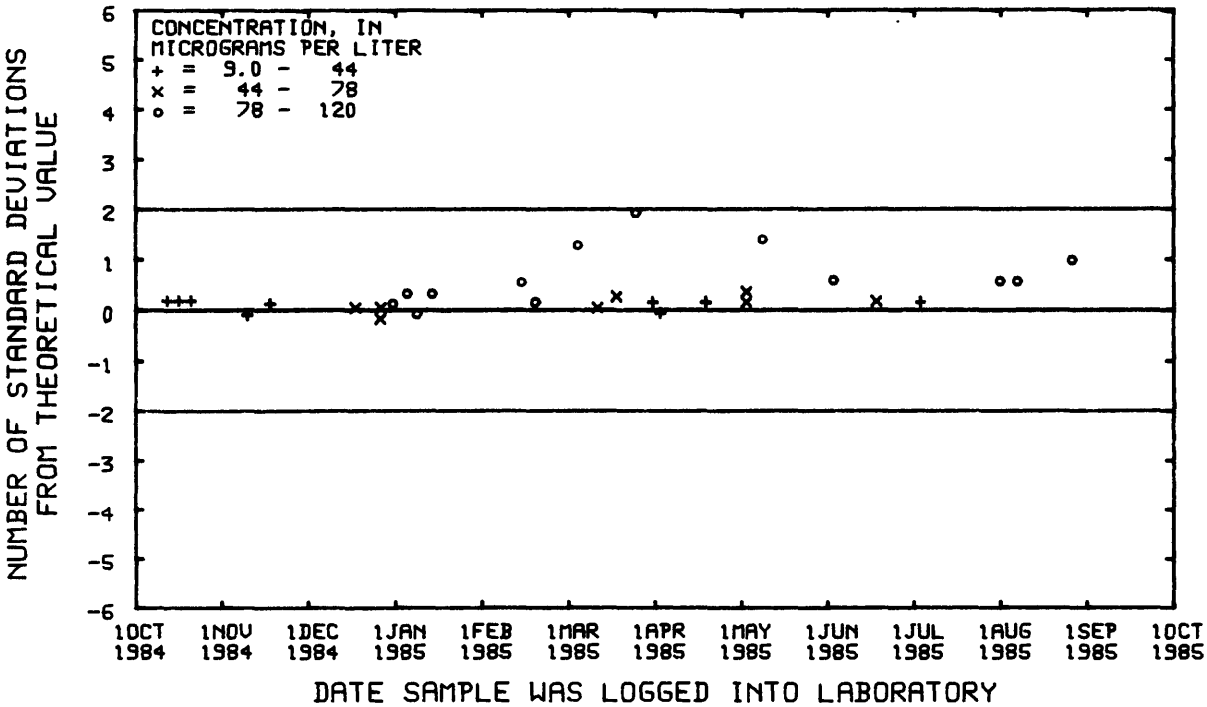

Figure 105--Zinc, total recoverable, data from the Atlanta laboratory.

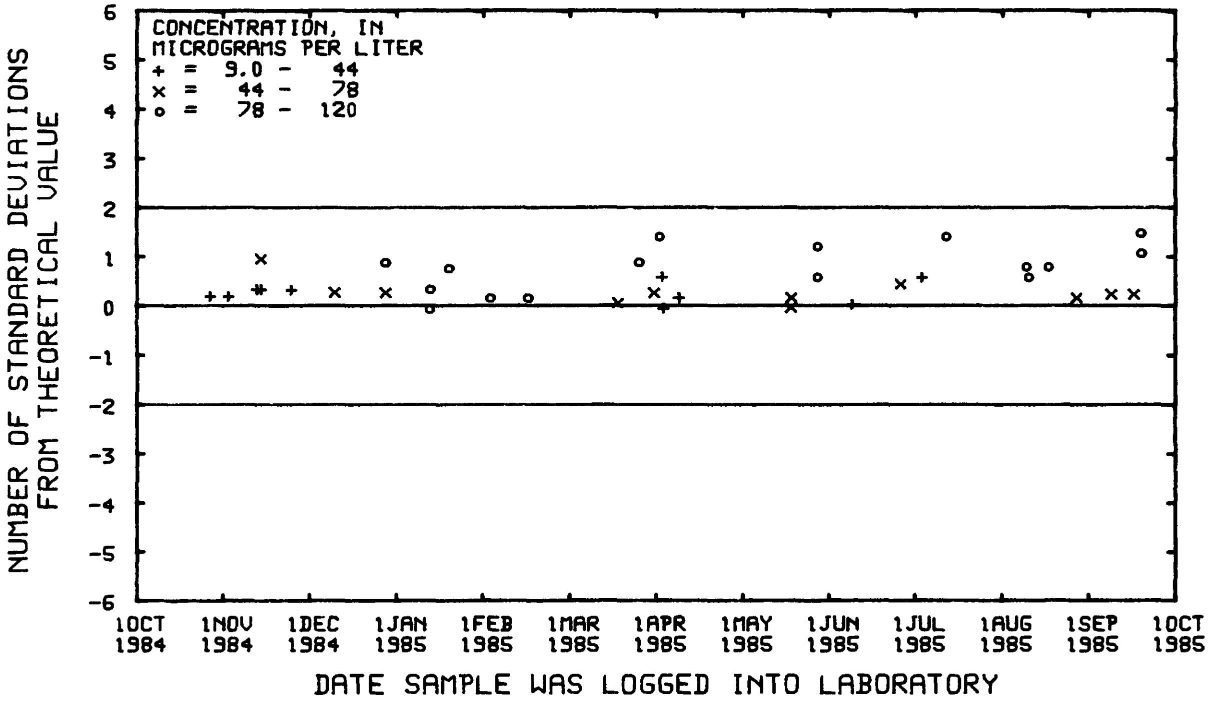

Figure 106--Zinc, total recoverable, data from the Denver laboratory.

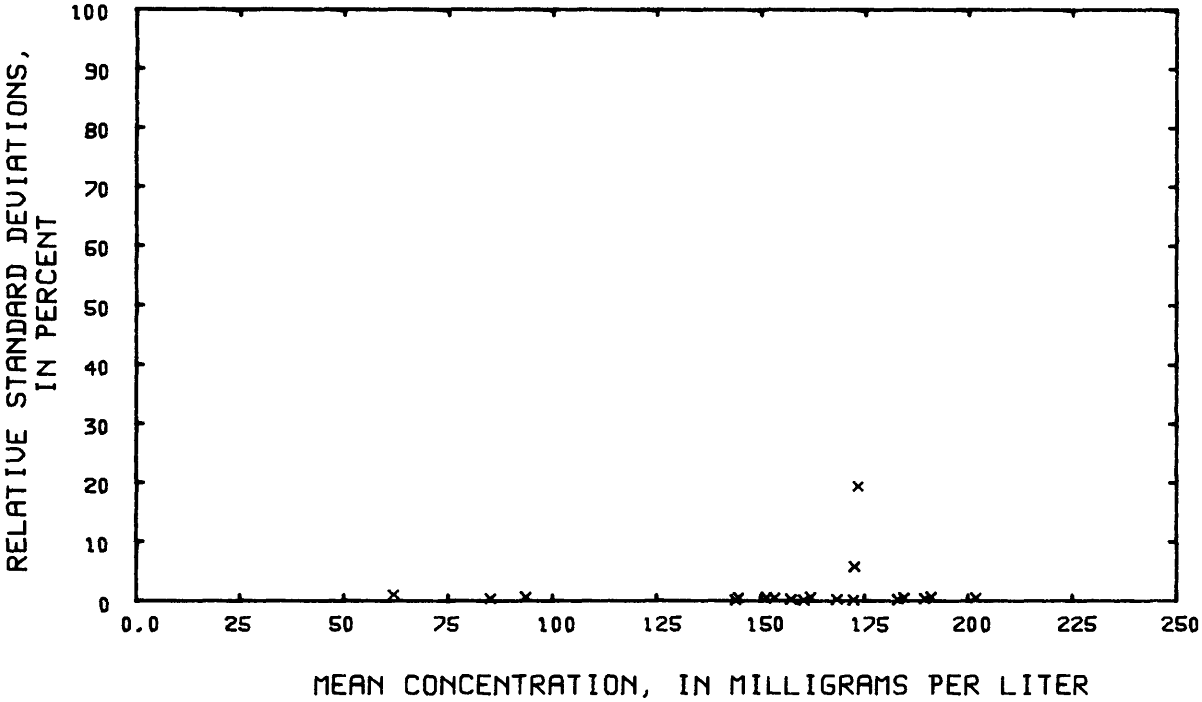

Figure 107--Precision data for alkalinity, dissolved, at the Atlanta laboratory.

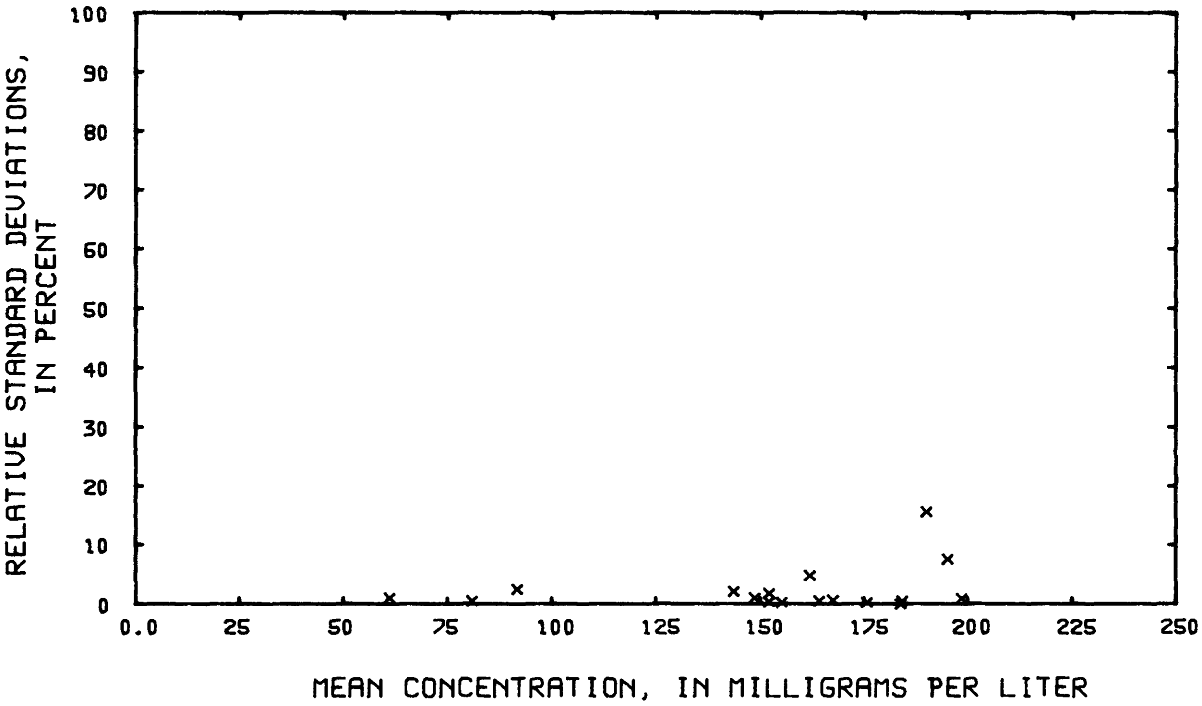

Figure 108--Precision data for alkalinity, dissolved, at the Denver laboratory.

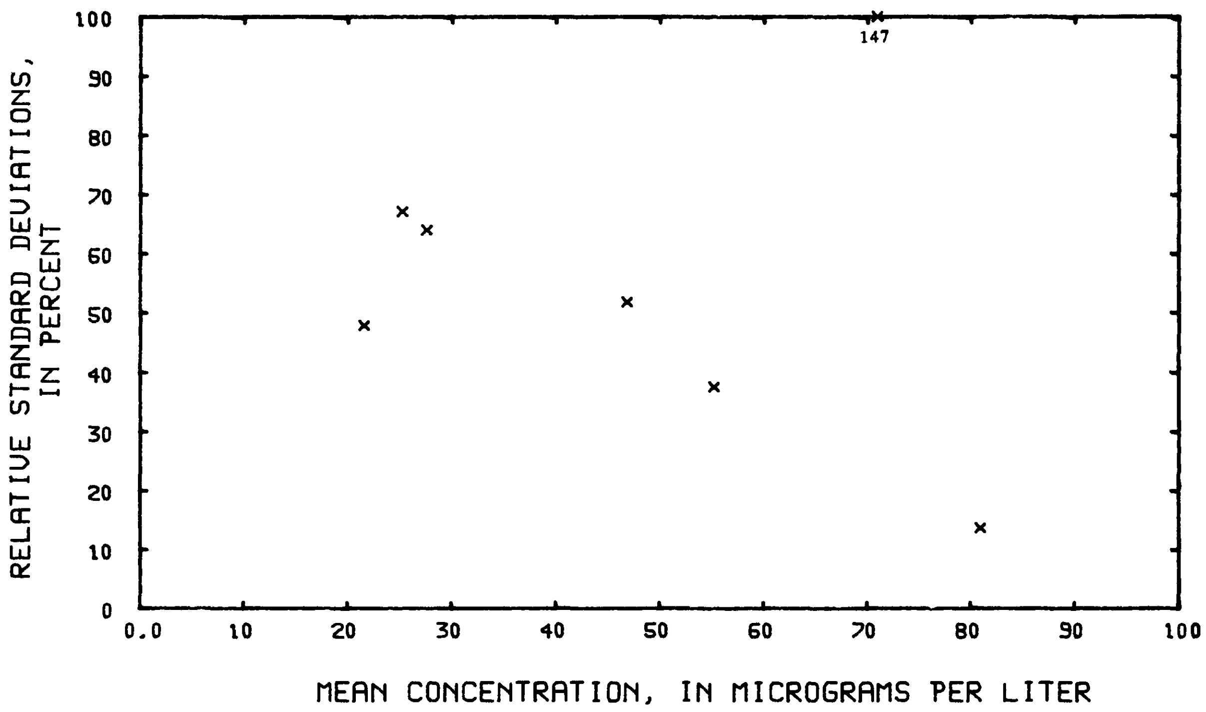

Figure 109--Precision data for aluminum, dissolved, at the Atlanta laboratory.

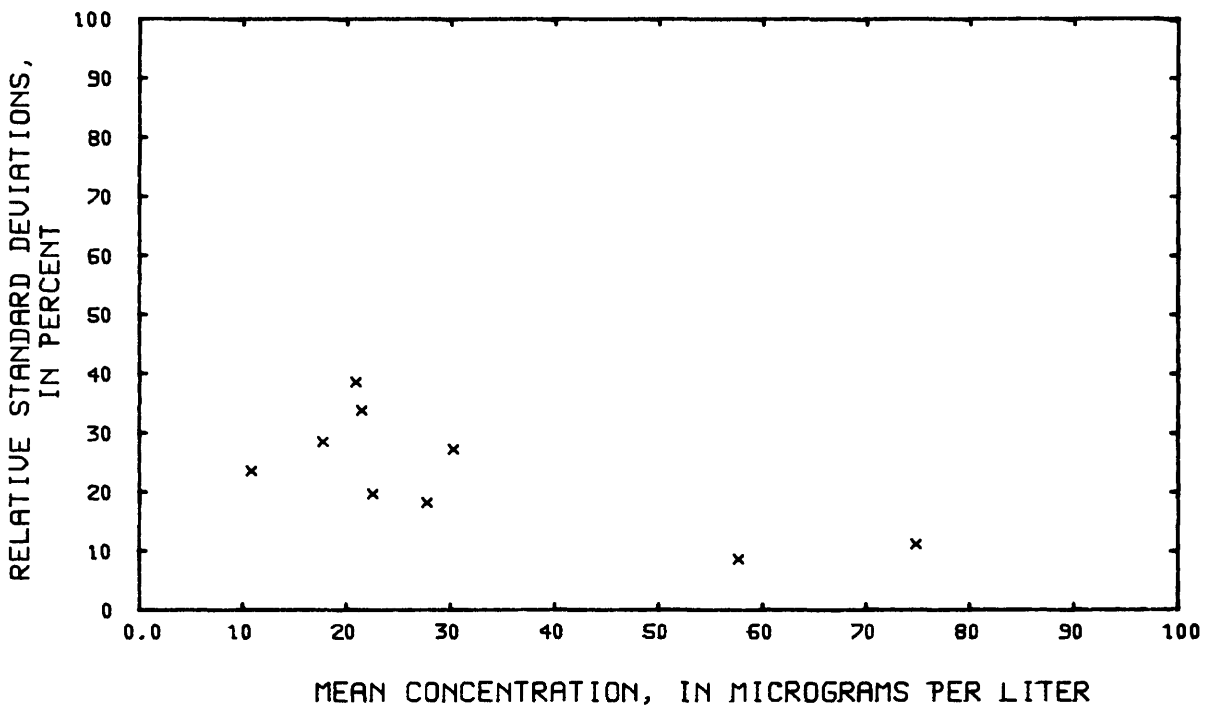

Figure 110--Precision data for aluminum, dissolved, at the Denver laboratory.

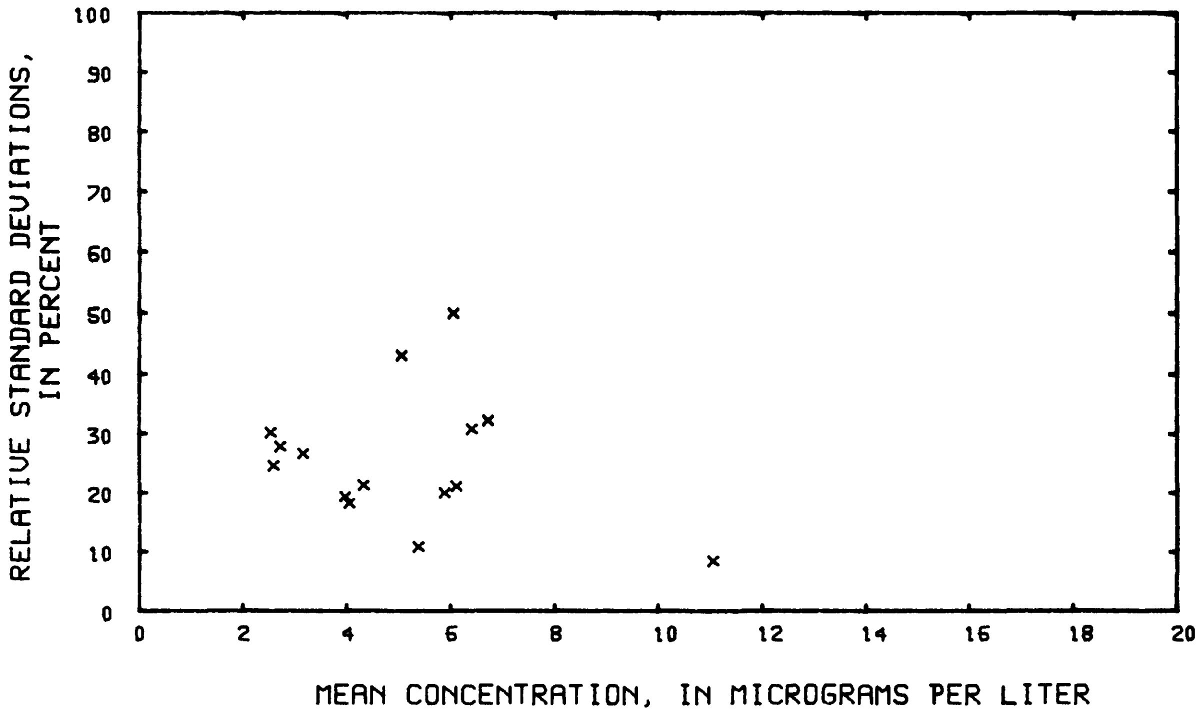

Figure 111--Precision data for arsenic, dissolved, at the Atlanta laboratory.

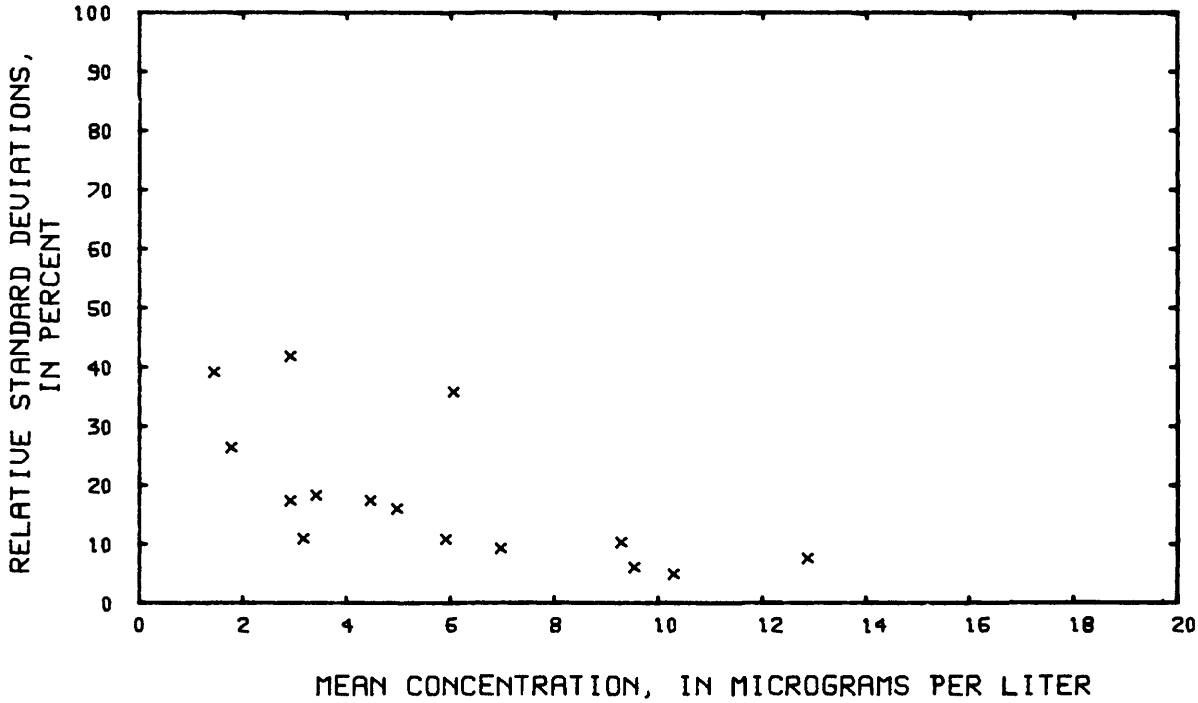

Figure 112--Precision data for arsenic, dissolved, at the Denver laboratory.

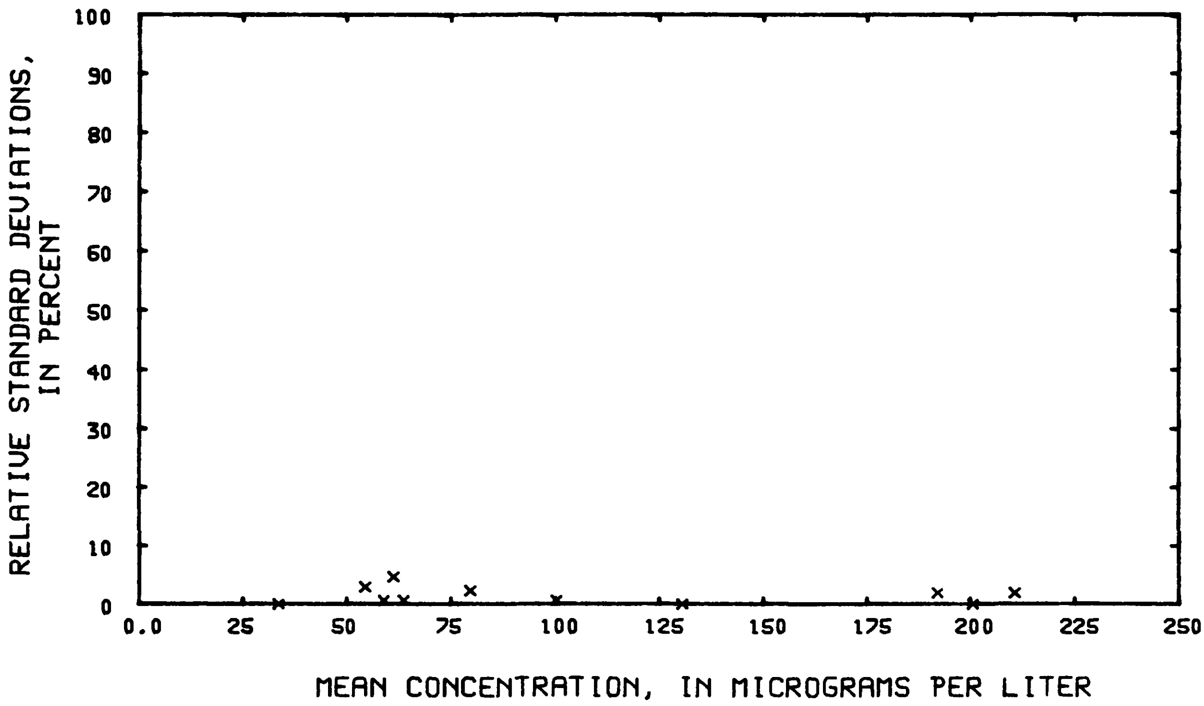

Figure 113--Precision data for barium, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

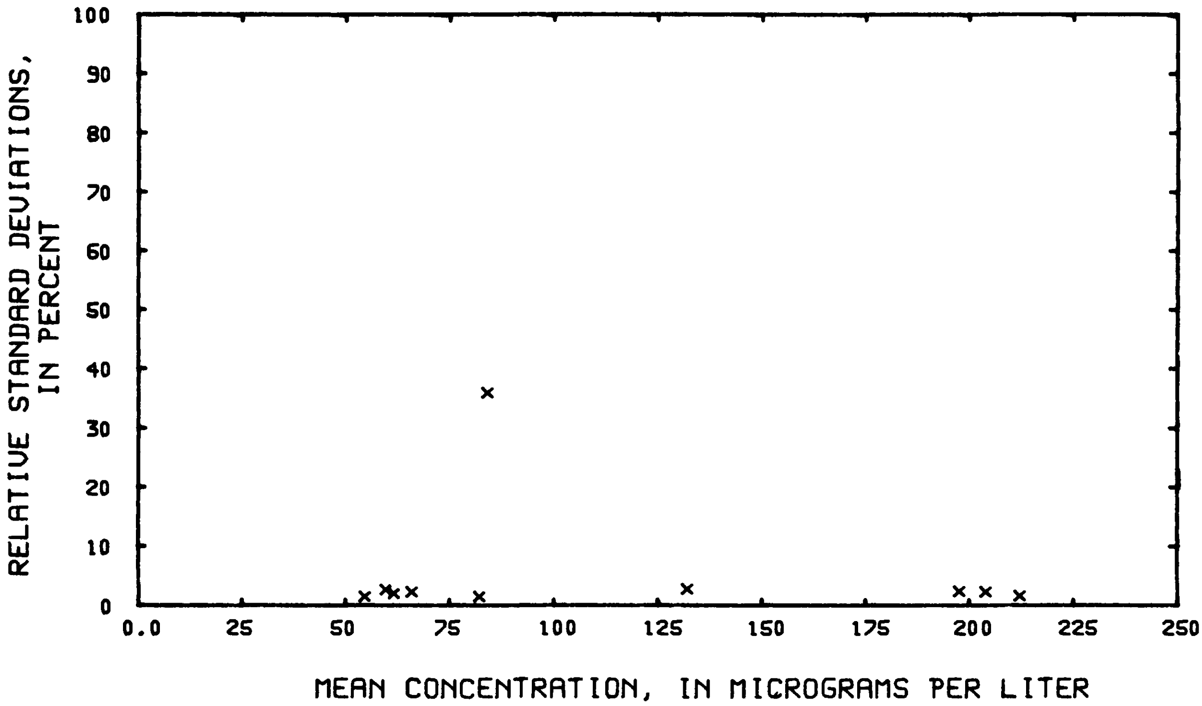

Figure 114--Precision data for barium, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

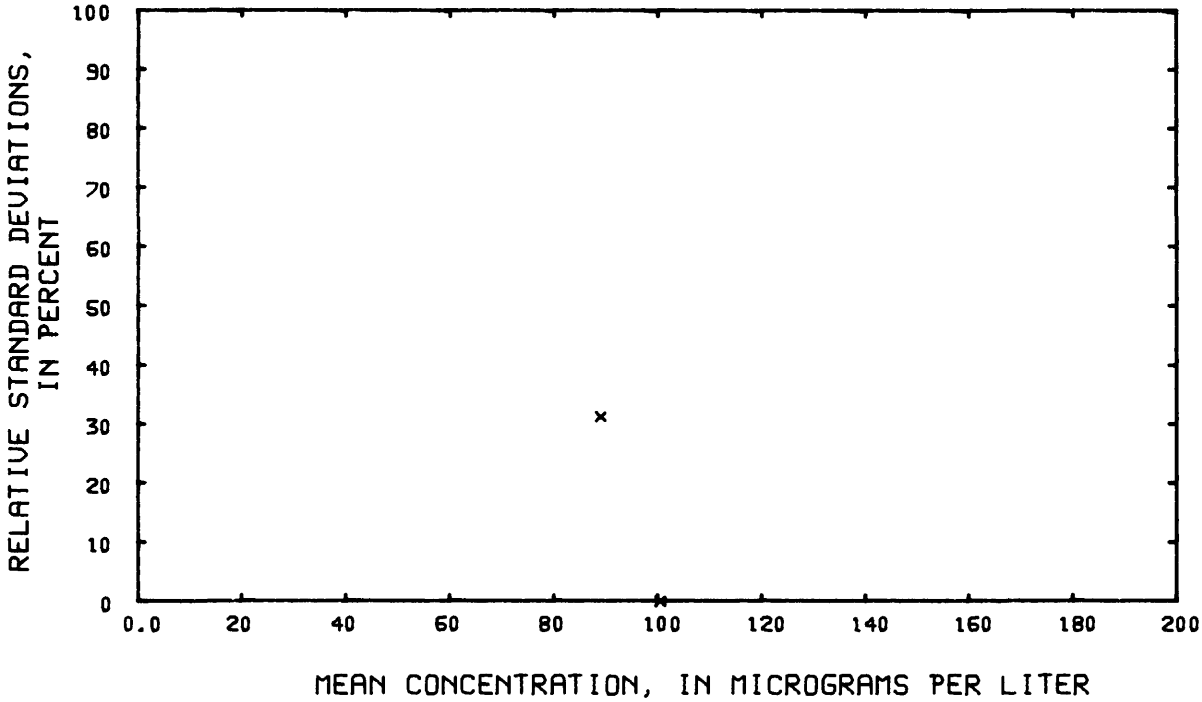

Figure 115--Precision data for barium, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

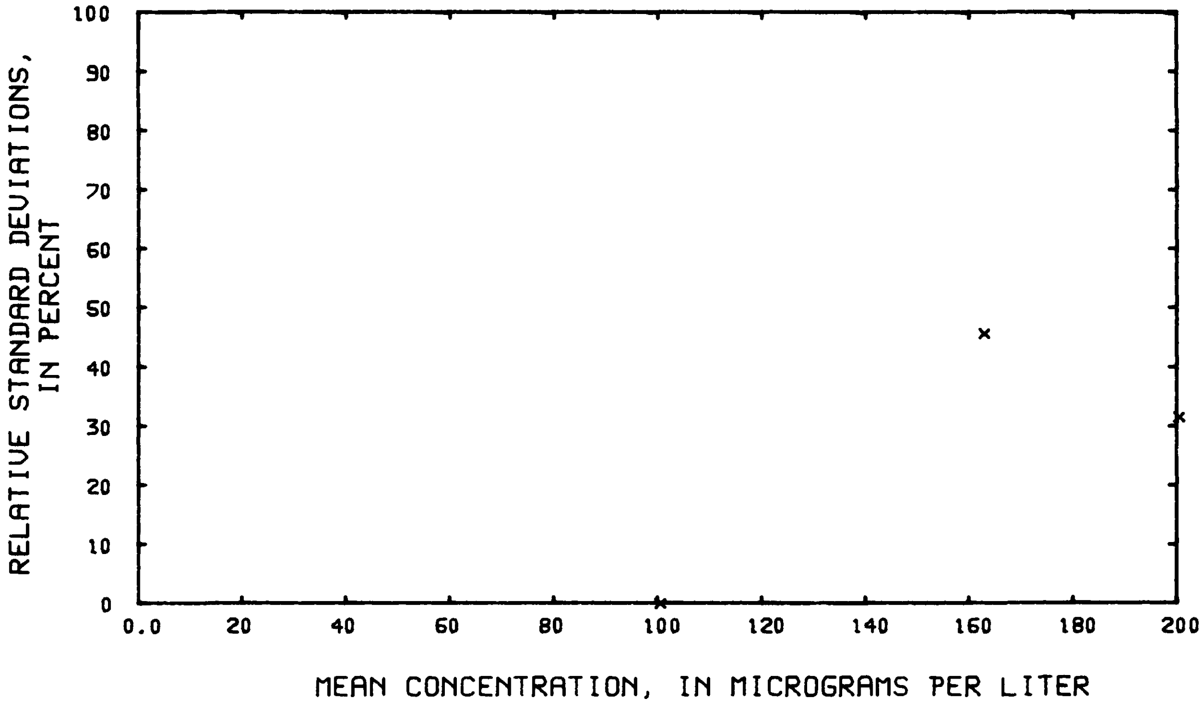

Figure 116--Precision data for barium, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

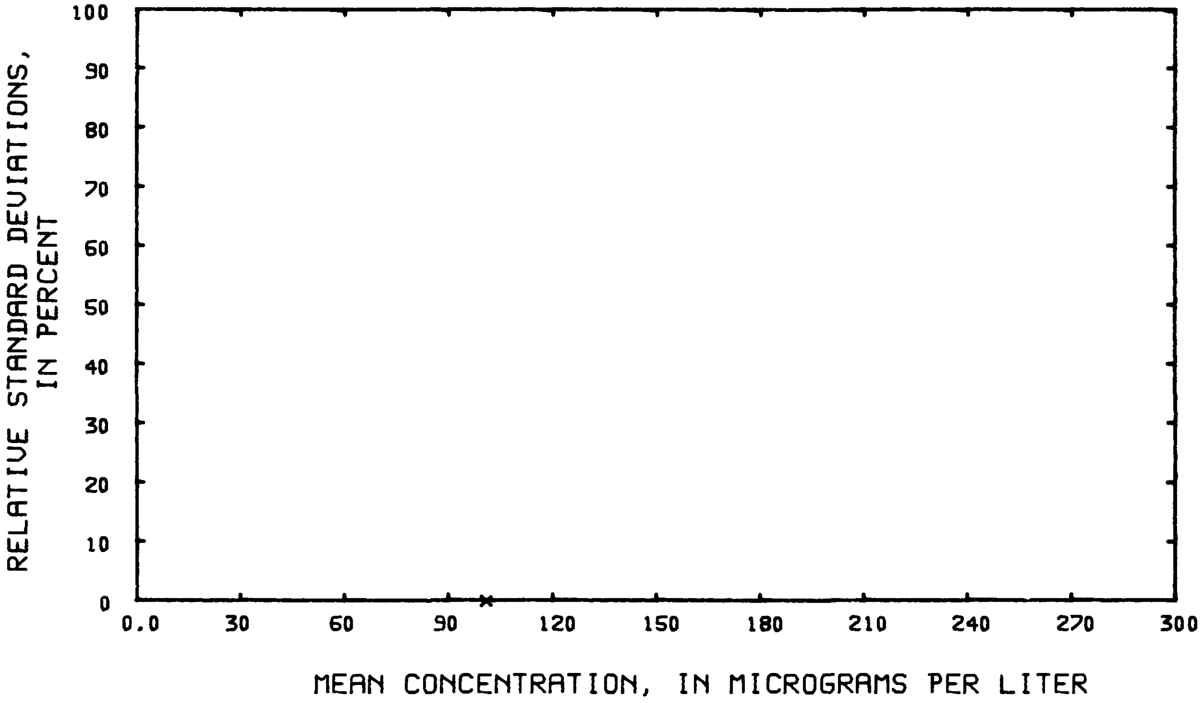

Figure 117--Precision data for barium, total recoverable, at the Atlanta laboratory.

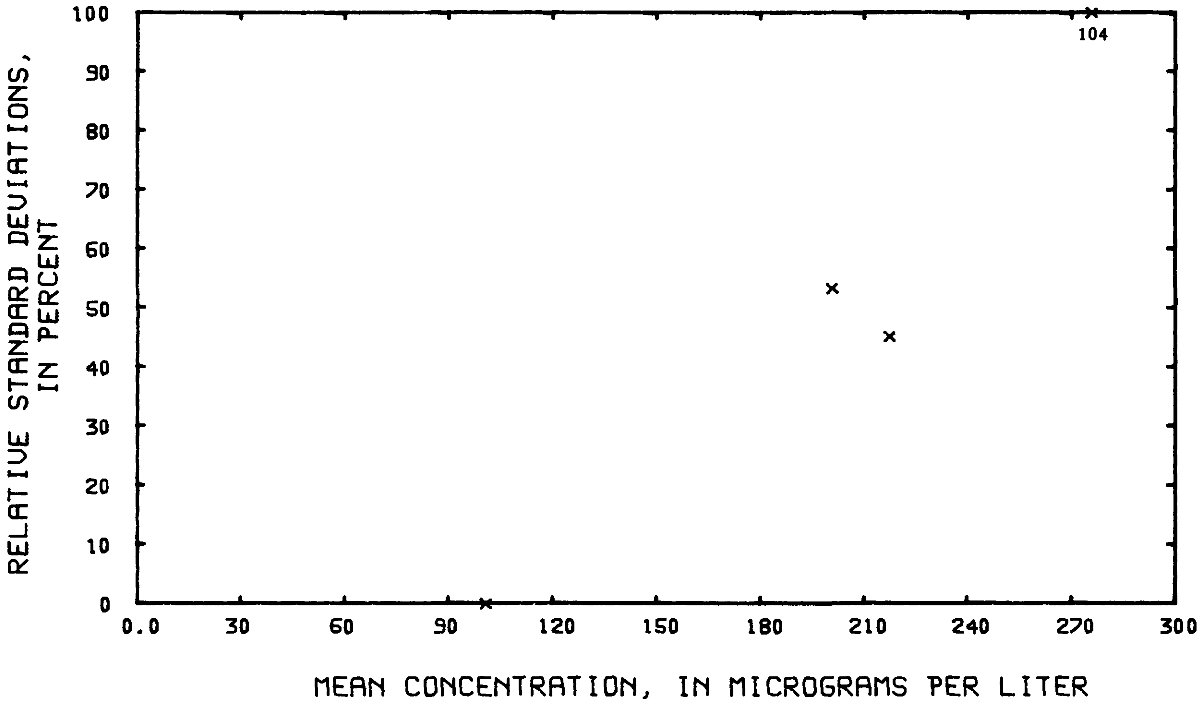

Figure 118--Precision data for barium, total recoverable, at the Denver laboratory.

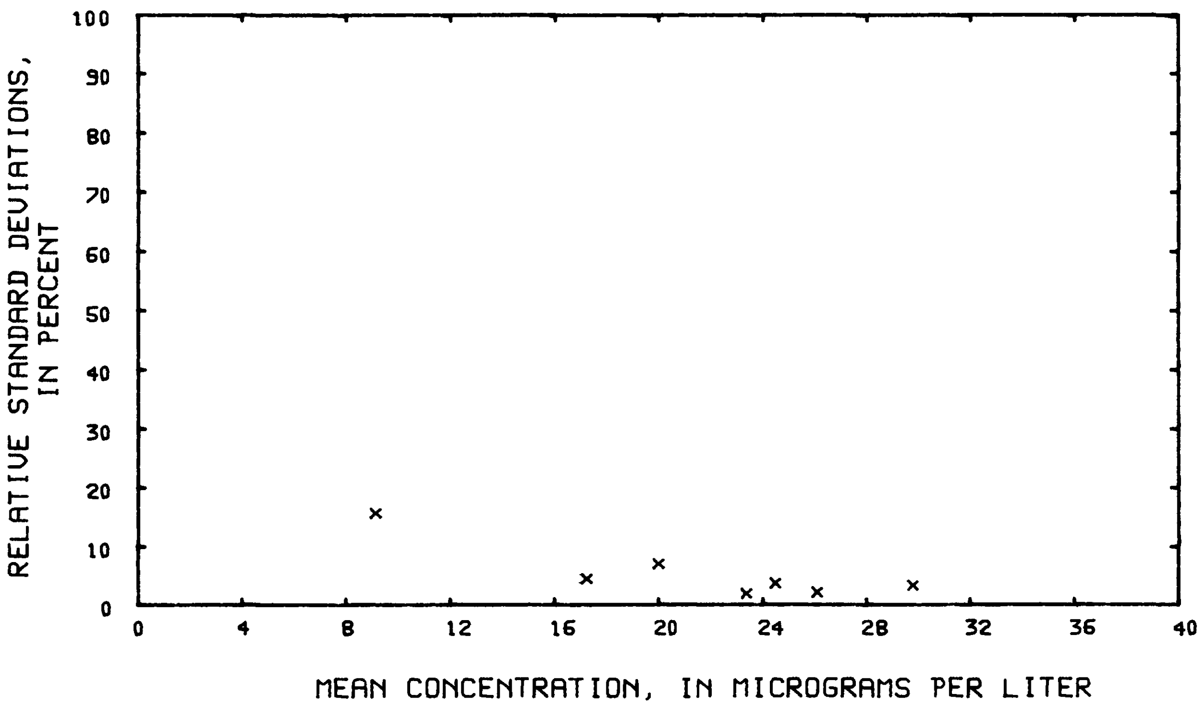

Figure 119--Precision data for beryllium, dissolved, at the Atlanta laboratory.

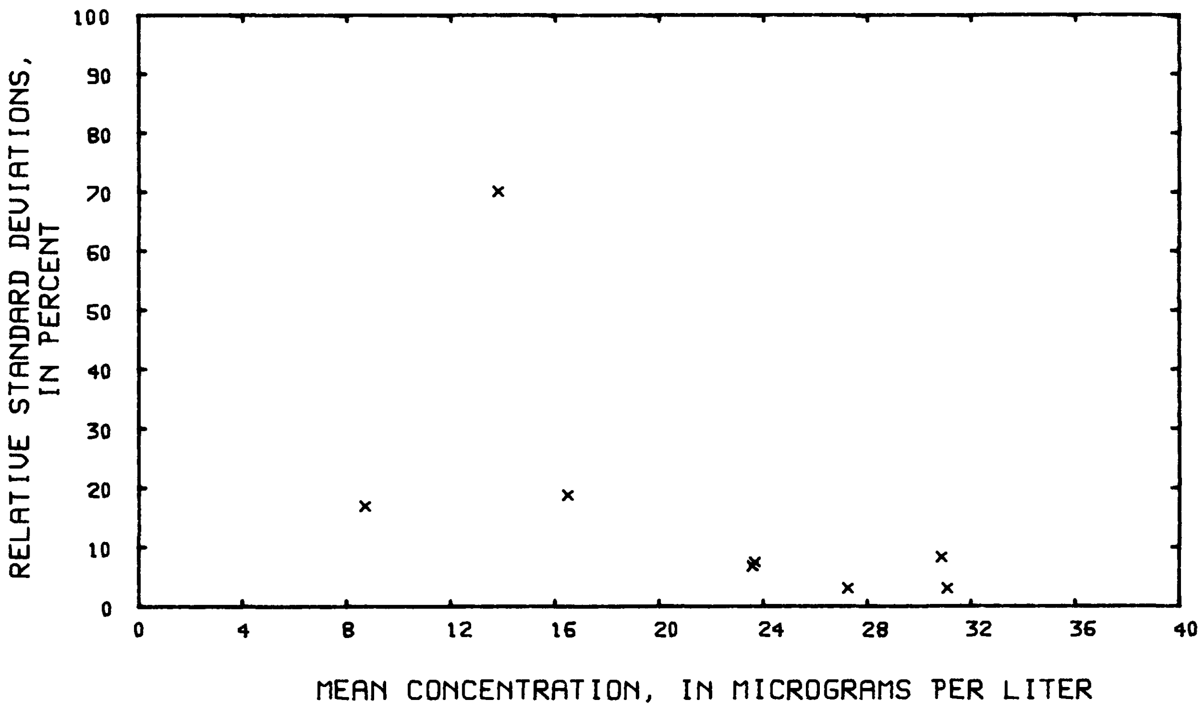

Figure 120--Precision data for beryllium, dissolved, at the Denver laboratory.

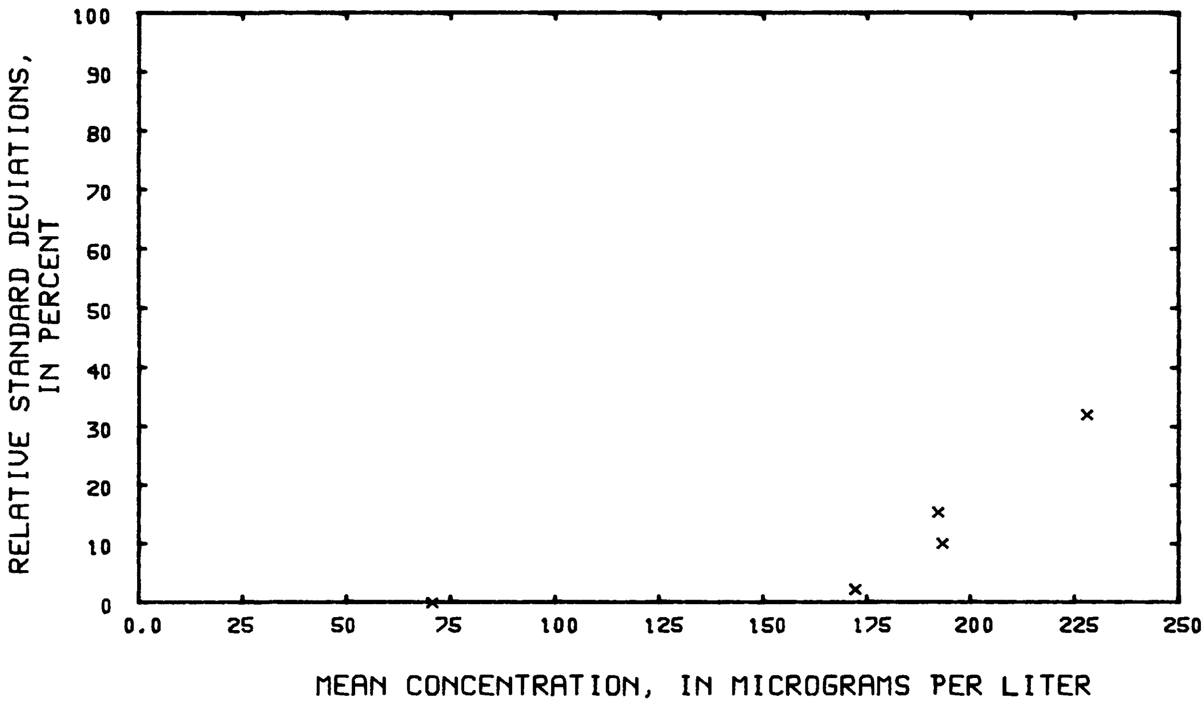

Figure 121--Precision data for boron, dissolved, at the Atlanta laboratory.

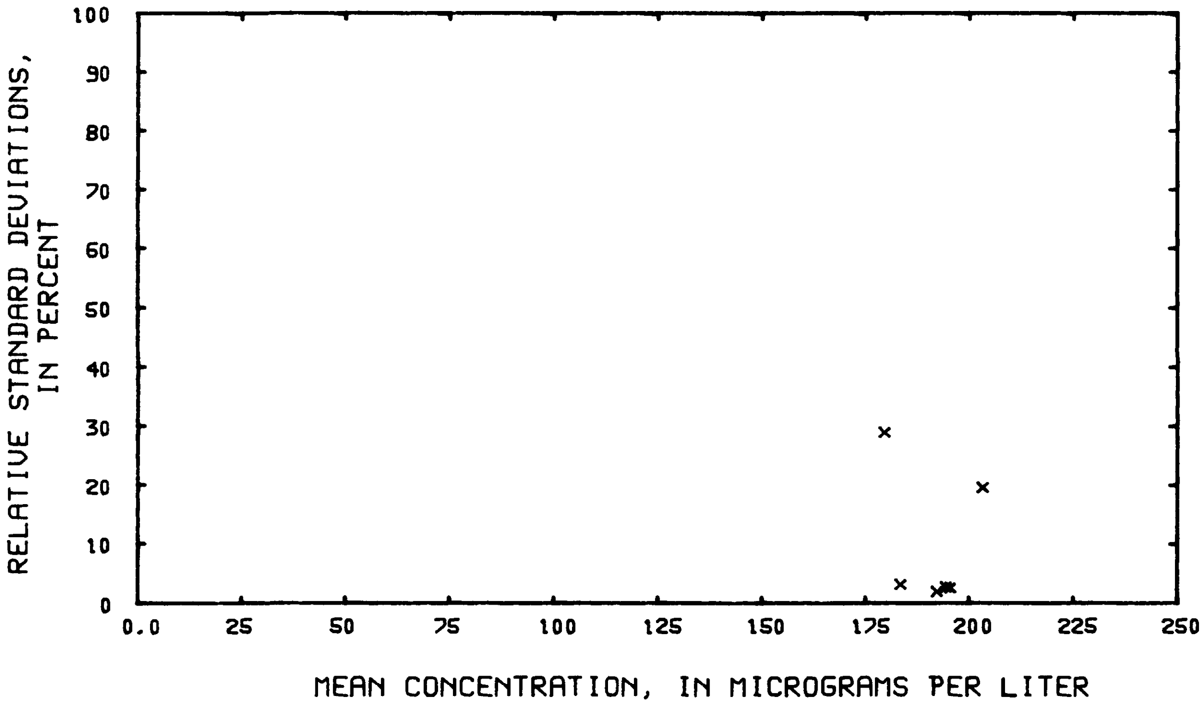

Figure 122--Precision data for boron, dissolved, at the Denver laboratory.

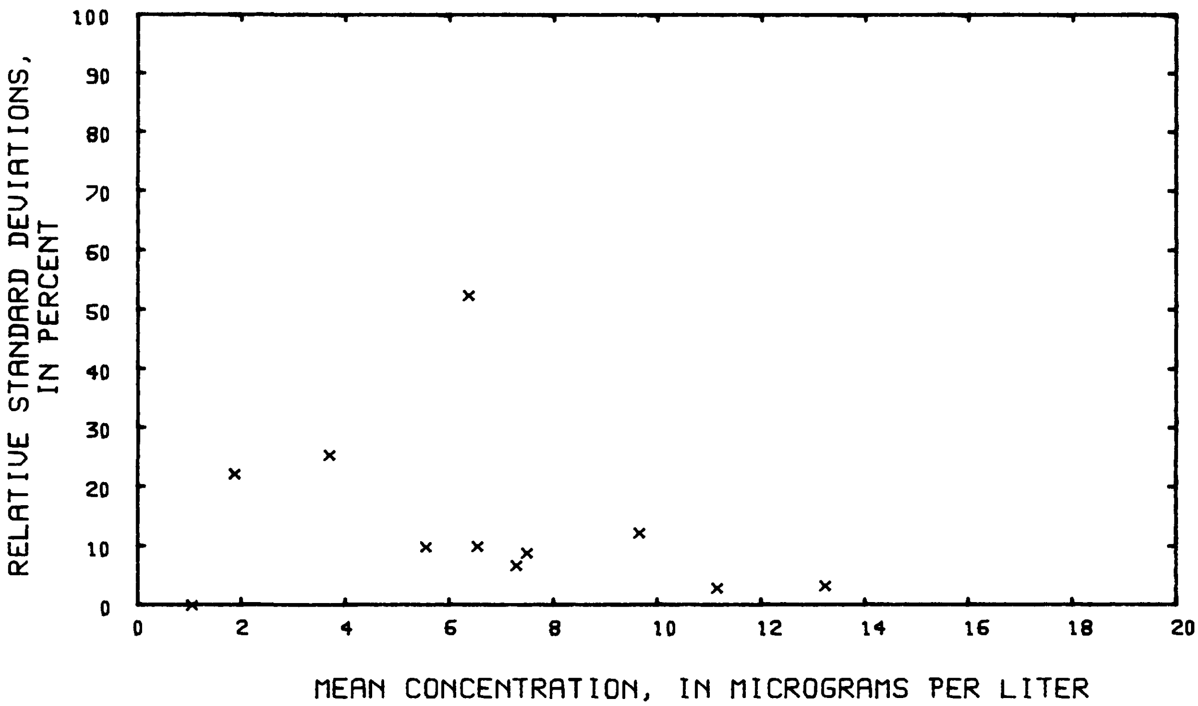

Figure 123--Precision data for cadmium, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

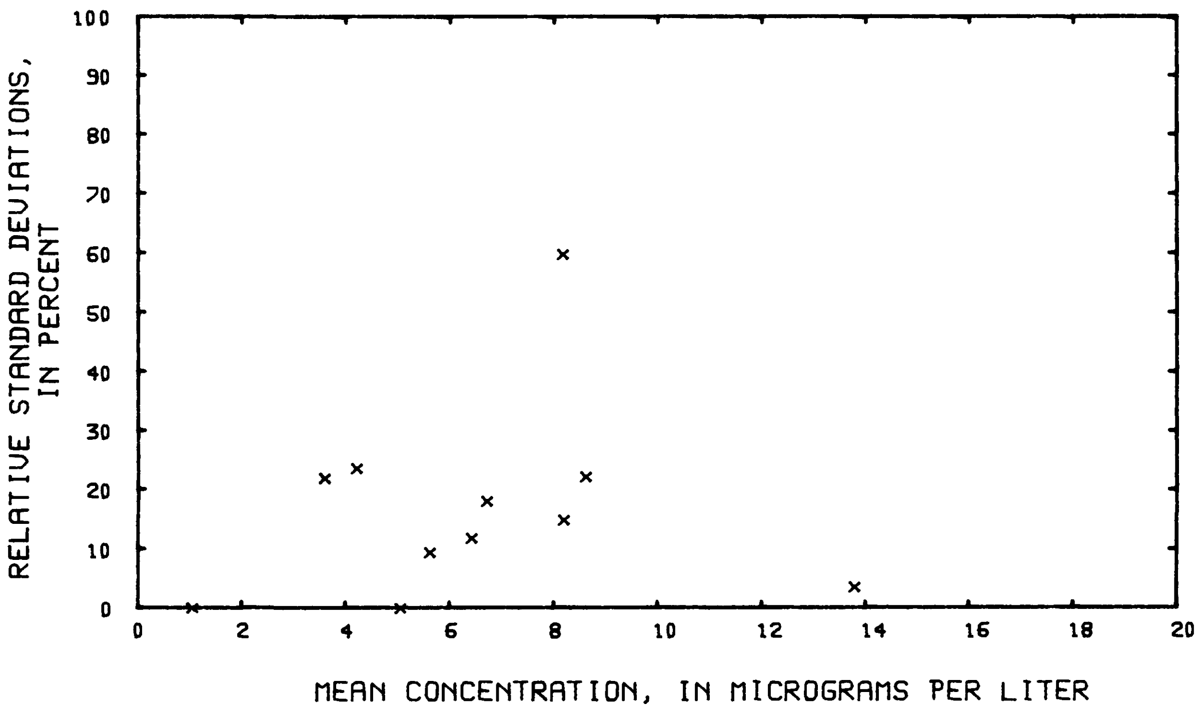

Figure 124--Precision data for cadmium, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

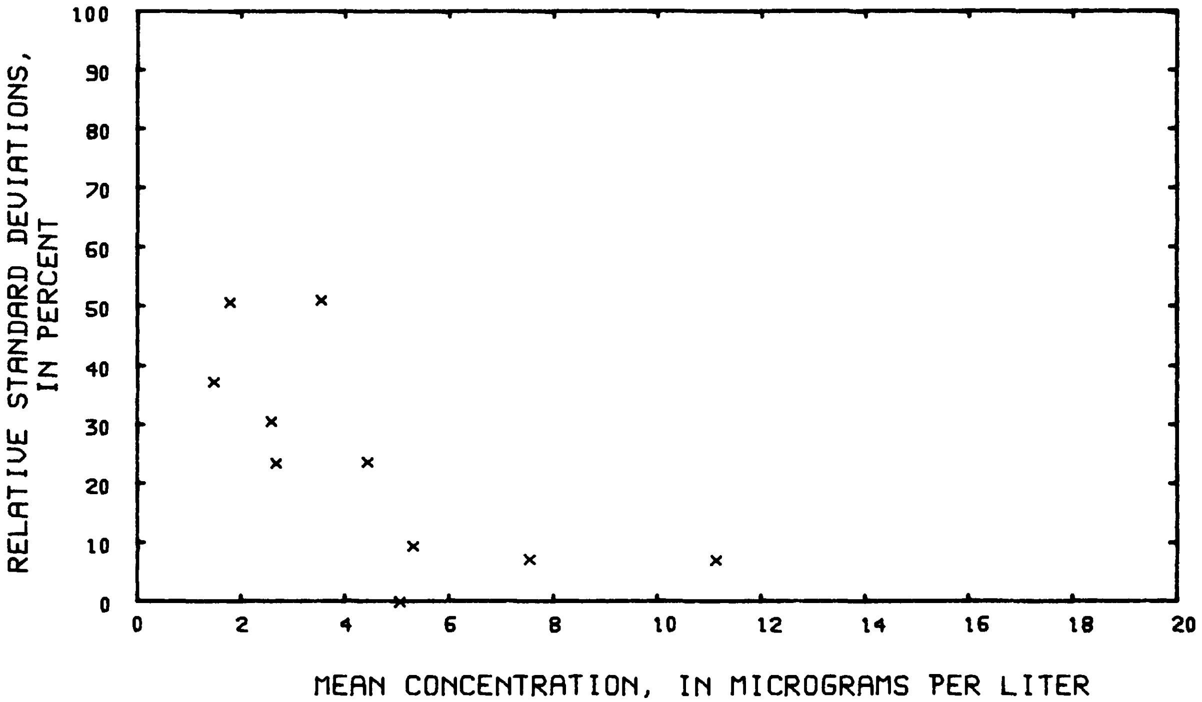

Figure 125--Precision data for cadmium, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

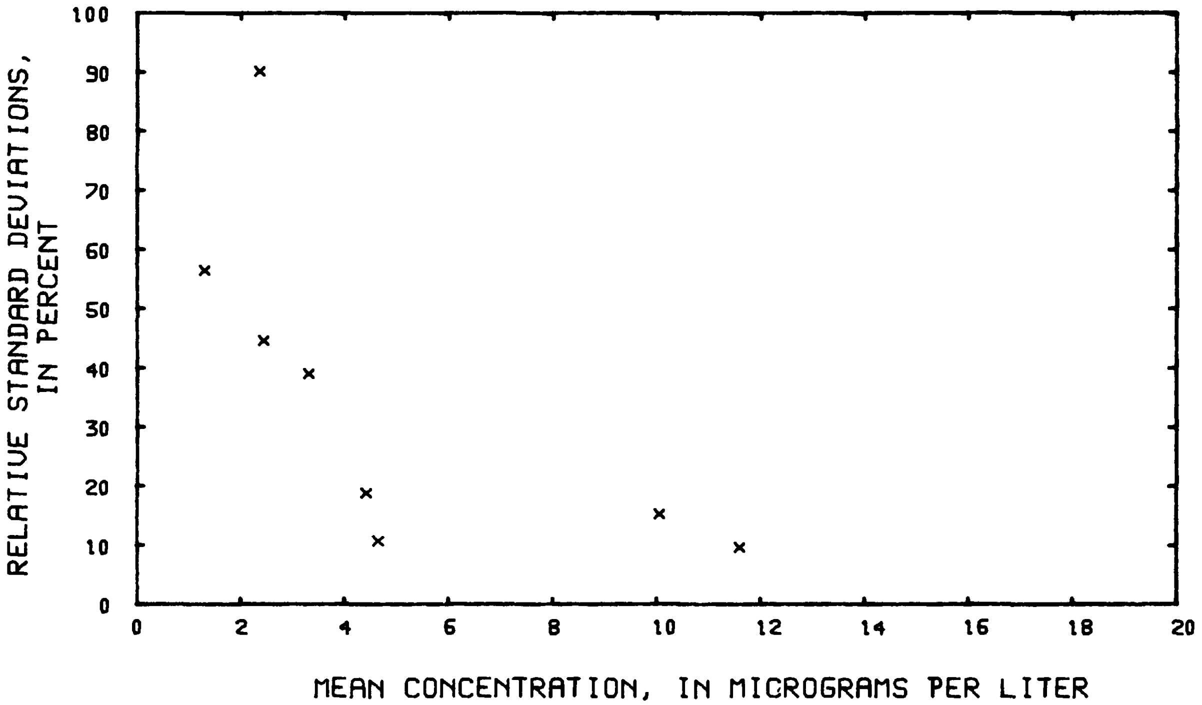

Figure 126--Precision data for cadmium, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

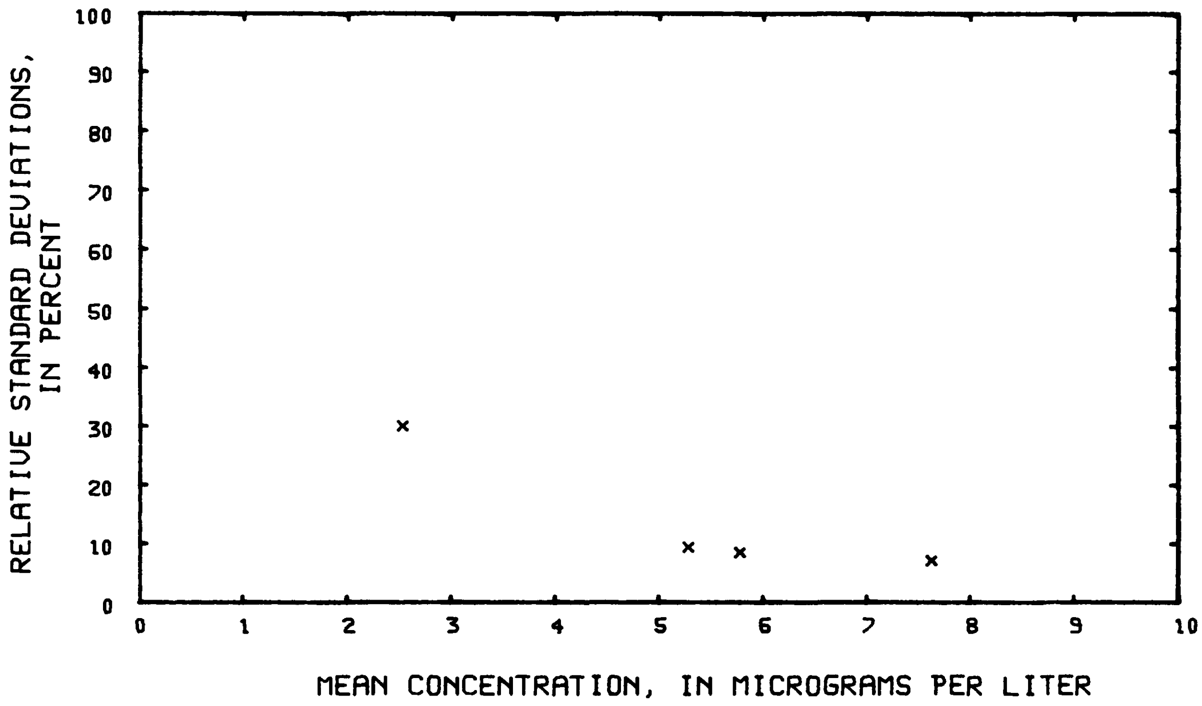

Figure 127--Precision data for cadmium, total recoverable, at the Atlanta laboratory.

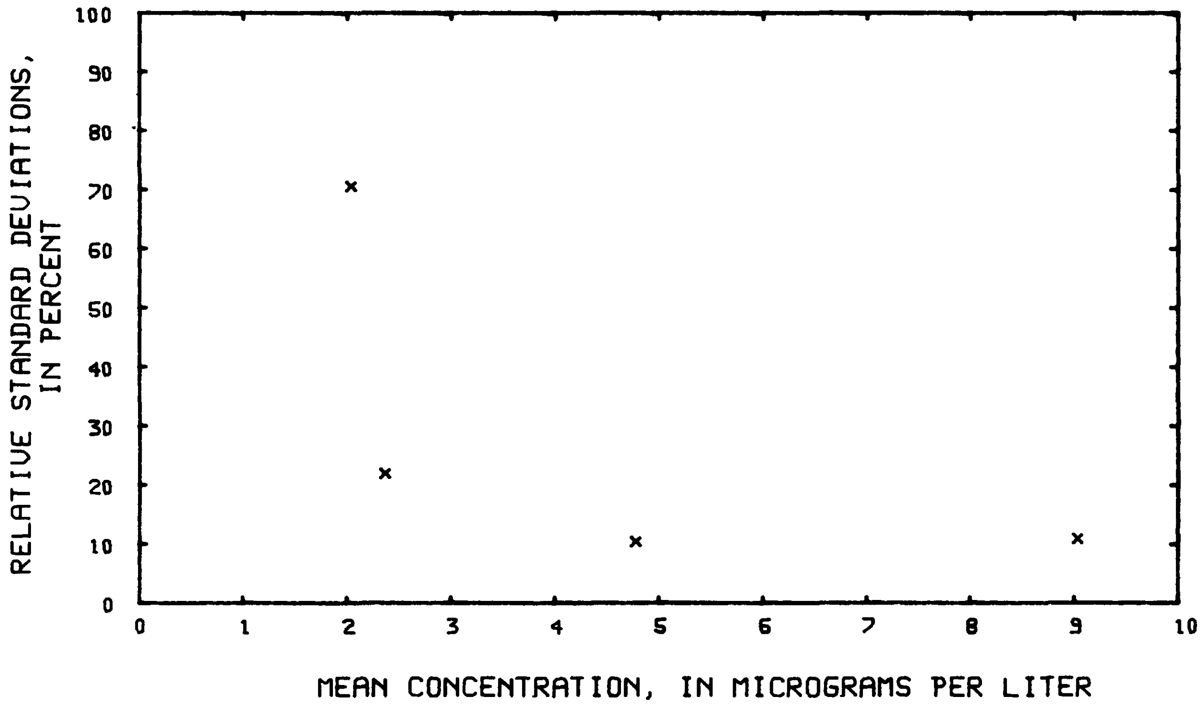

Figure 128--Precision data for cadmium, total recoverable, at the Denver laboratory.

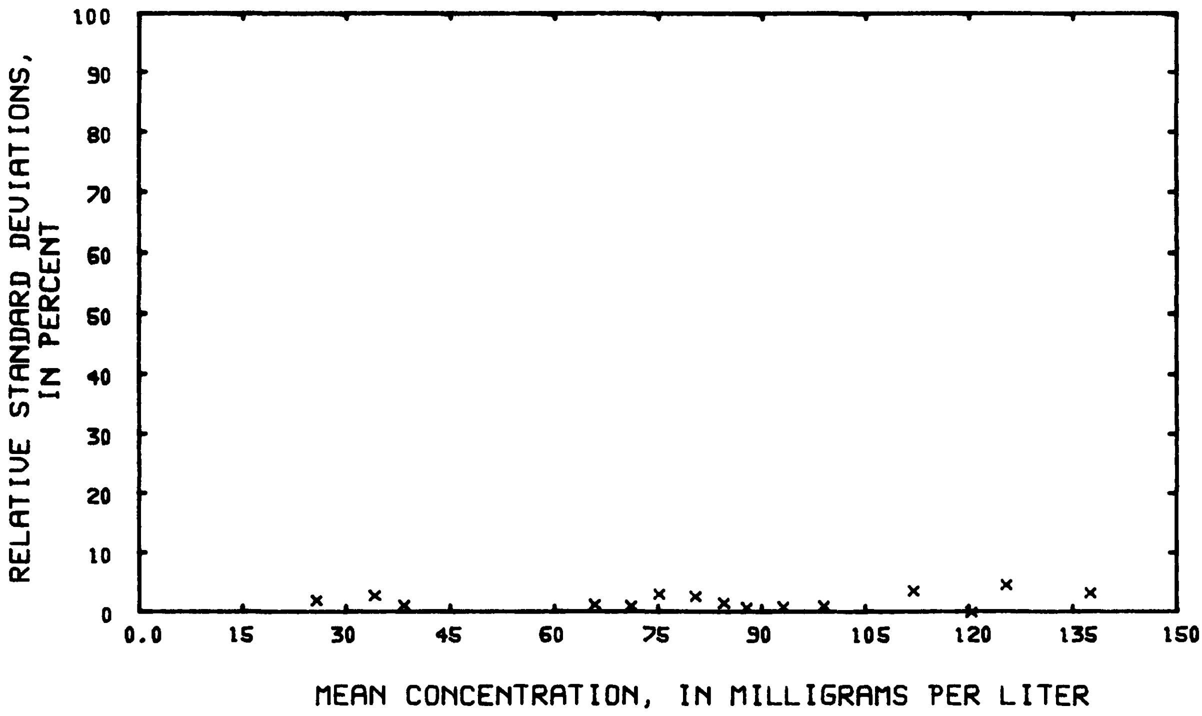

Figure 129--Precision data for calcium, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

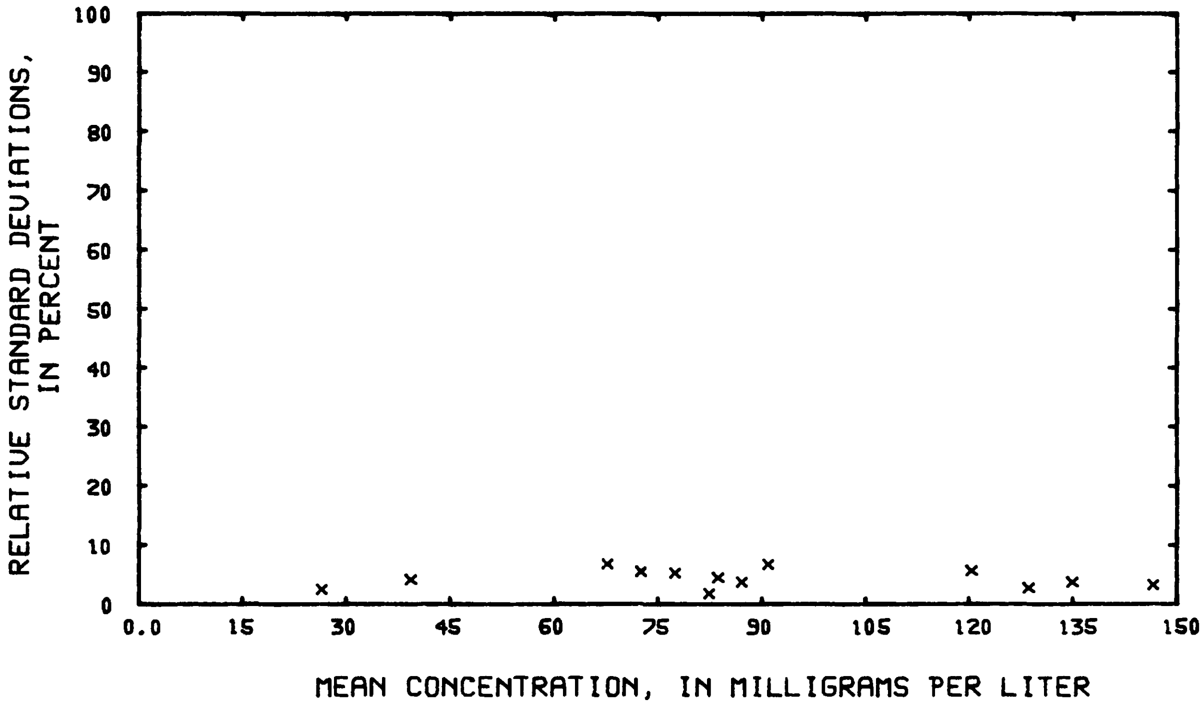

Figure 130--Precision data for calcium, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

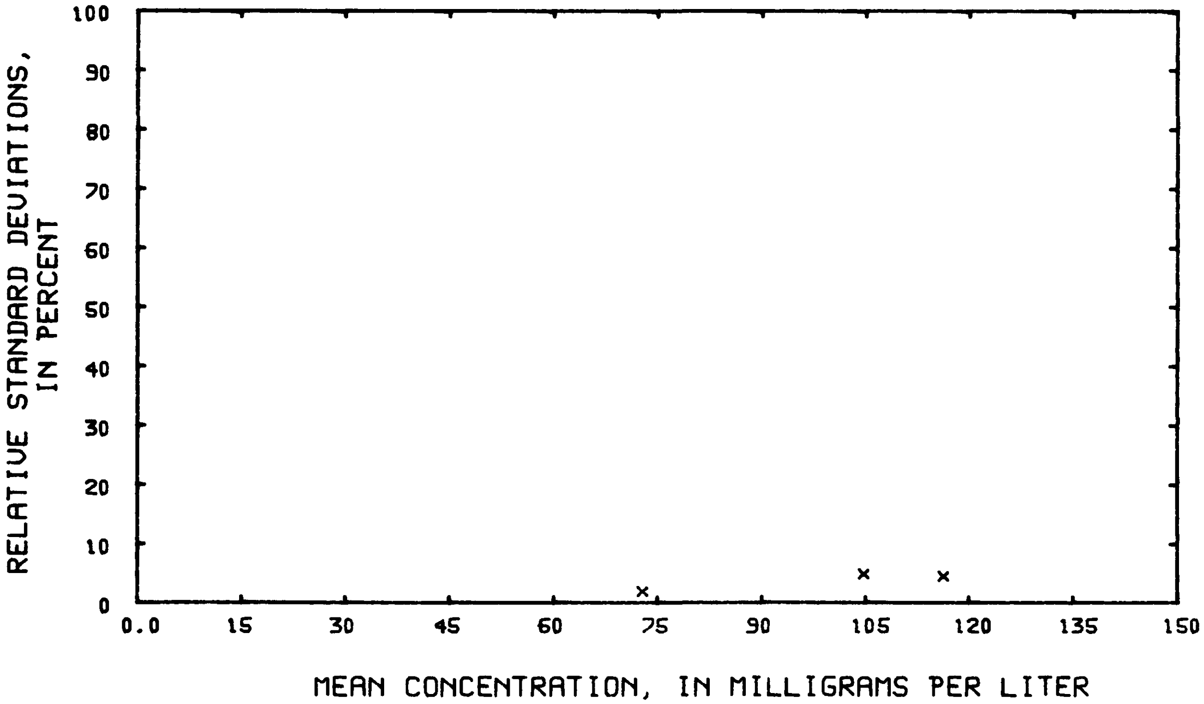

Figure 131--Precision data for calcium, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

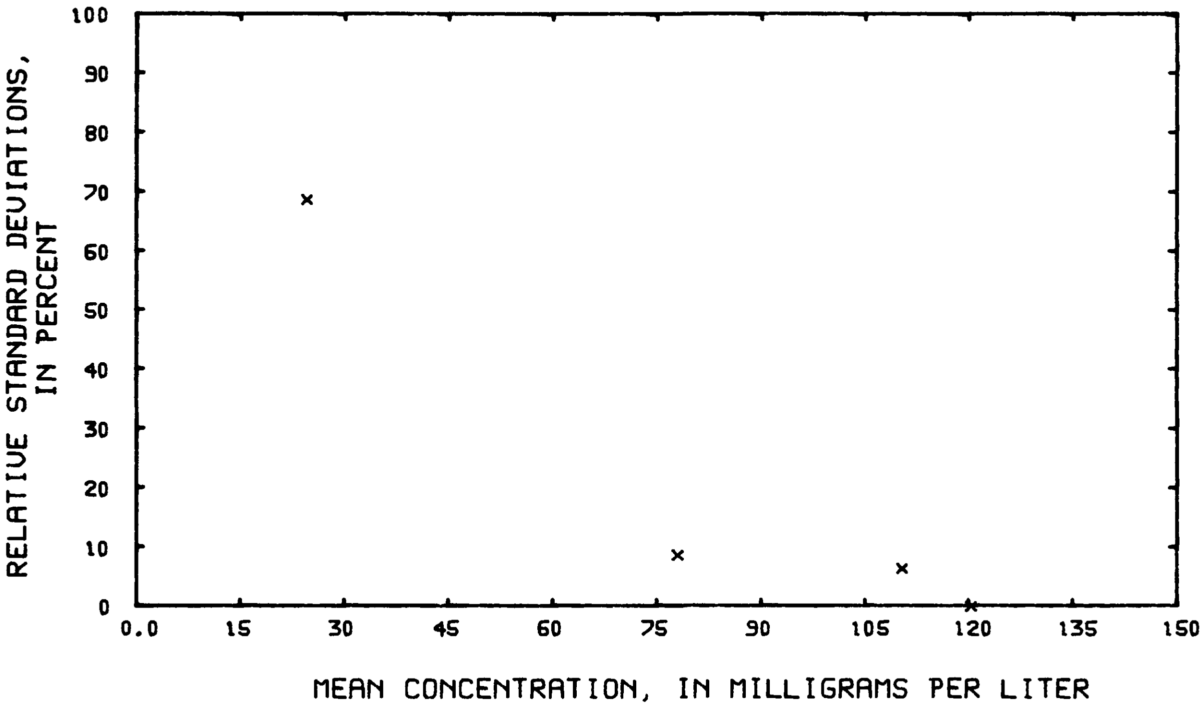

Figure 132--Precision data for calcium, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

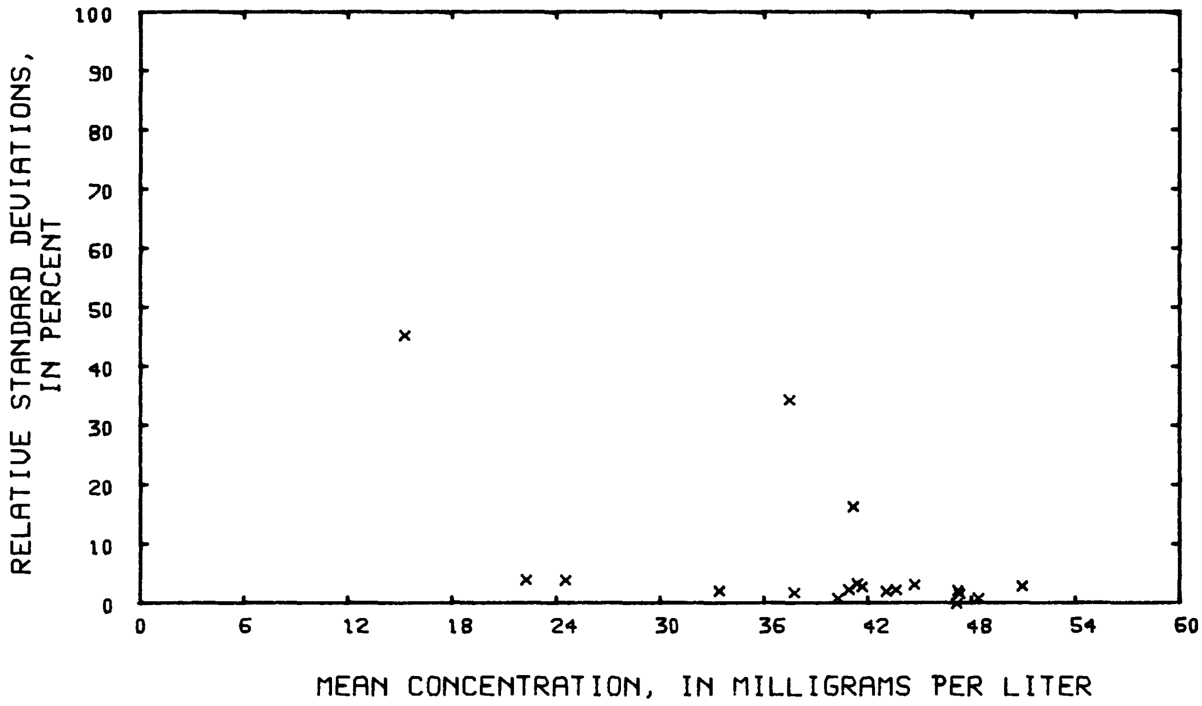

Figure 133--Precision data for chloride, dissolved, at the Atlanta laboratory.

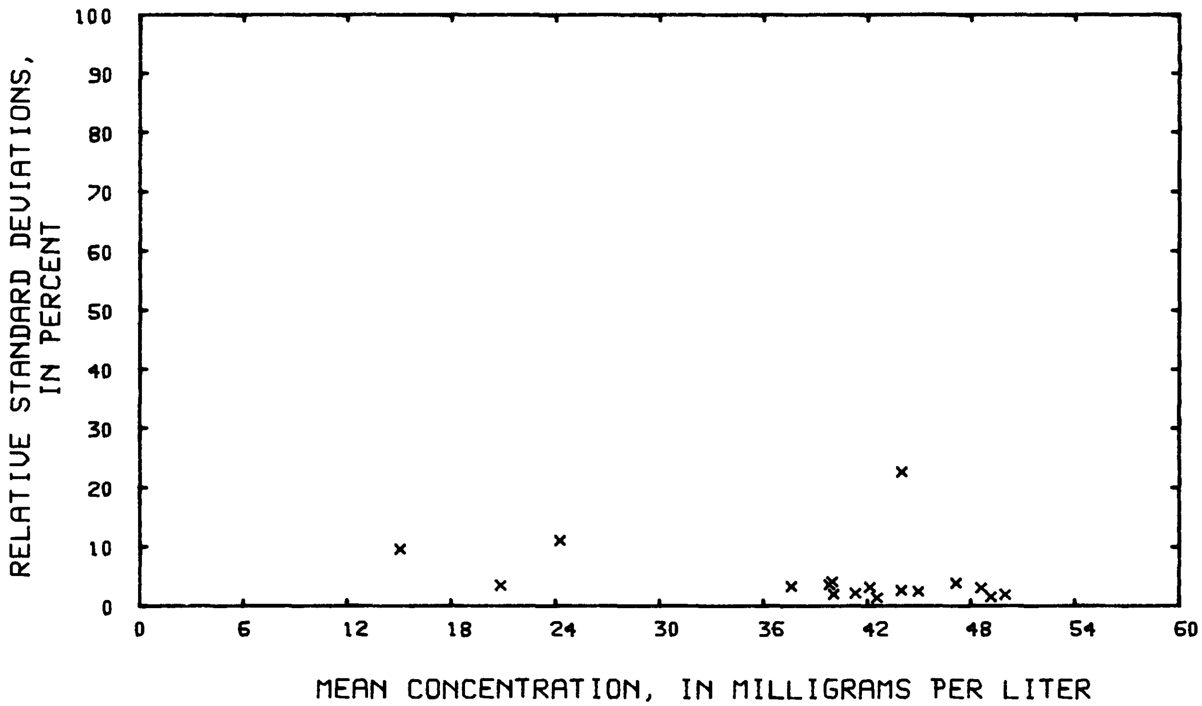

Figure 134--Precision data for chloride, dissolved, at the Denver laboratory.

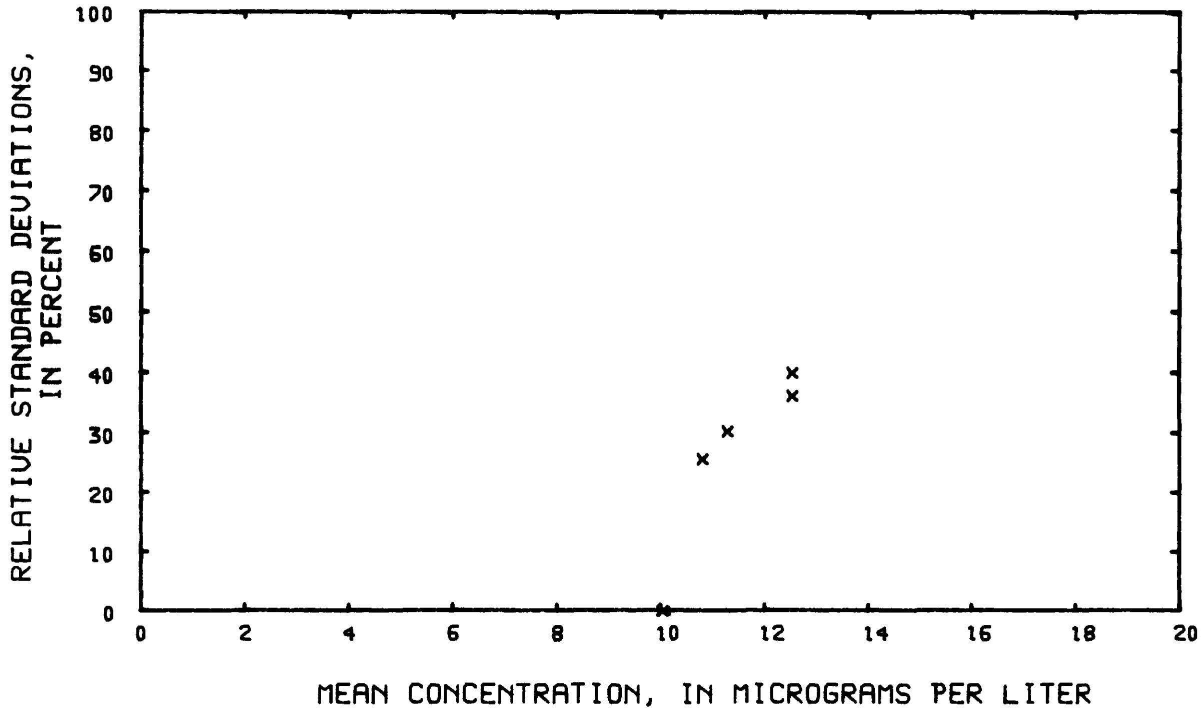

Figure 135--Precision data for chromium, dissolved, at the Atlanta laboratory.

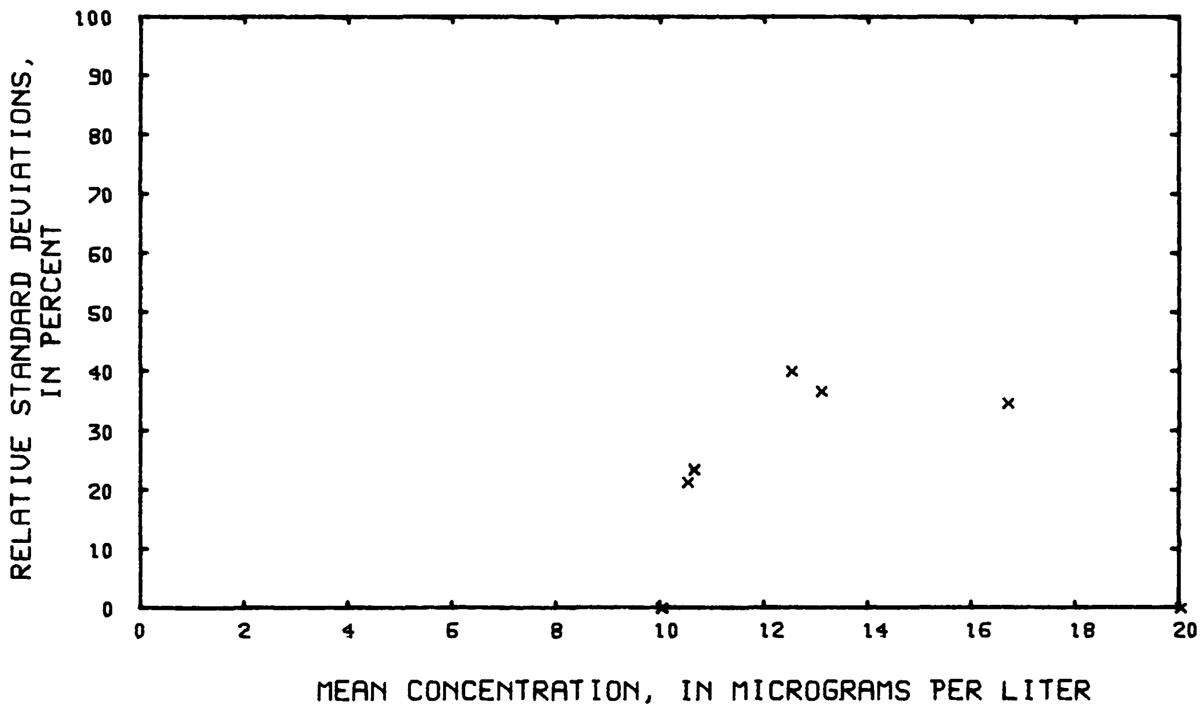

Figure 136--Precision data for chromium, dissolved, at the Denver laboratory.

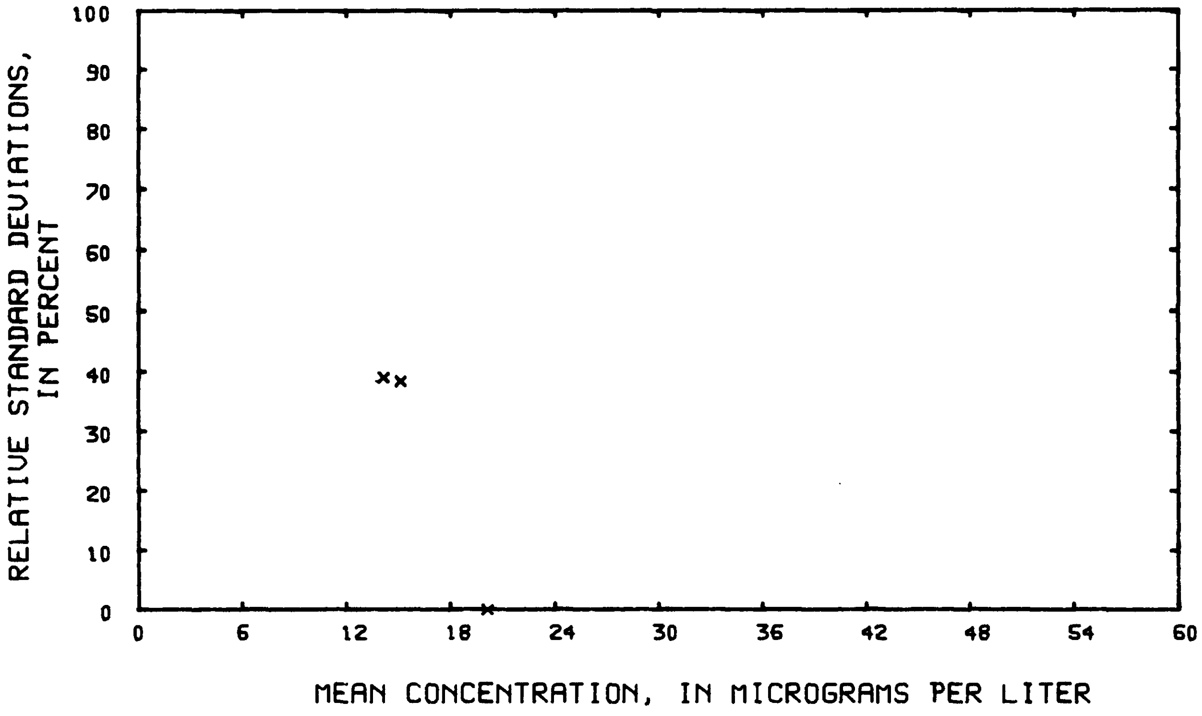

Figure 137--Precision data for chromium, total recoverable, at the Atlanta laboratory.

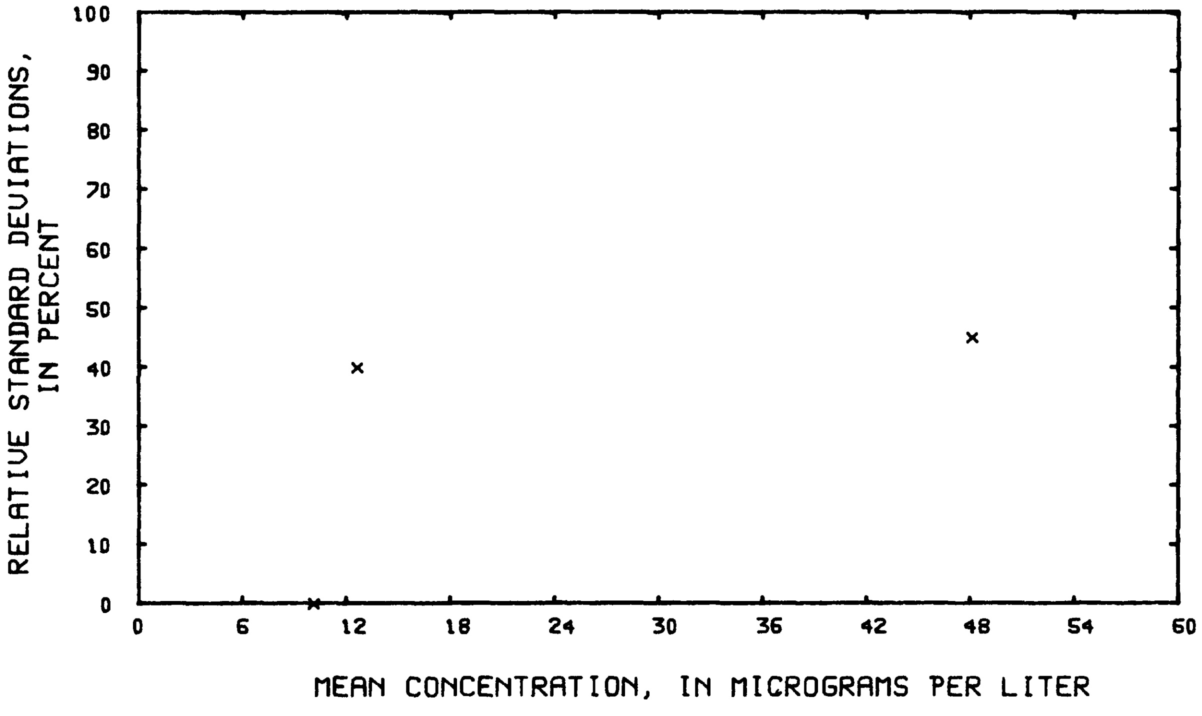

Figure 138--Precision data for chromium, total recoverable, at the Denver laboratory.

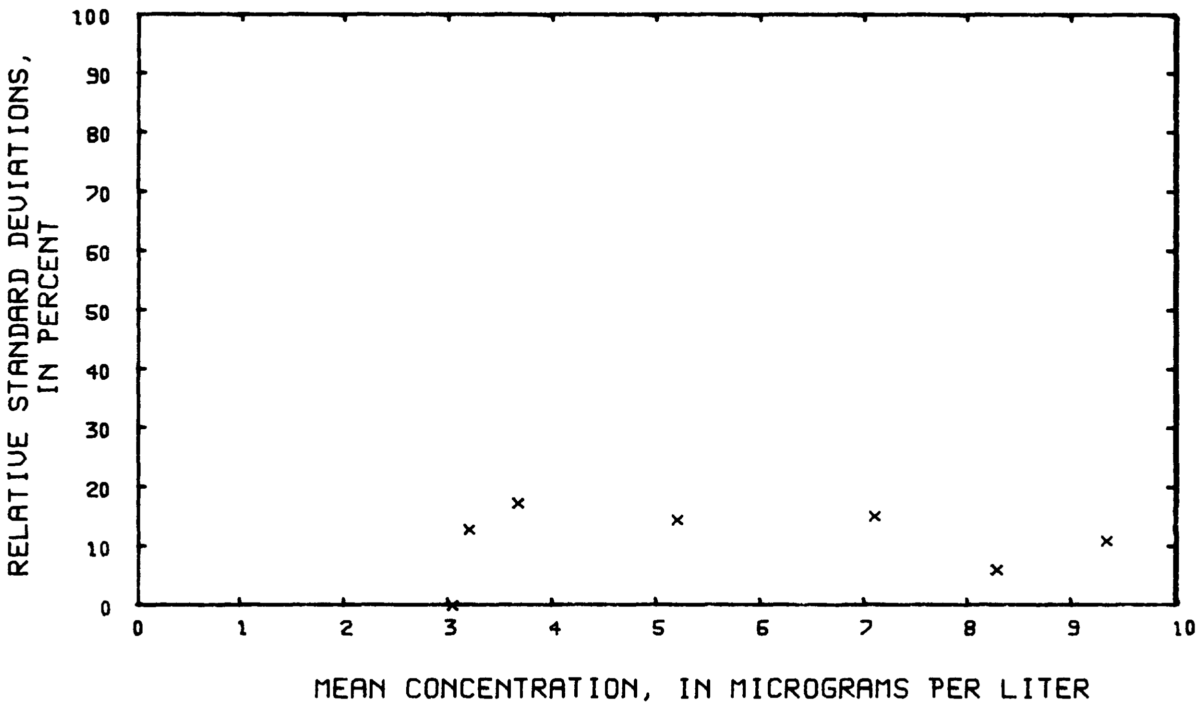

Figure 139--Precision data for cobalt, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

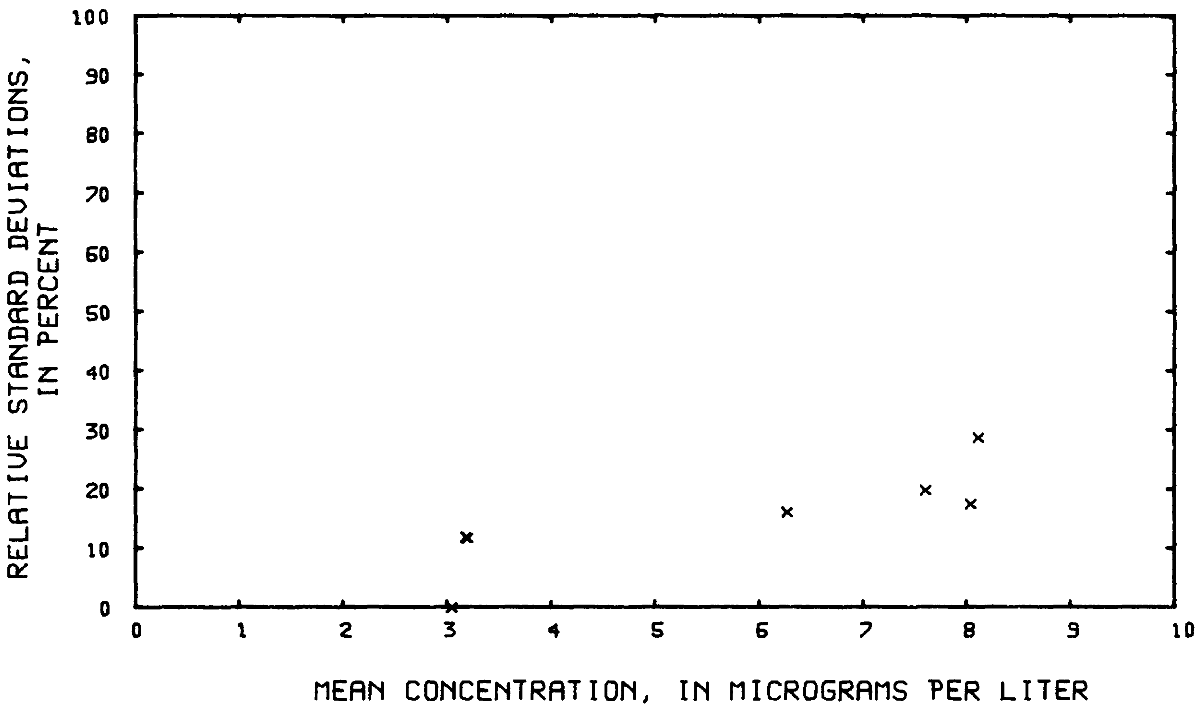

Figure 140--Precision data for cobalt, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

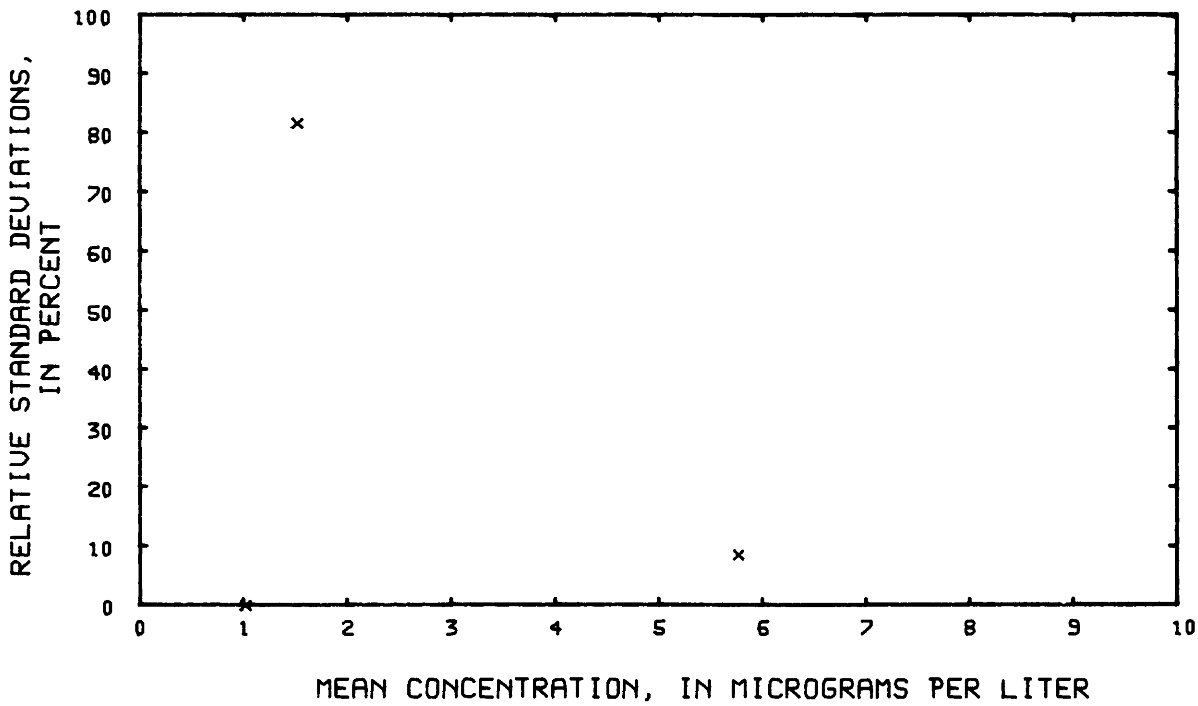

Figure 141--Precision data for cobalt, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

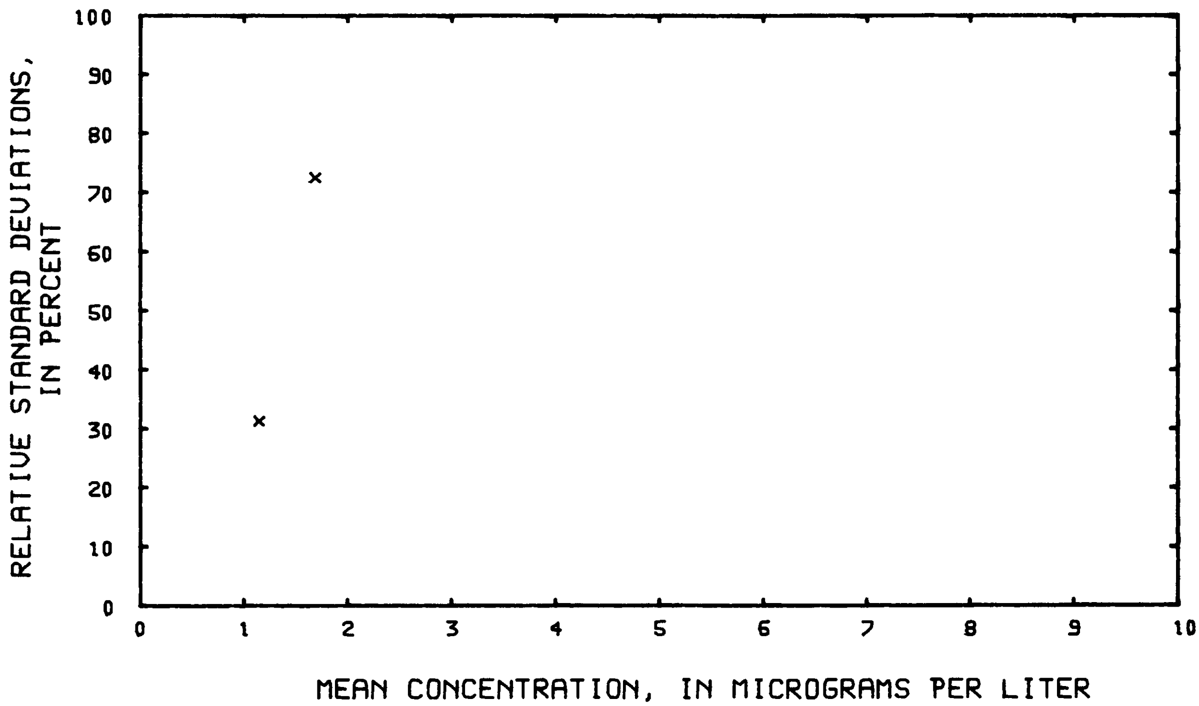

Figure 142--Precision data for cobalt, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

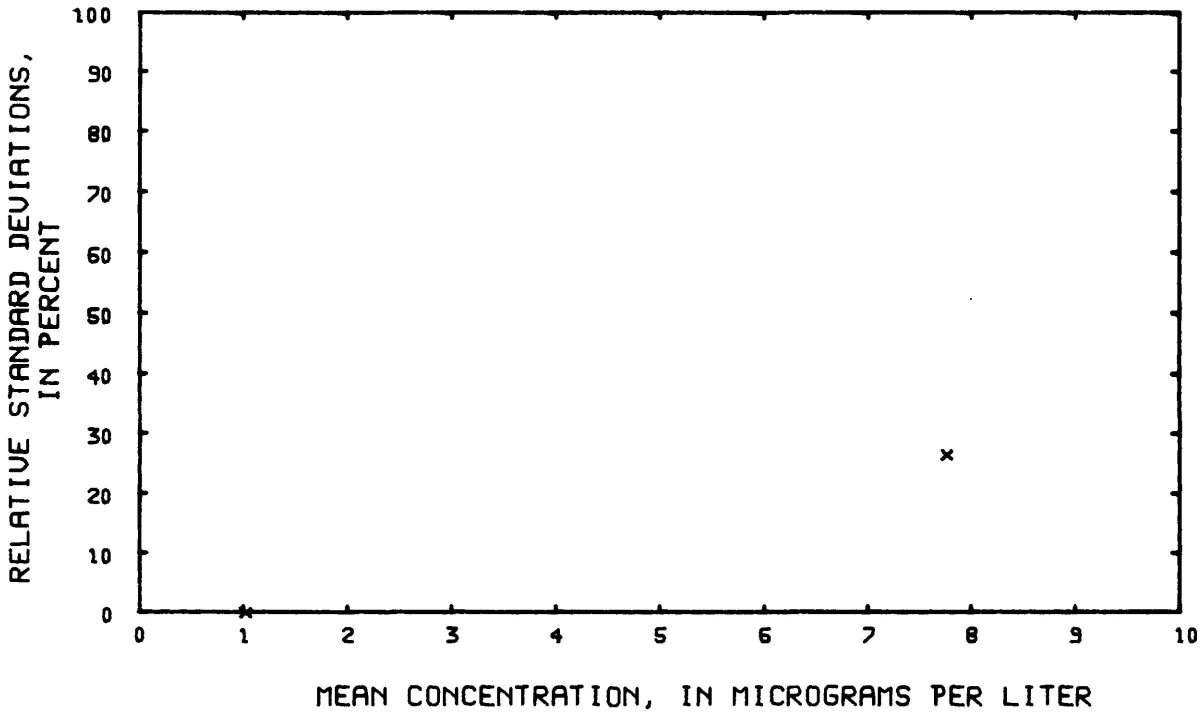

Figure 143--Precision data for cobalt, total recoverable, at the Atlanta laboratory.

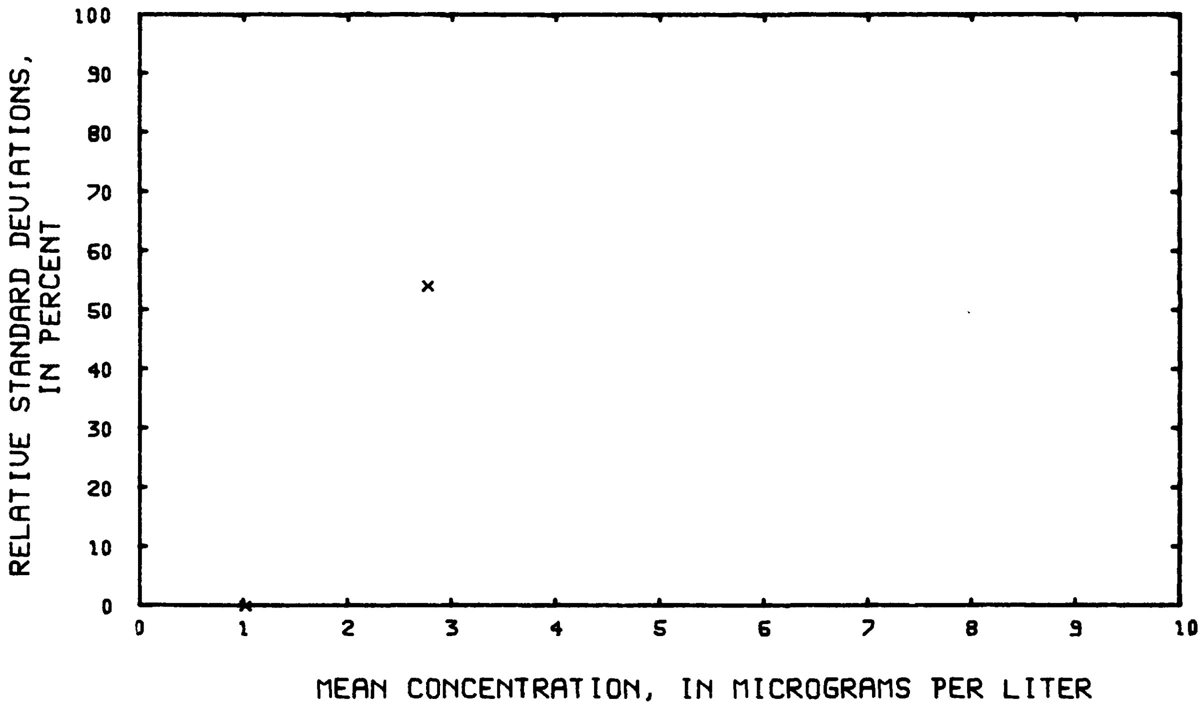

Figure 144--Precision data for cobalt, total recoverable, at the Denver laboratory.

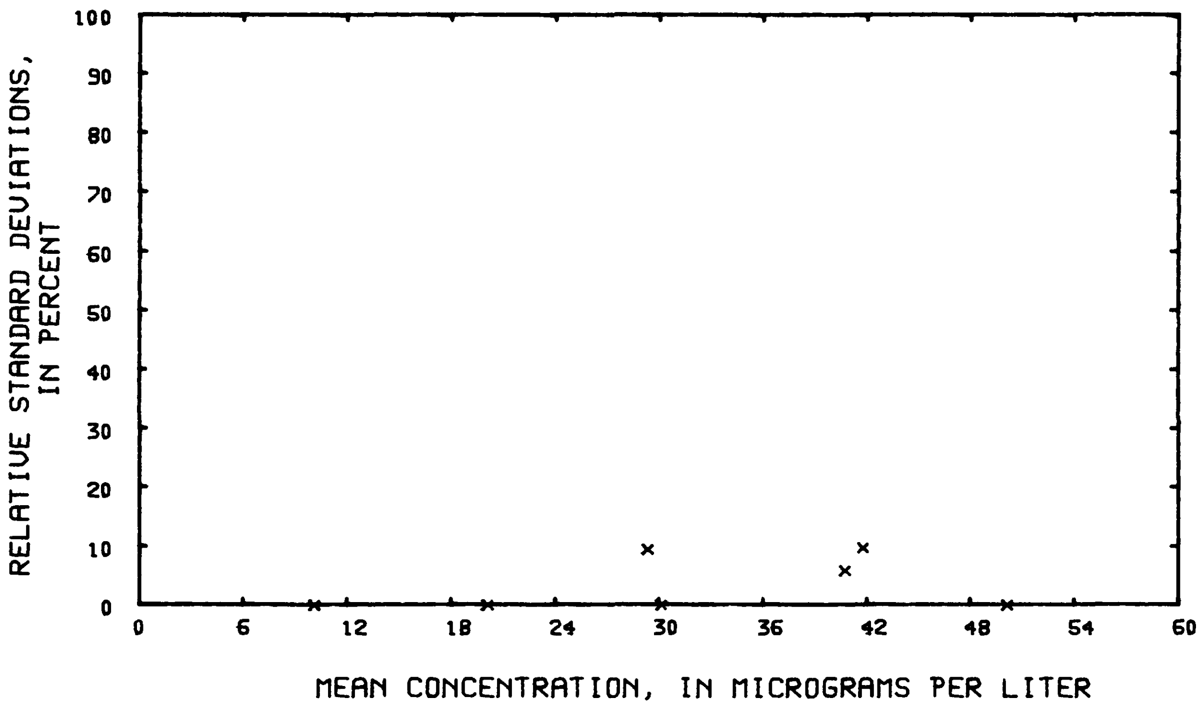

Figure 145--Precision data for copper, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

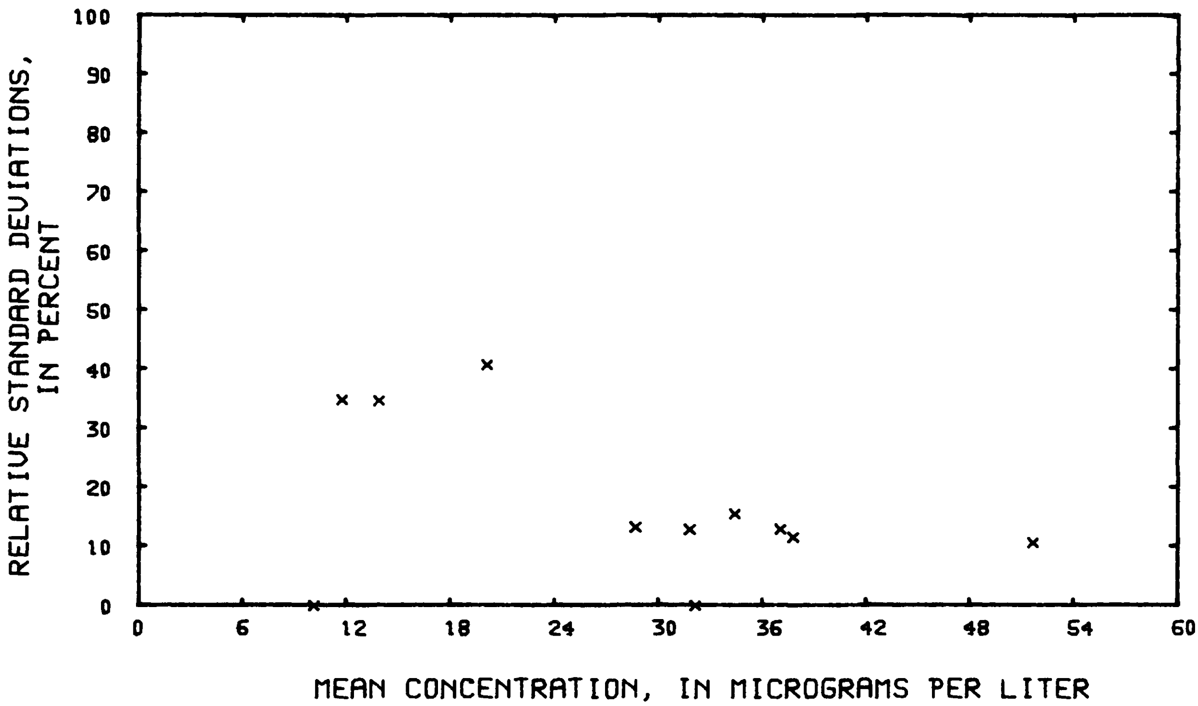

Figure 146--Precision data for copper, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

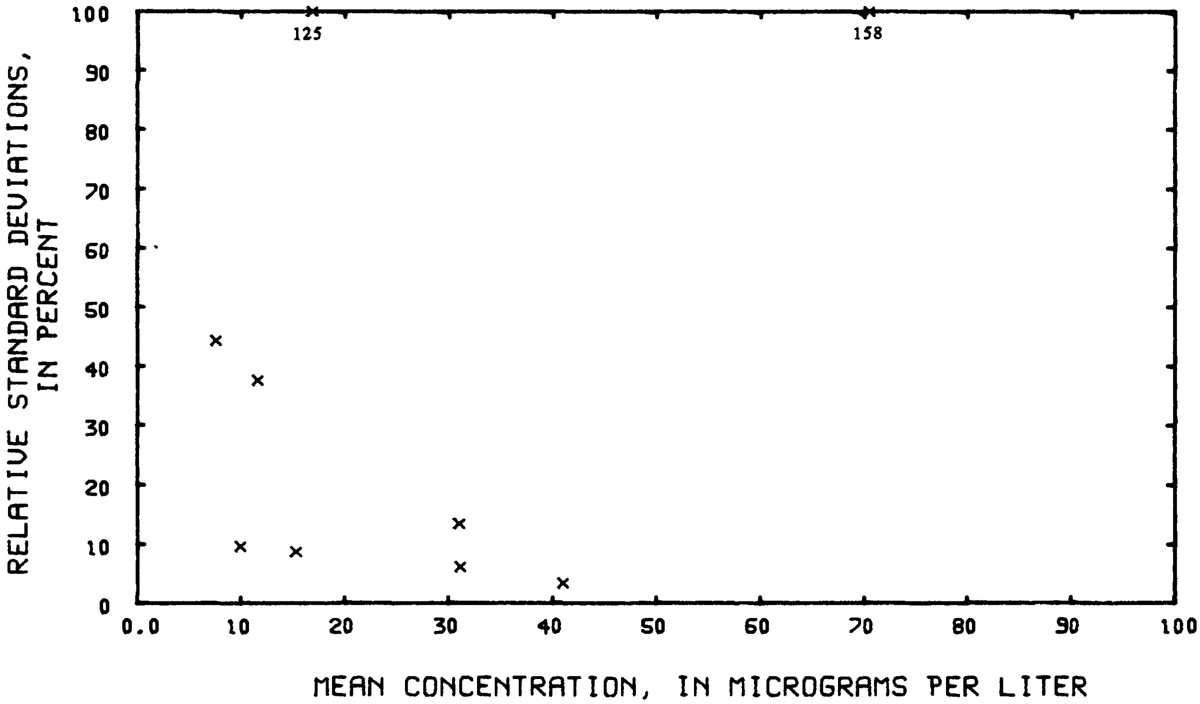

Figure 147--Precision data for copper, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

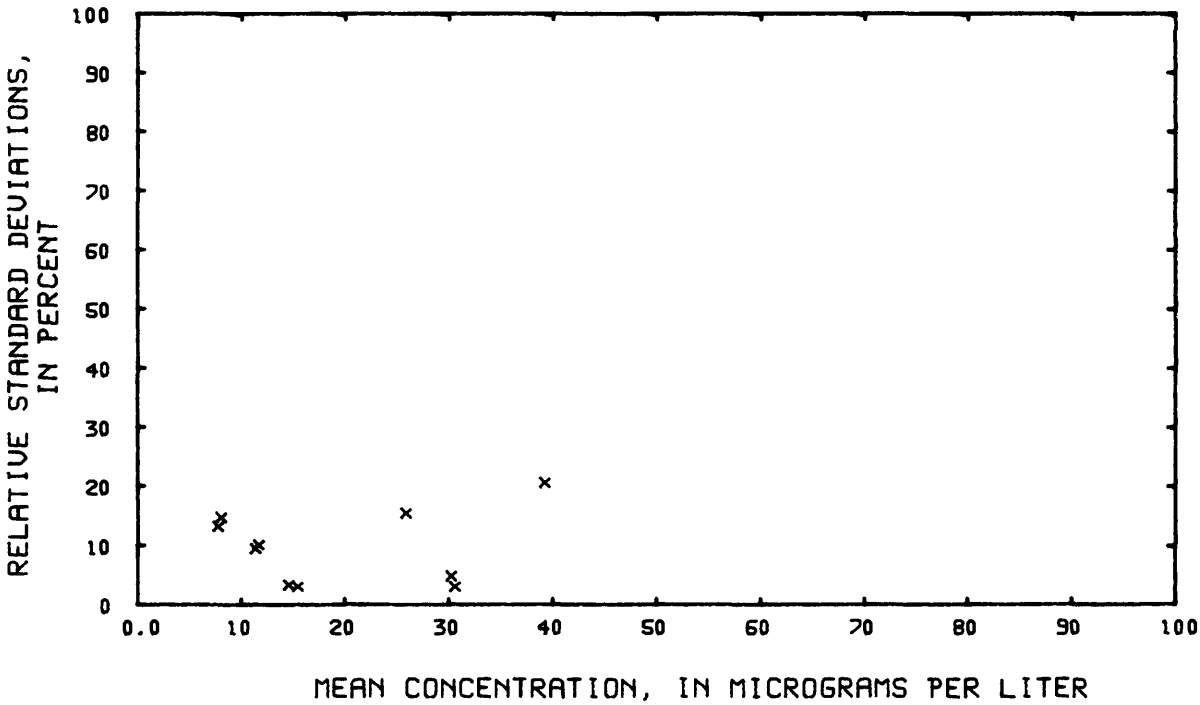

Figure 148--Precision data for copper, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

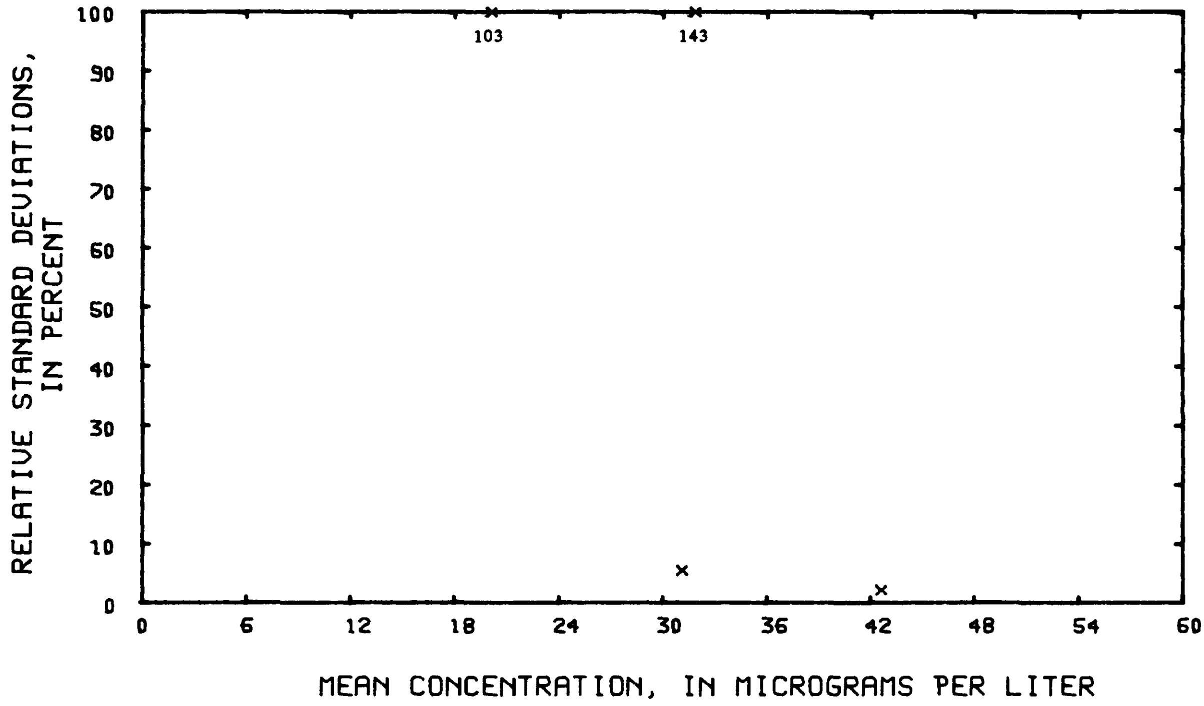

Figure 149--Precision data for copper, total recoverable, at the Atlanta laboratory.

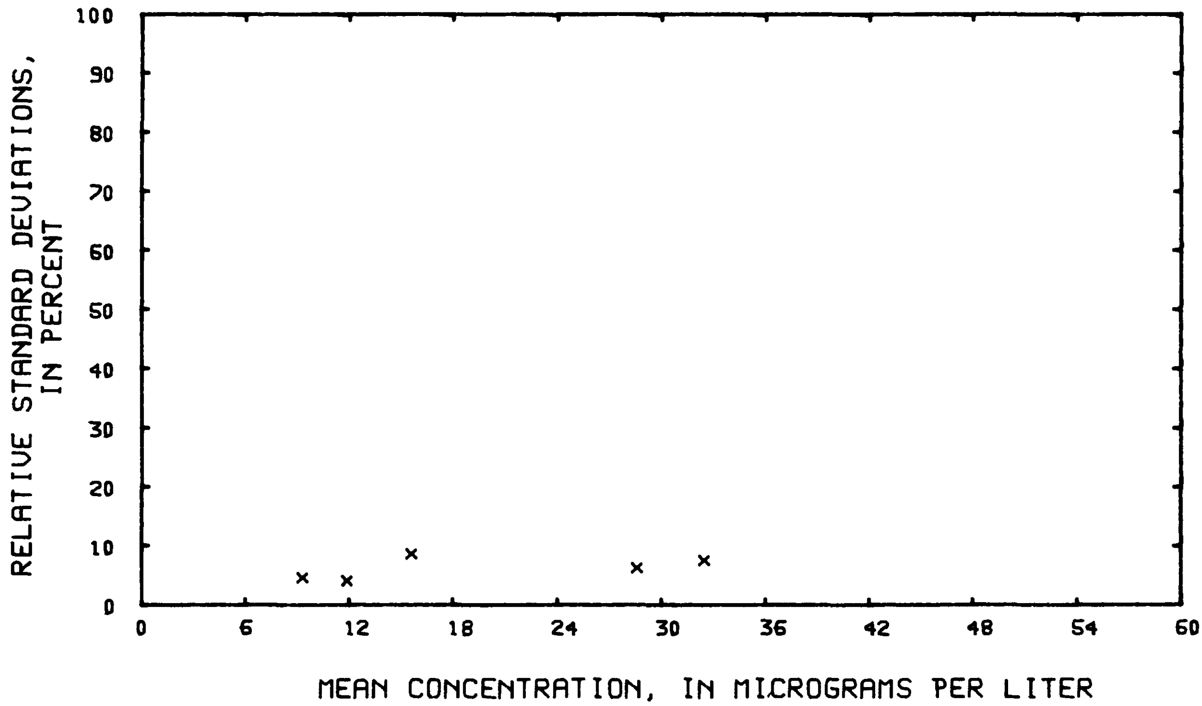

Figure 150--Precision data for copper, total recoverable, at the Denver laboratory.

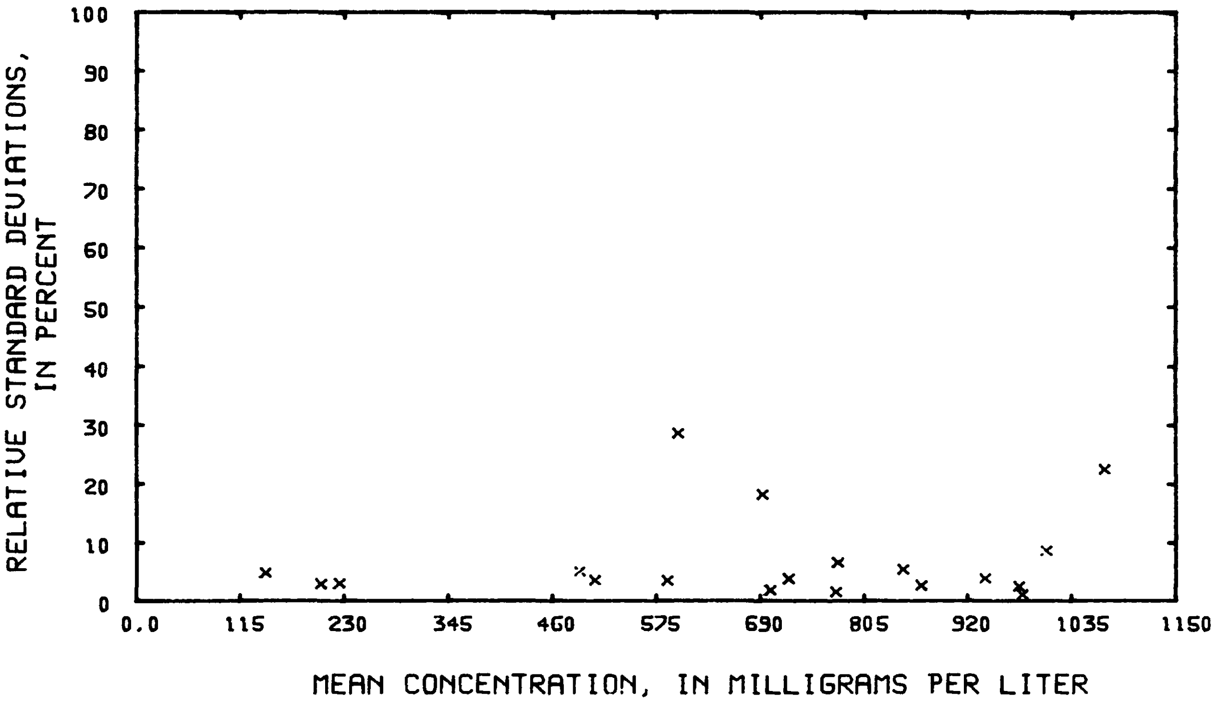

Figure 151--Precision data for dissolved solids at the Atlanta laboratory.

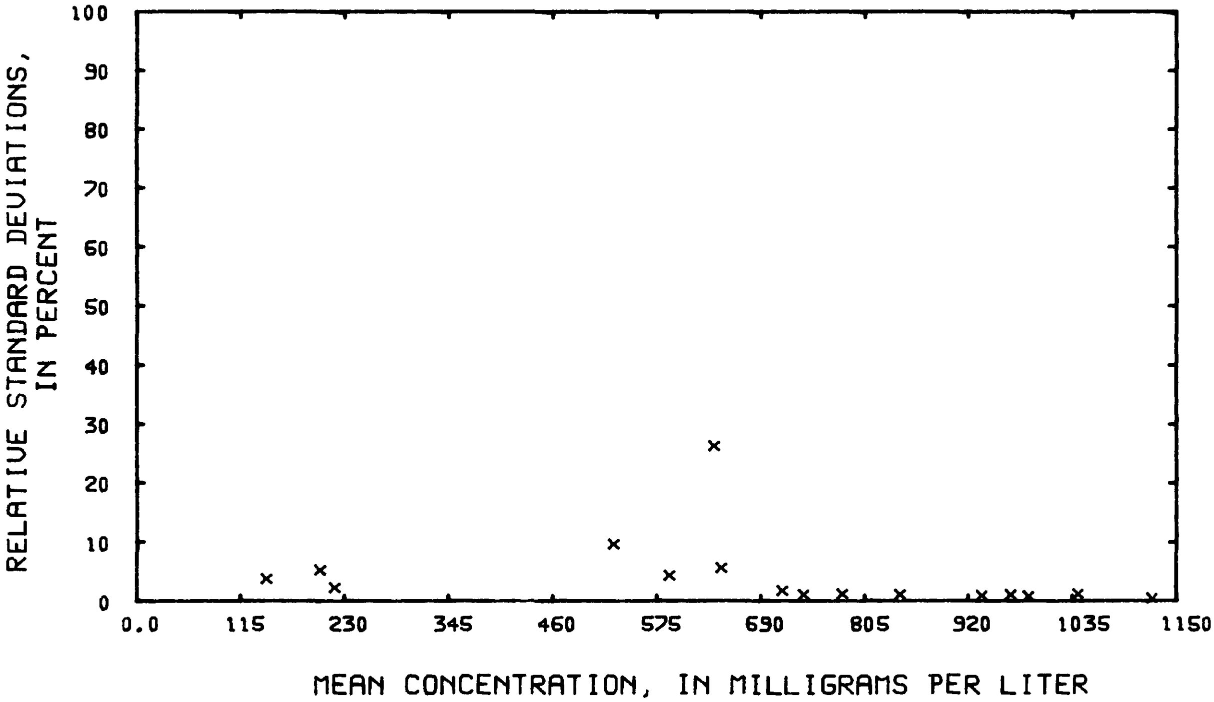

Figure 152--Precision data for dissolved solids at the Denver laboratory.

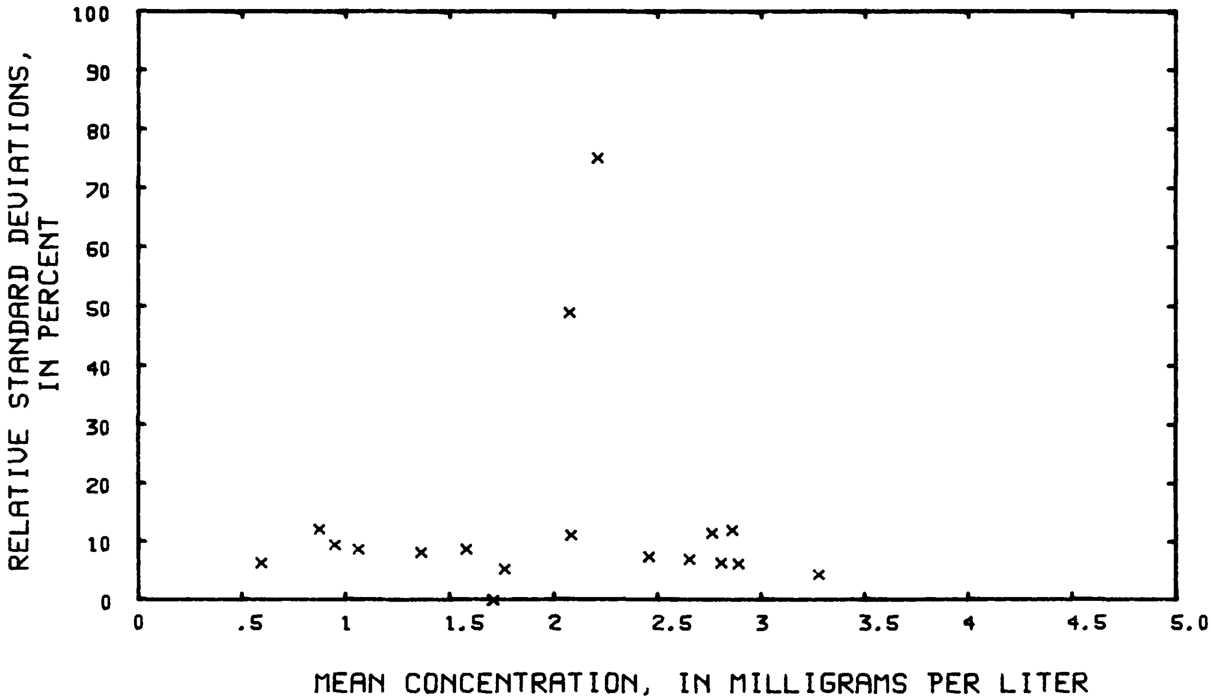

Figure 153--Precision data for flouride, dissolved, at the Atlanta laboratory.

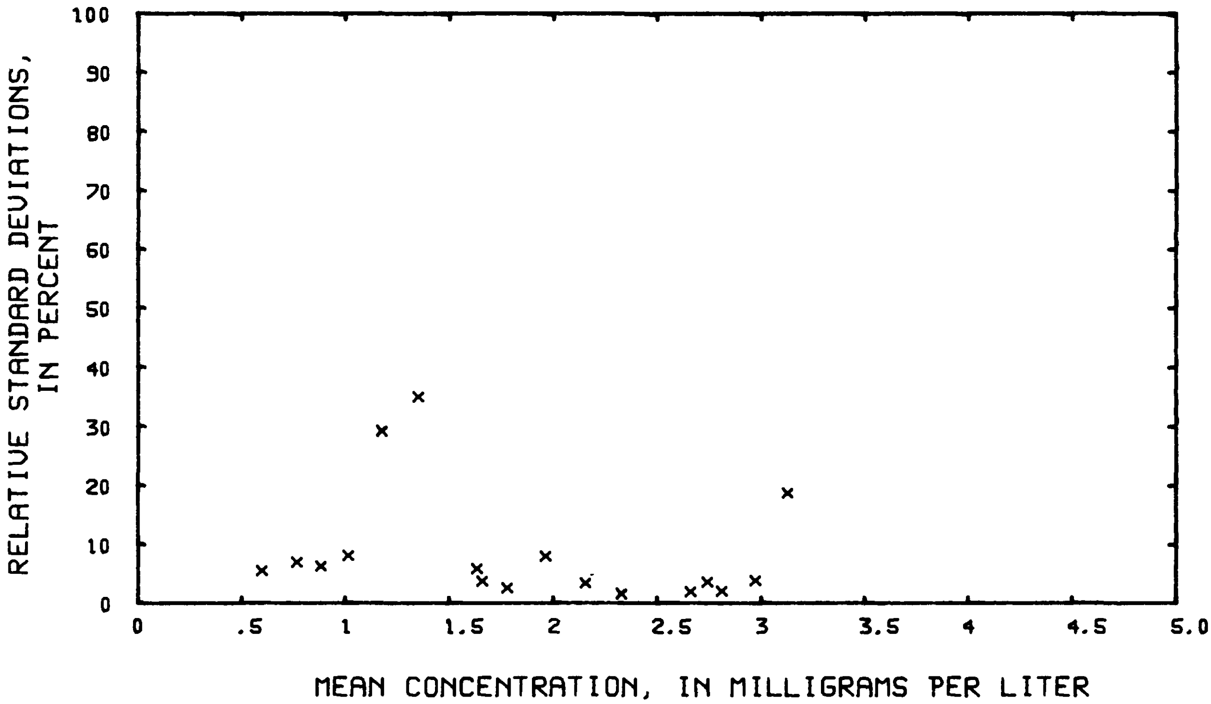

Figure 154--Precision data for flouride, dissolved, at the Denver laboratory.

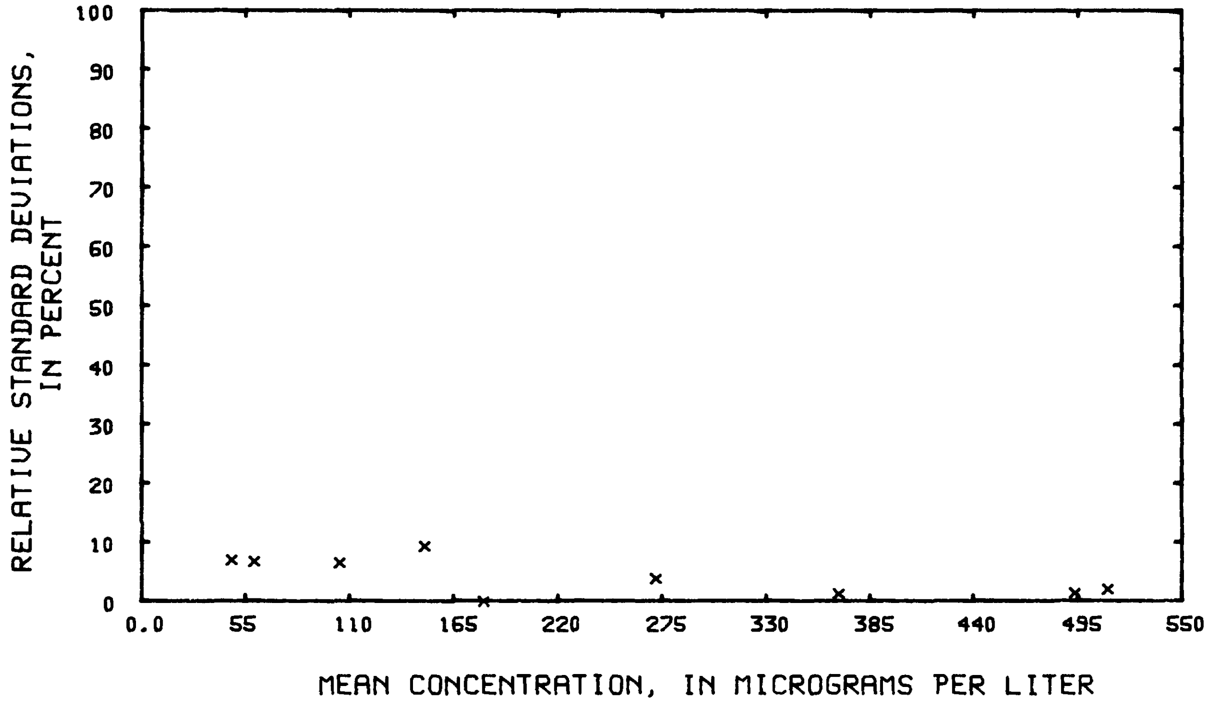

Figure 155--Precision data for iron, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

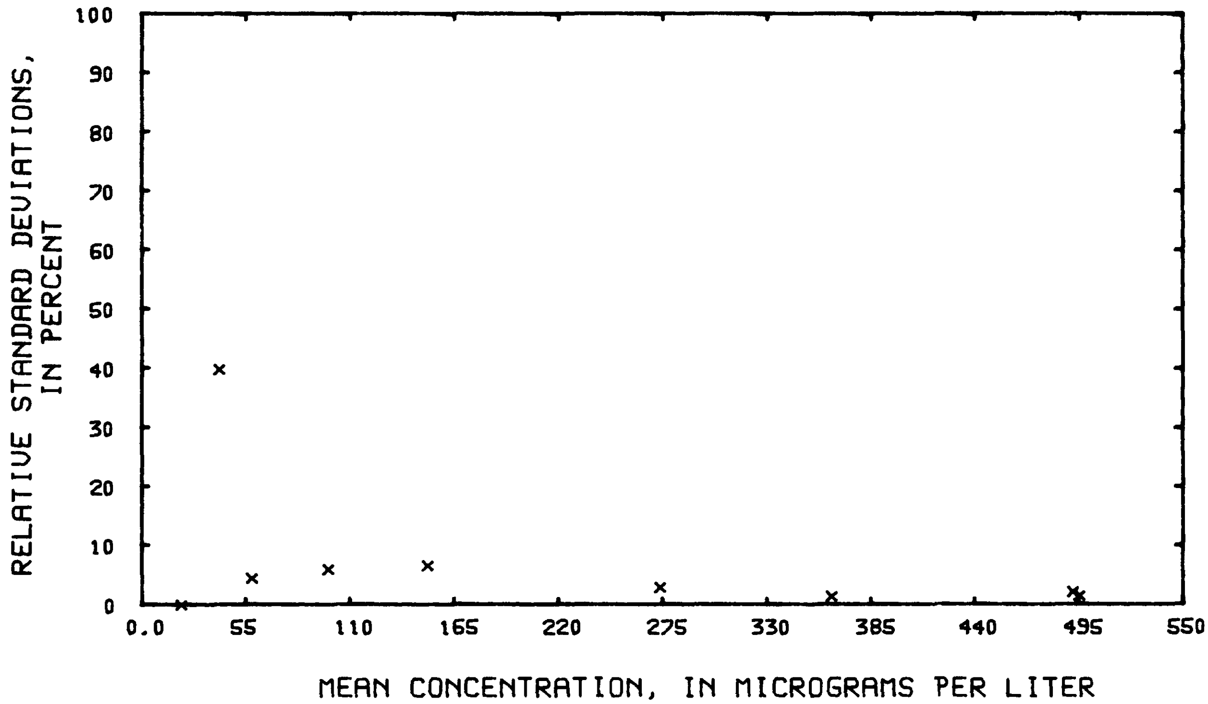

Figure 156--Precision data for iron, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

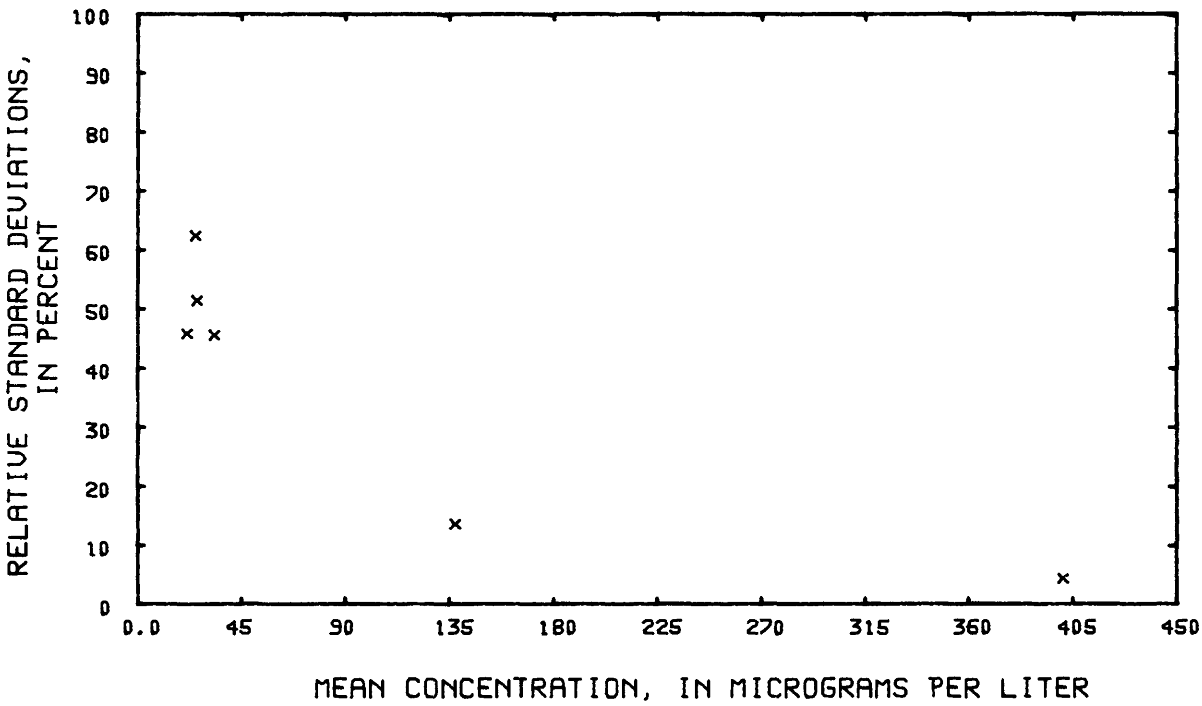

Figure 157--Precision data for iron, dissolved,
(atomic absorption spectrometry)
at the Atlanta laboratory.

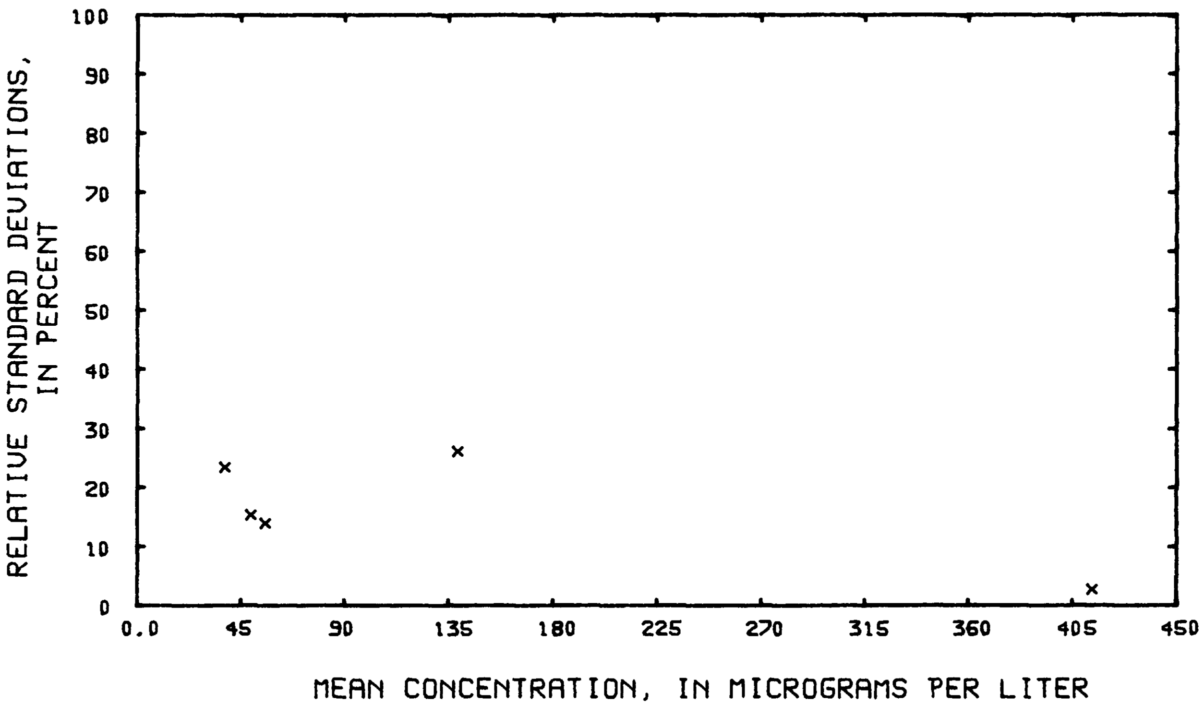

Figure 158--Precision data for iron, dissolved,
(atomic absorption spectrometry)
at the Denver laboratory.

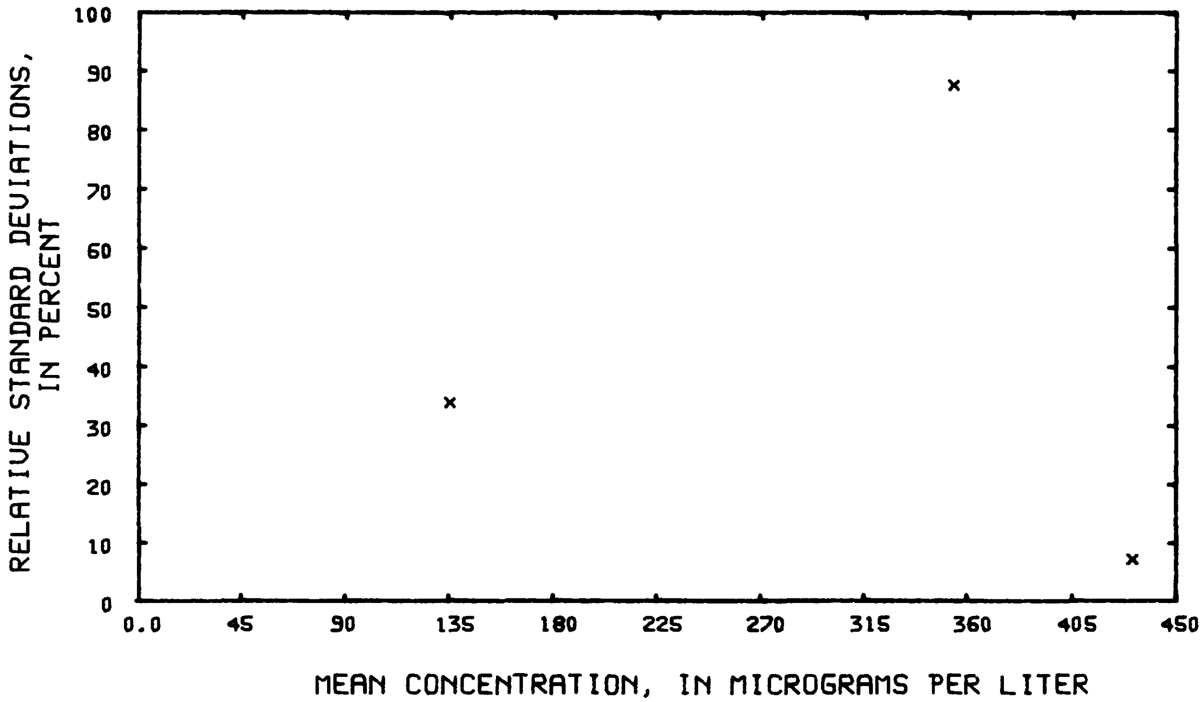

Figure 159--Precision data for iron, total recoverable, at the Atlanta laboratory.

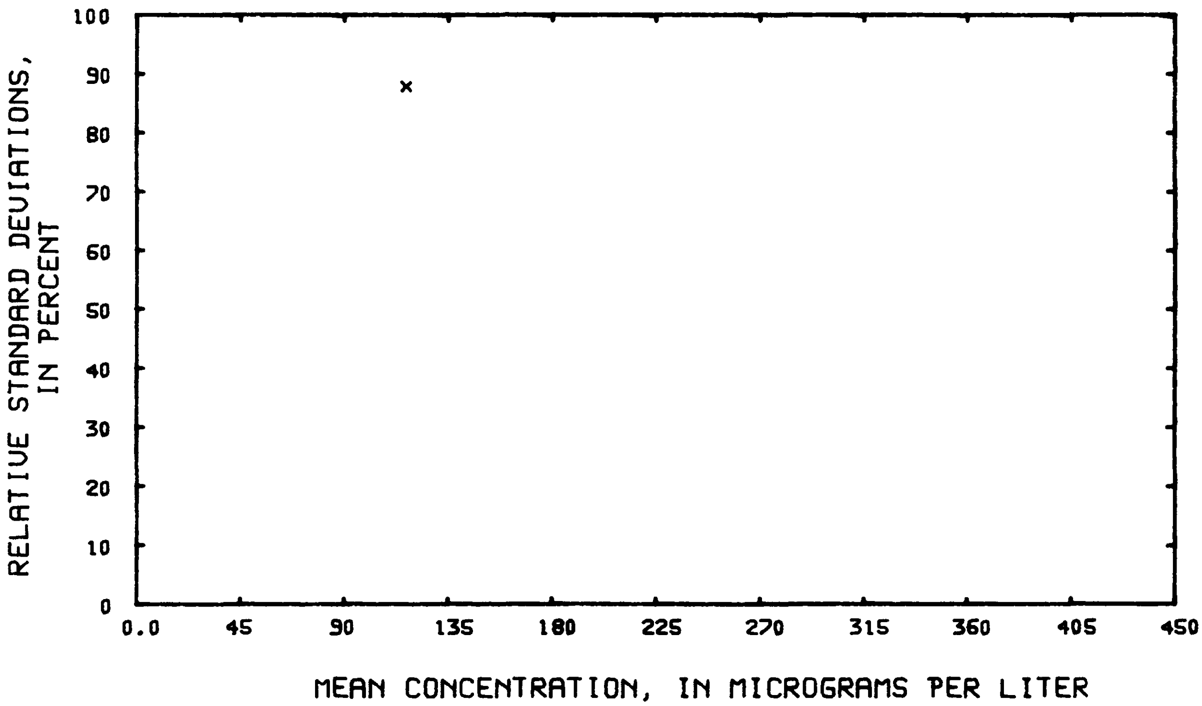

Figure 160--Precision data for iron, total recoverable, at the Denver laboratory.

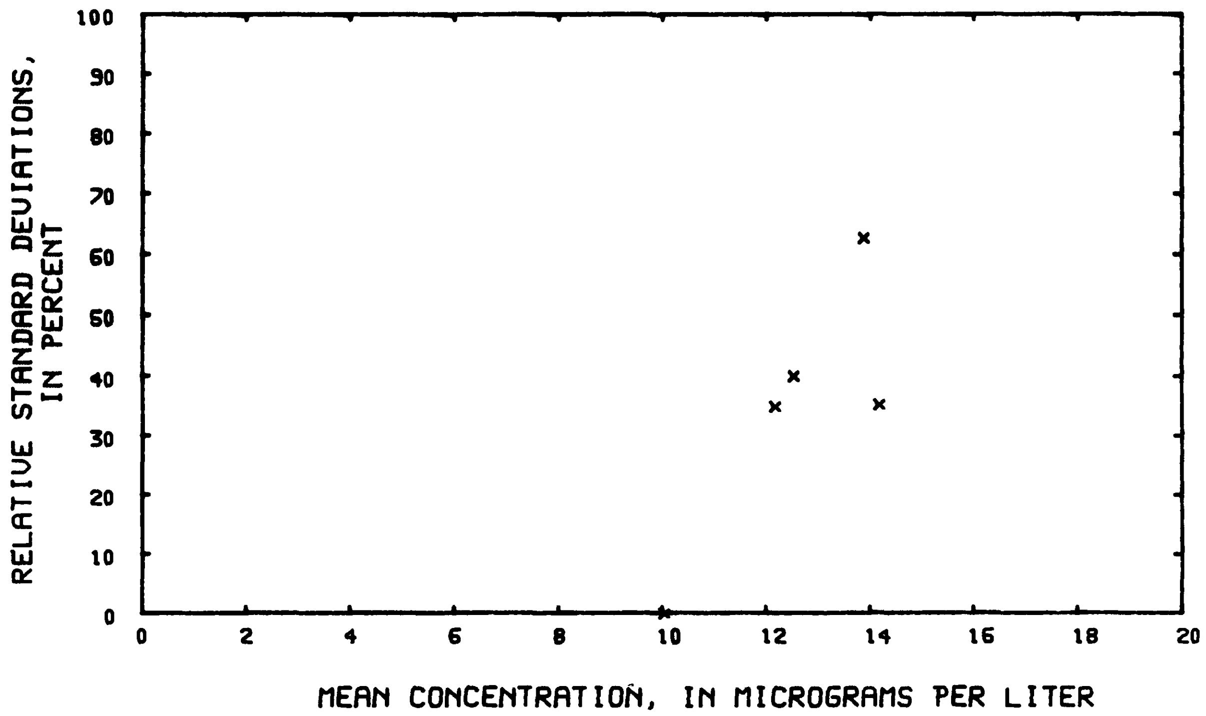

Figure 161--Precision data for lead, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

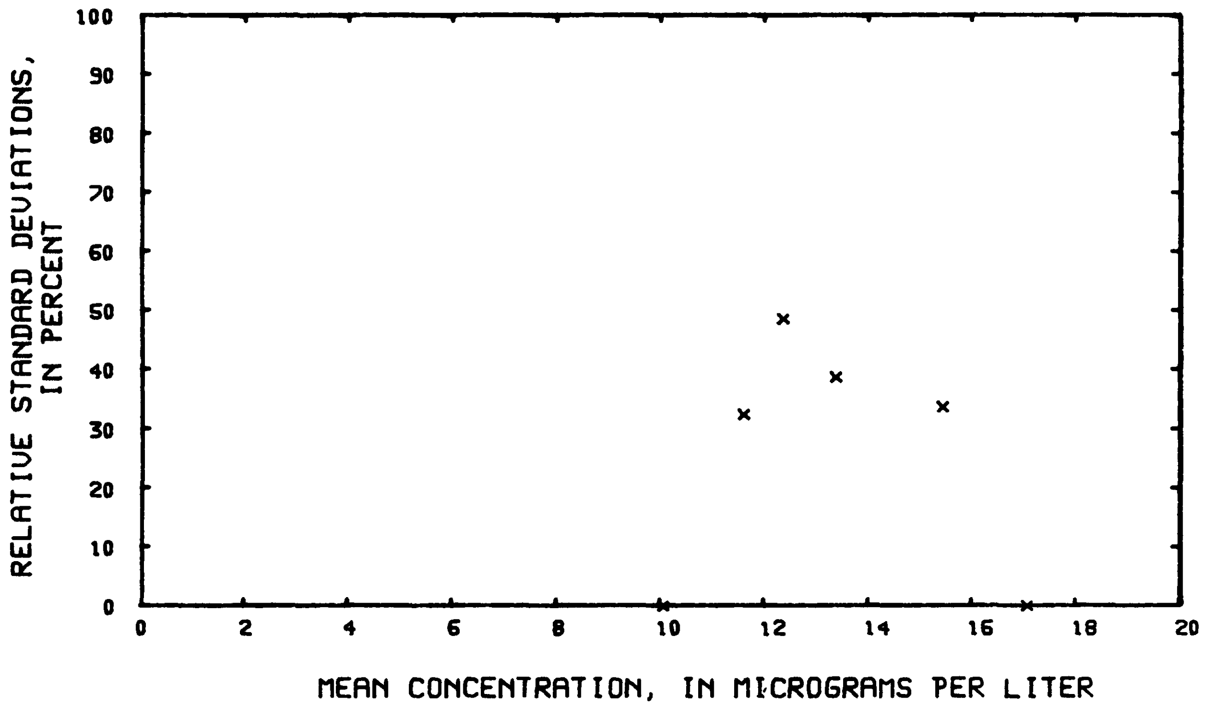

Figure 162--Precision data for lead, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

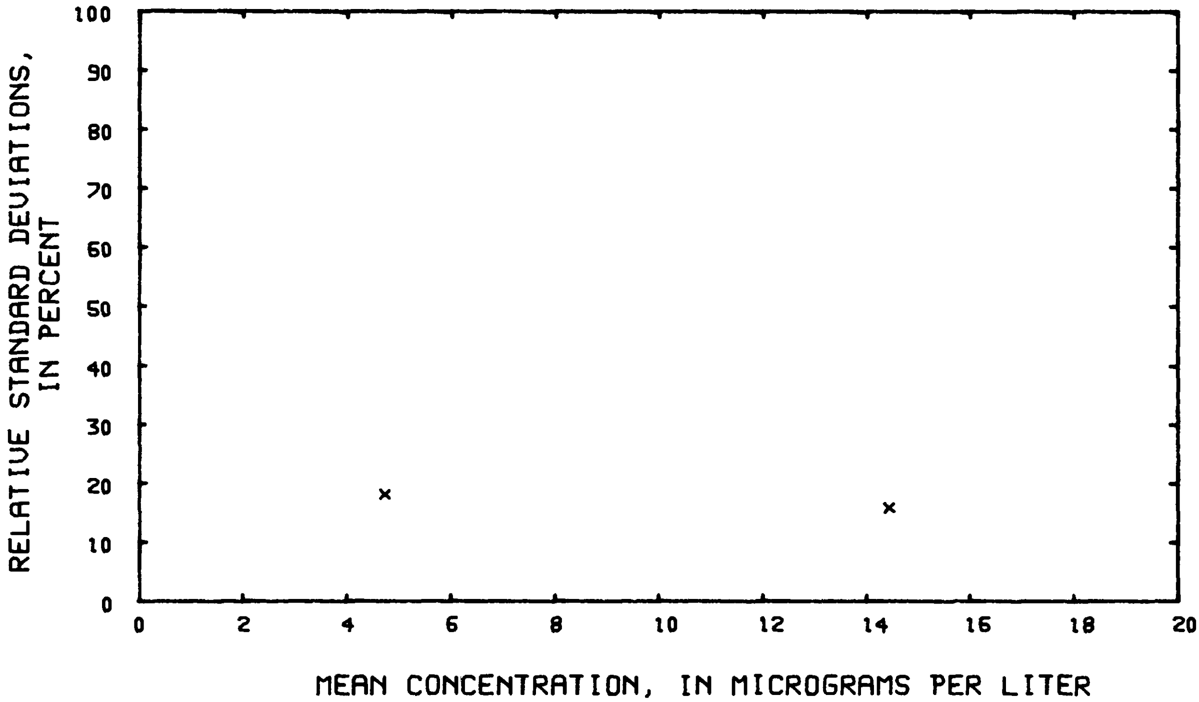

Figure 163--Precision data for lead, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

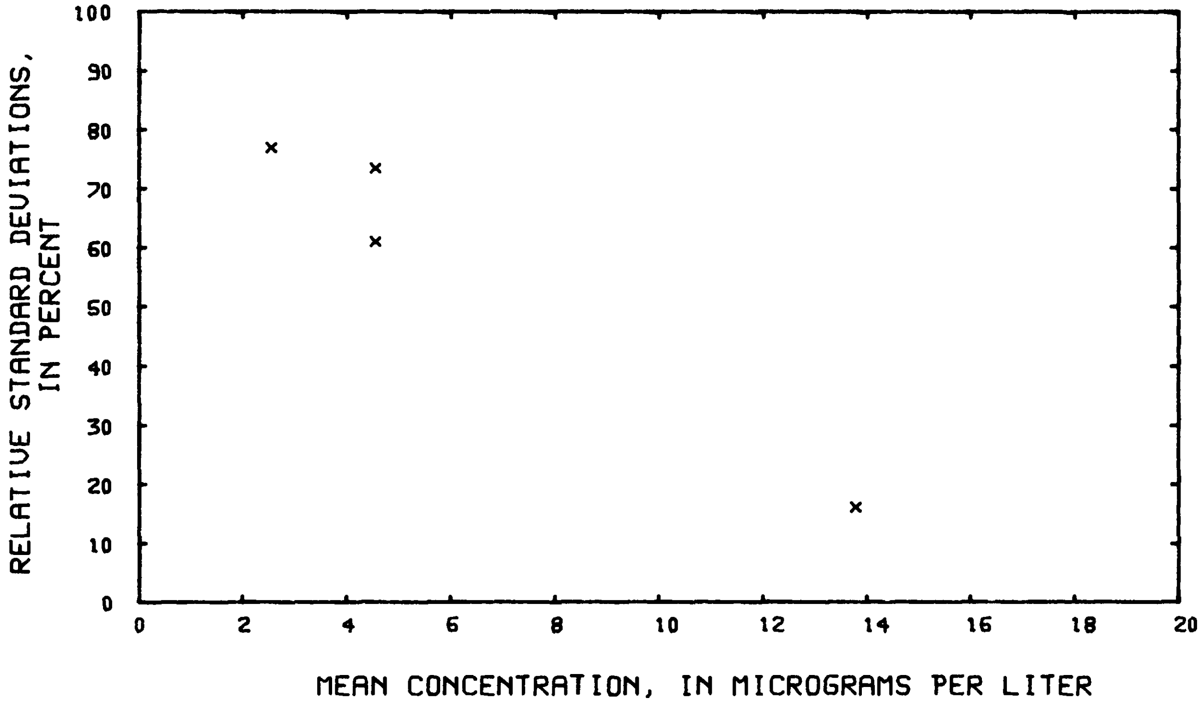

Figure 164--Precision data for lead, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

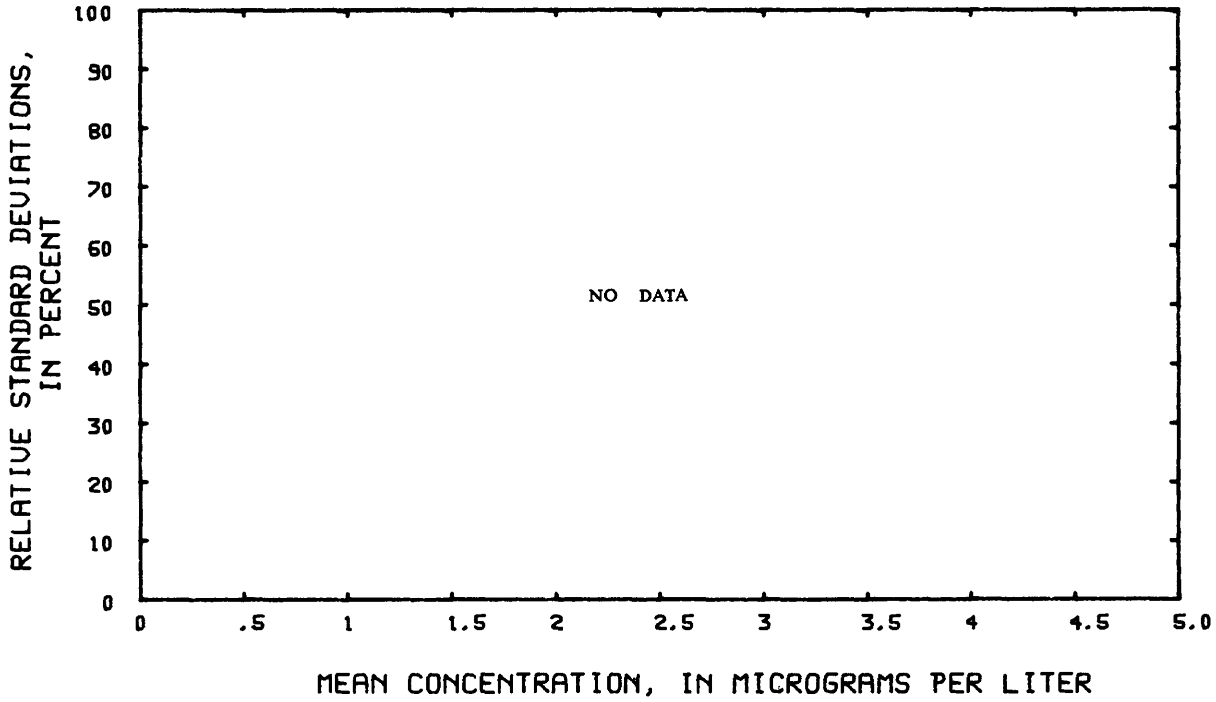

Figure 165--Precision data for lead, total recoverable, at the Atlanta laboratory.

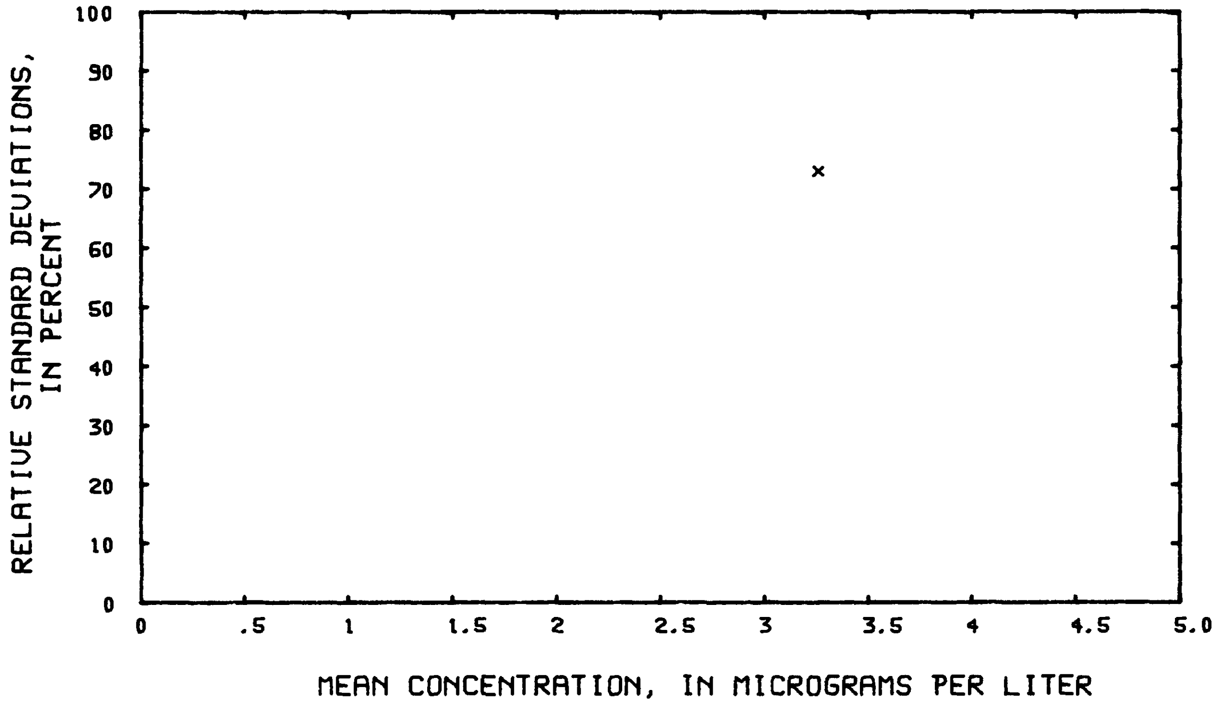

Figure 166--Precision data for lead, total recoverable, at the Denver laboratory.

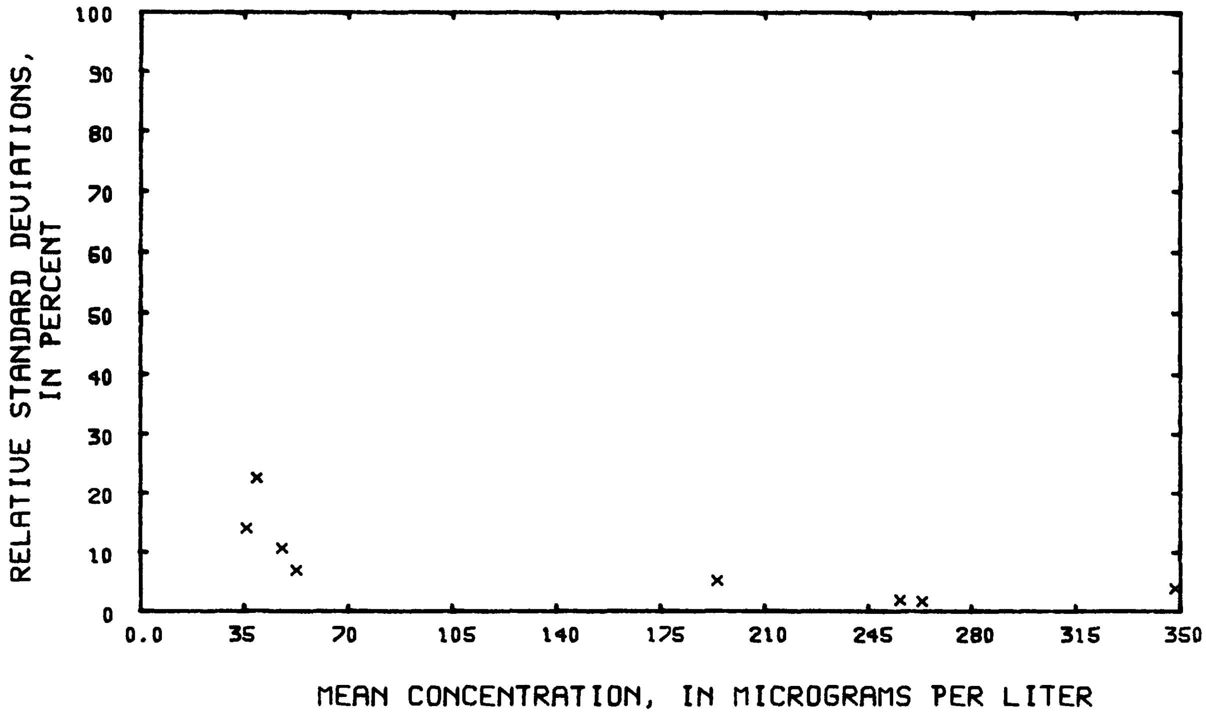

Figure 167--Precision data for lithium, dissolved, at the Atlanta laboratory.

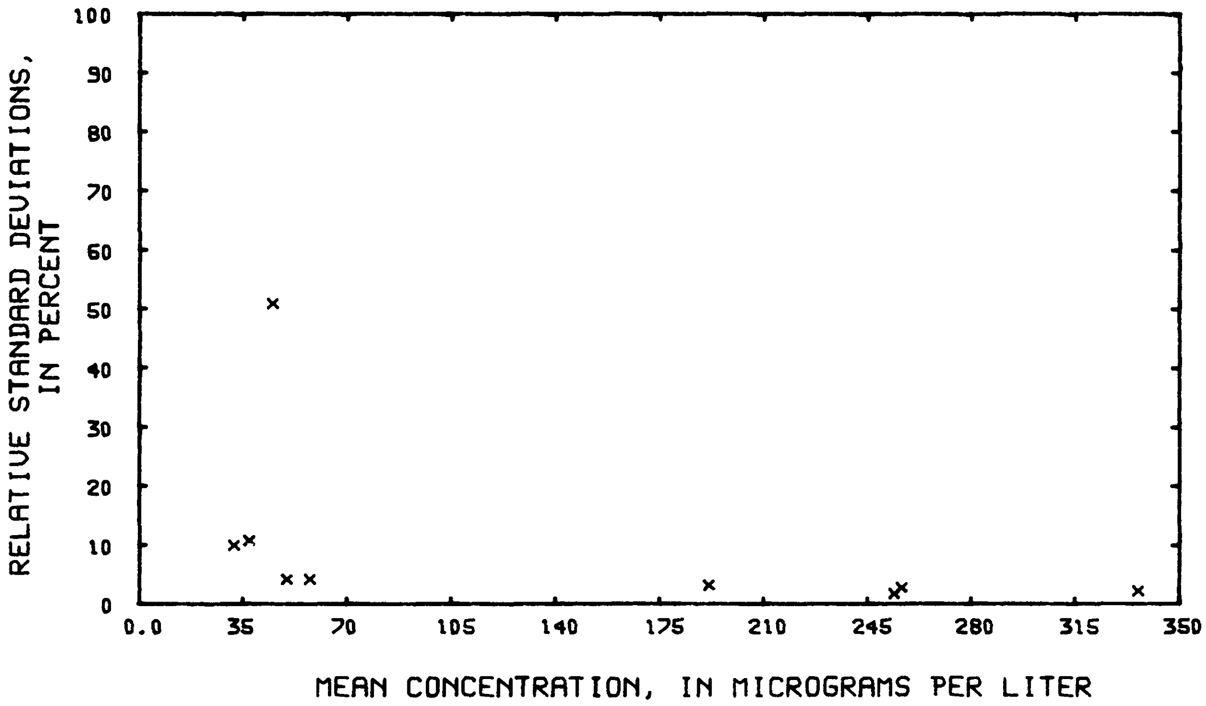

Figure 168--Precision data for lithium, dissolved, at the Denver laboratory.

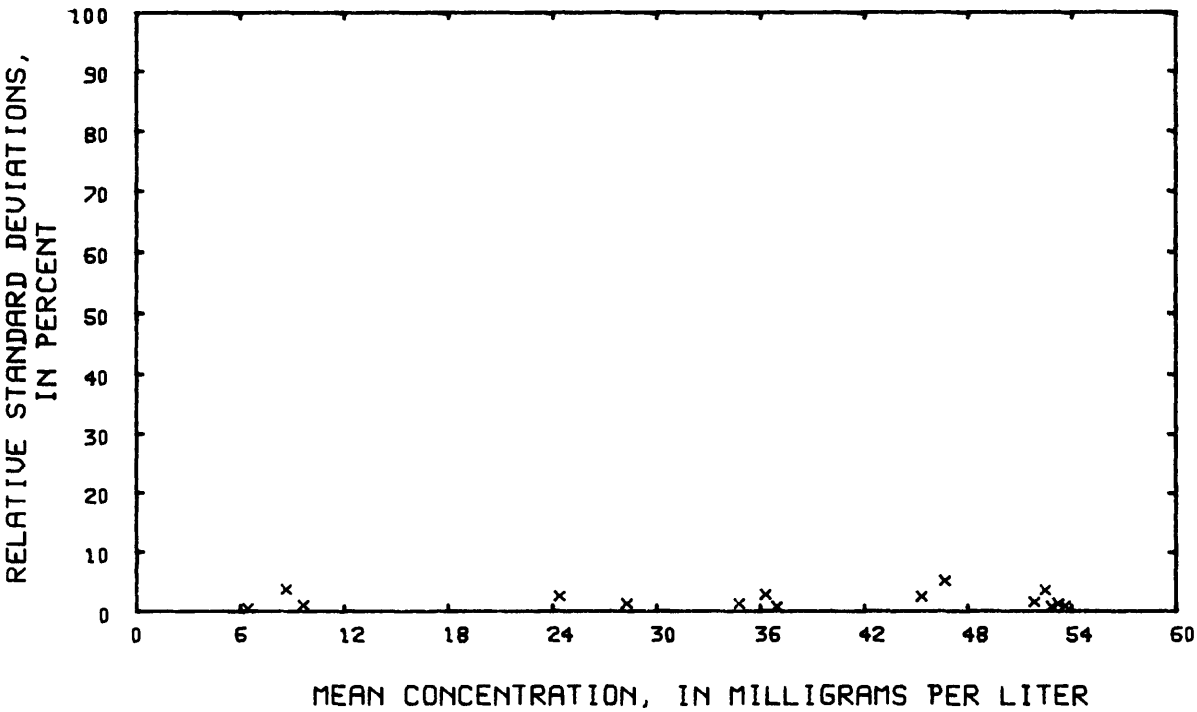

Figure 169--Precision data for magnesium, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

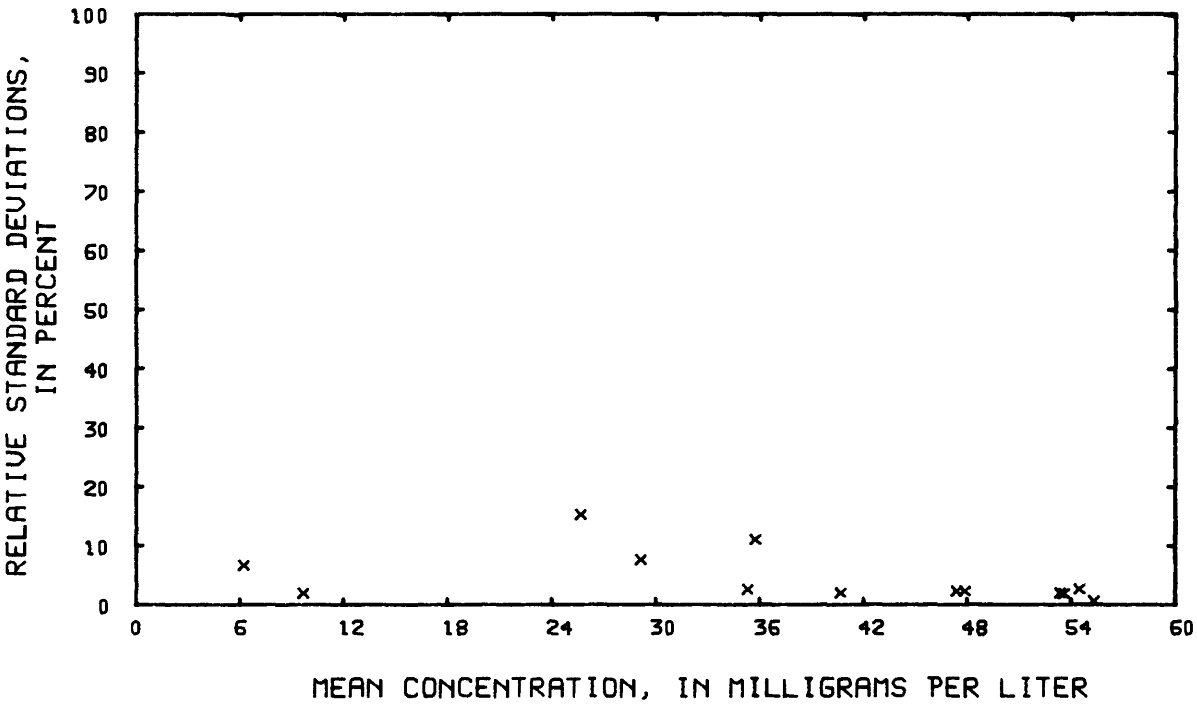

Figure 170--Precision data for magnesium, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

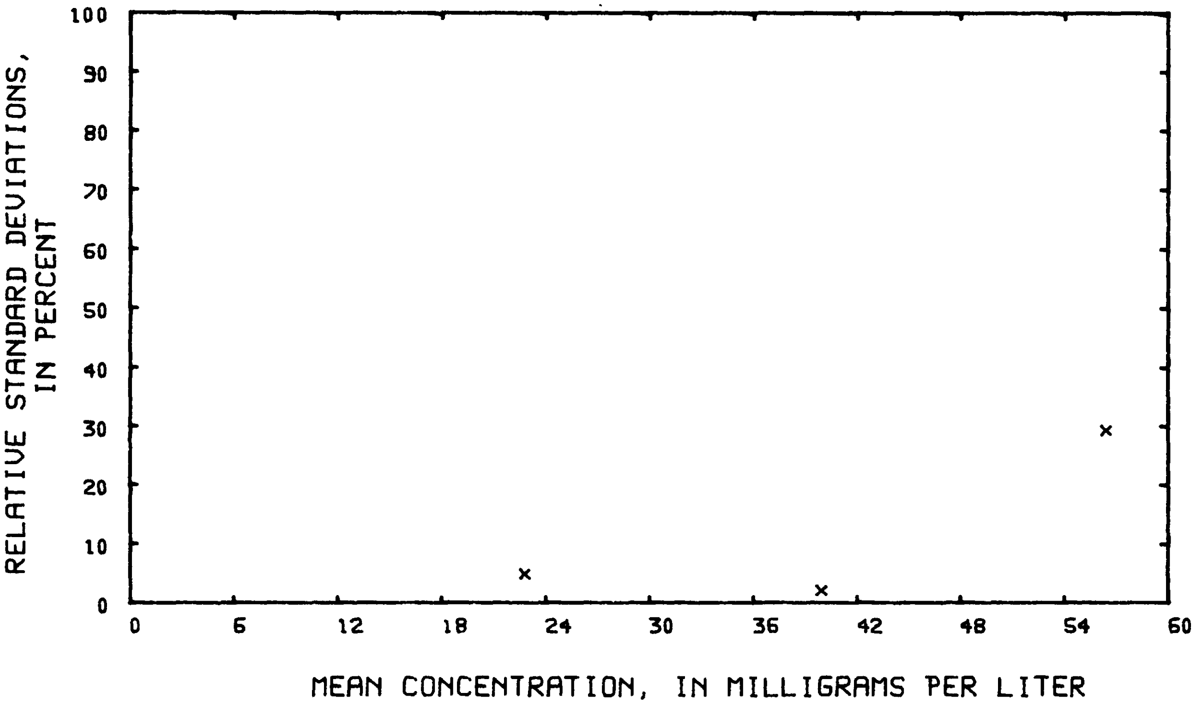

Figure 171--Precision data for magnesium, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

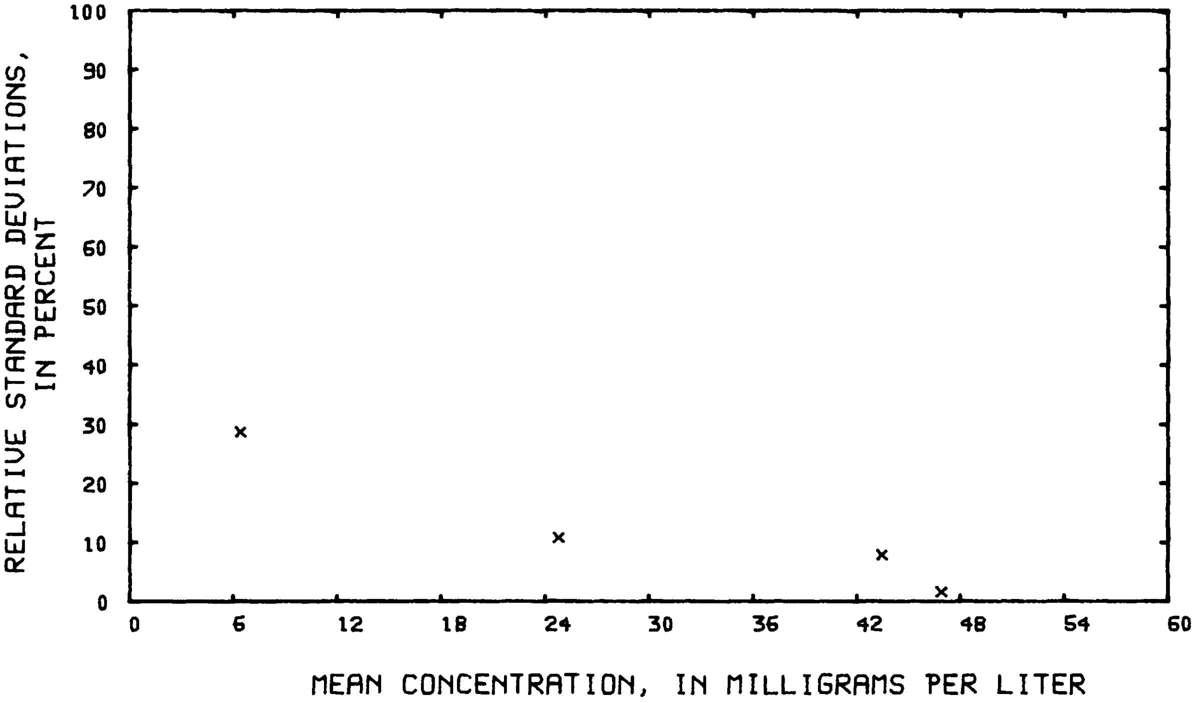

Figure 172--Precision data for magnesium, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

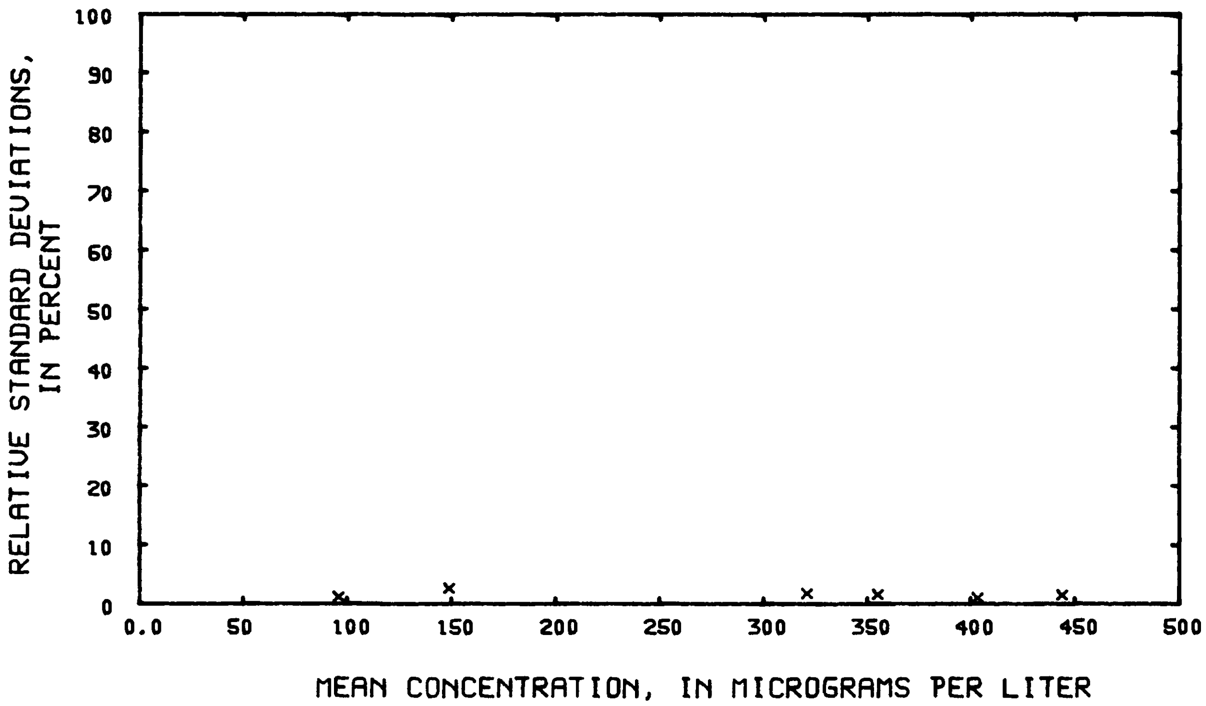

Figure 173--Precision data for manganese, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

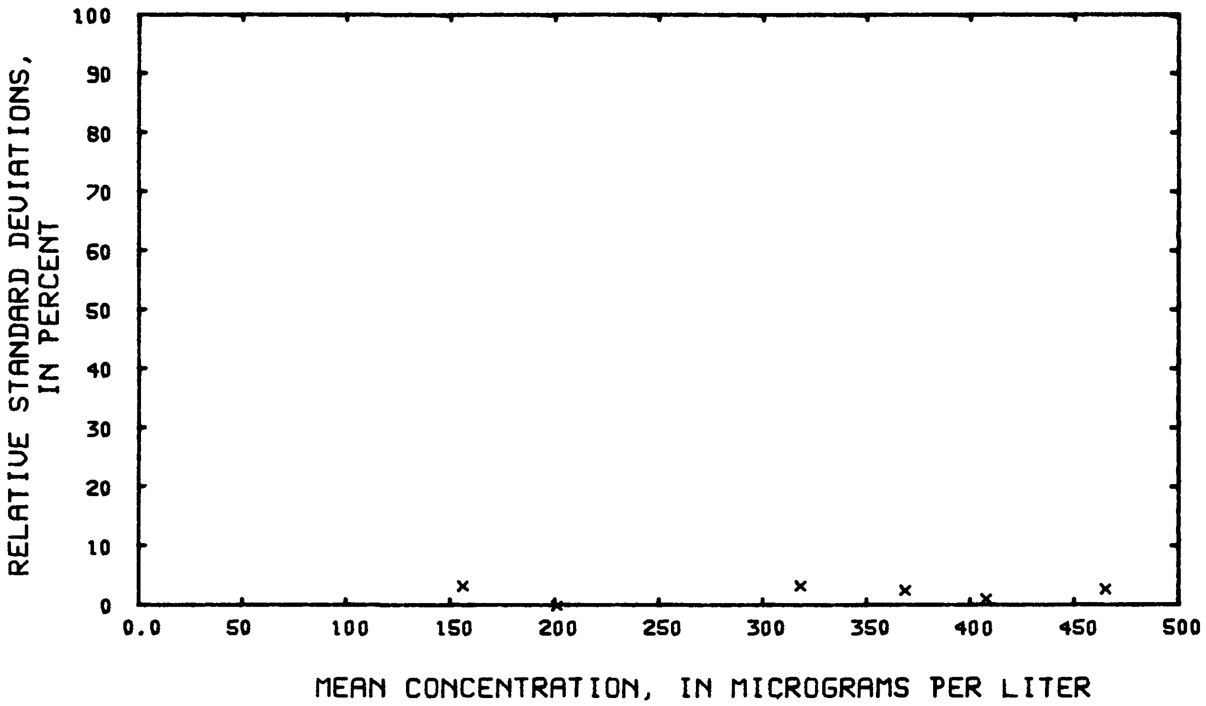

Figure 174--Precision data for manganese, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

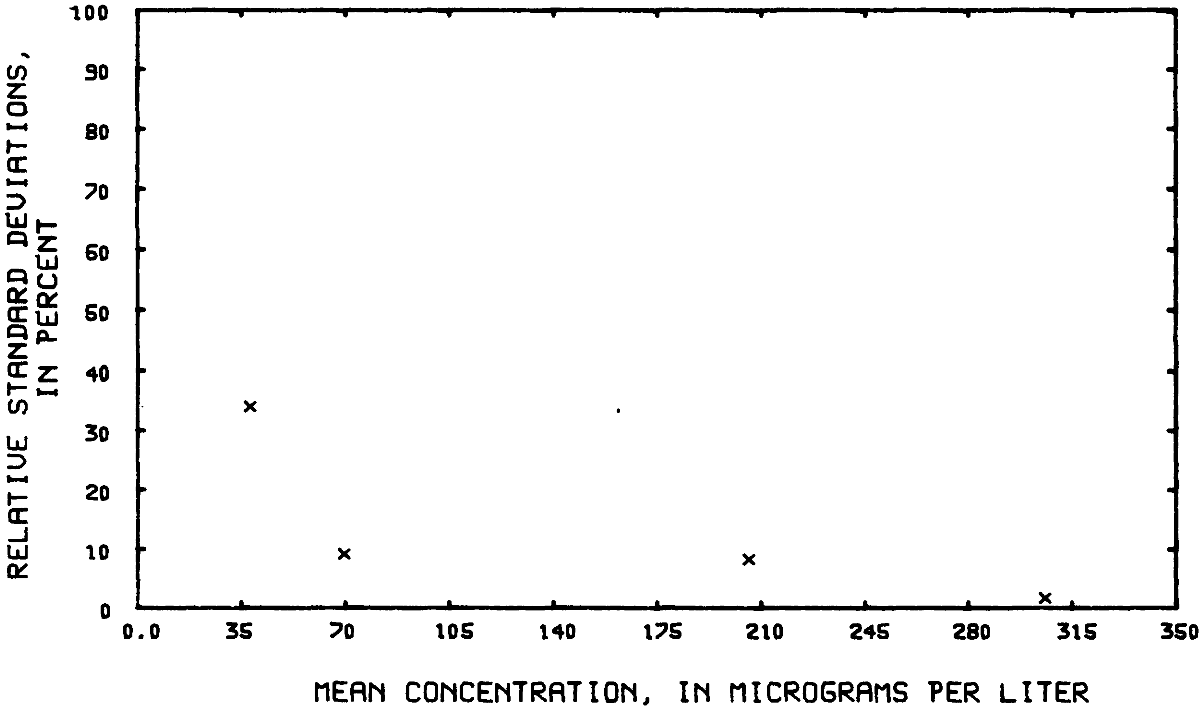

Figure 175--Precision data for manganese, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

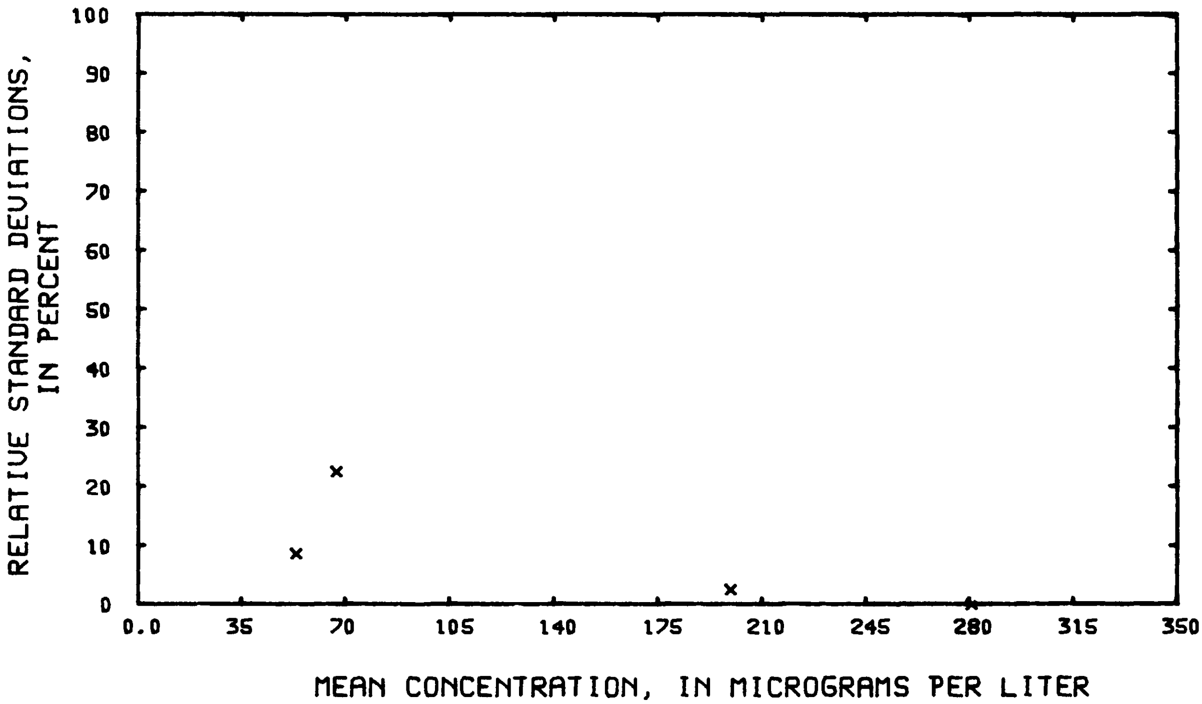

Figure 176--Precision data for manganese, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

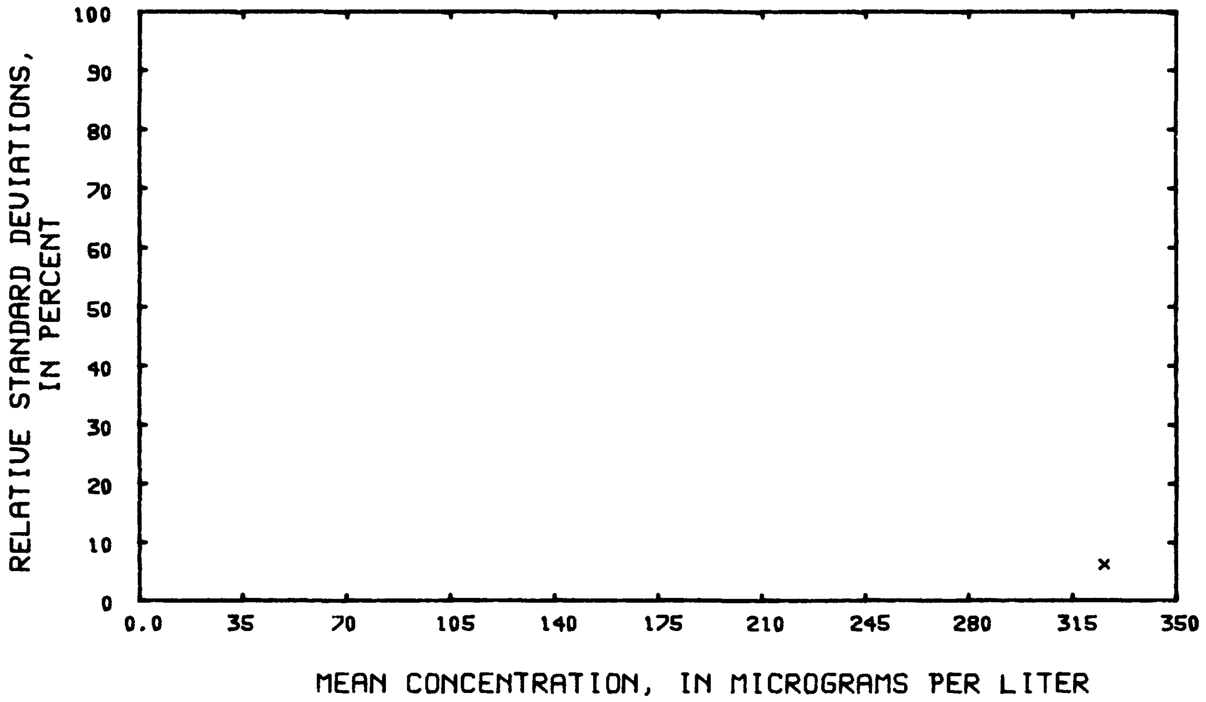

Figure 177--Precision data for manganese, total recoverable, at the Atlanta laboratory.

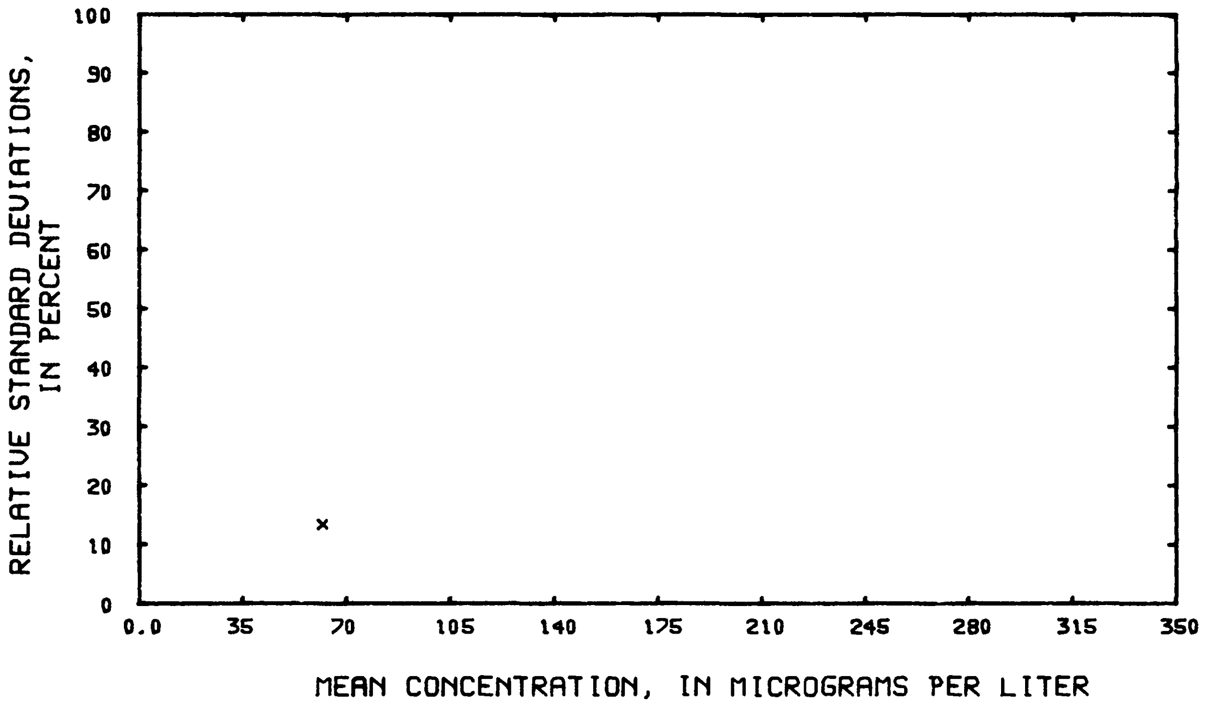

Figure 178--Precision data for manganese, total recoverable, at the Denver laboratory.

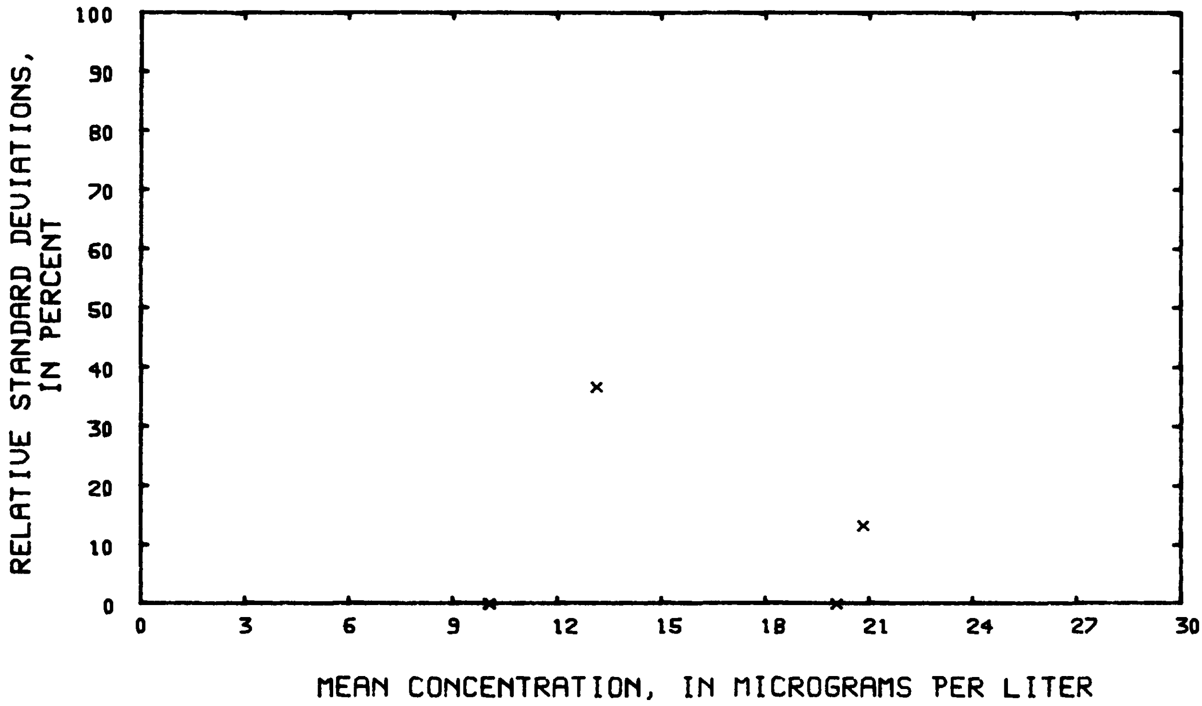

Figure 179--Precision data for molybdenum, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

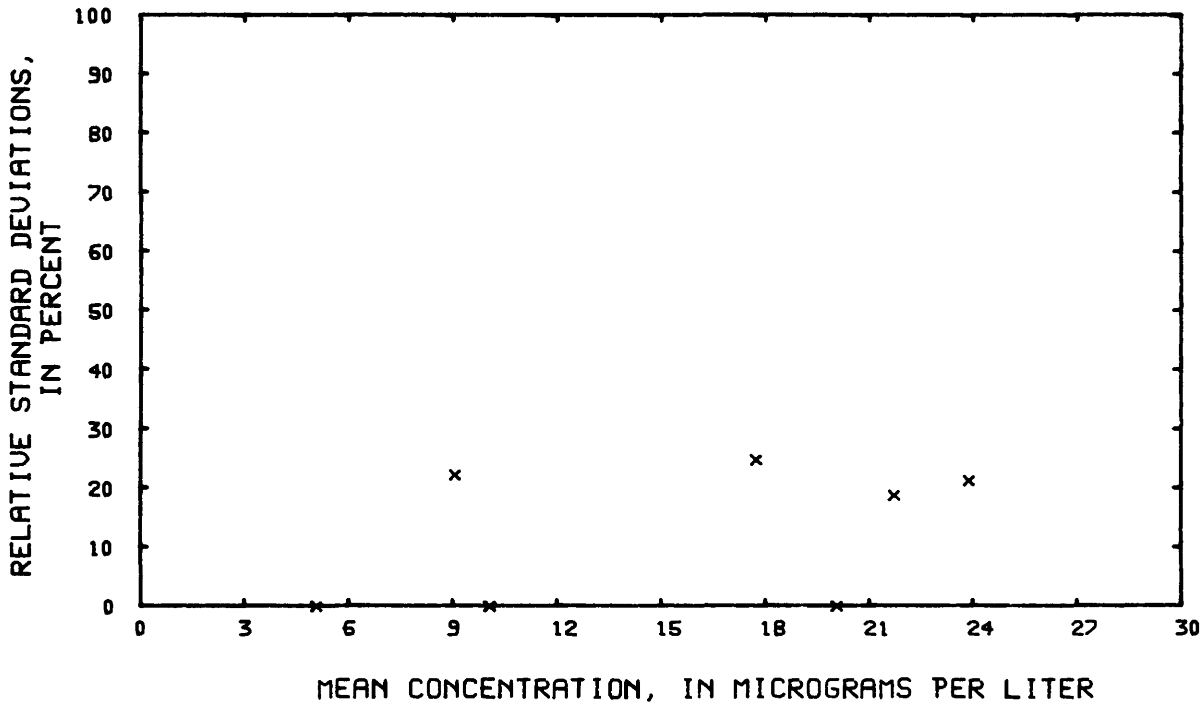

Figure 180--Precision data for molybdenum, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

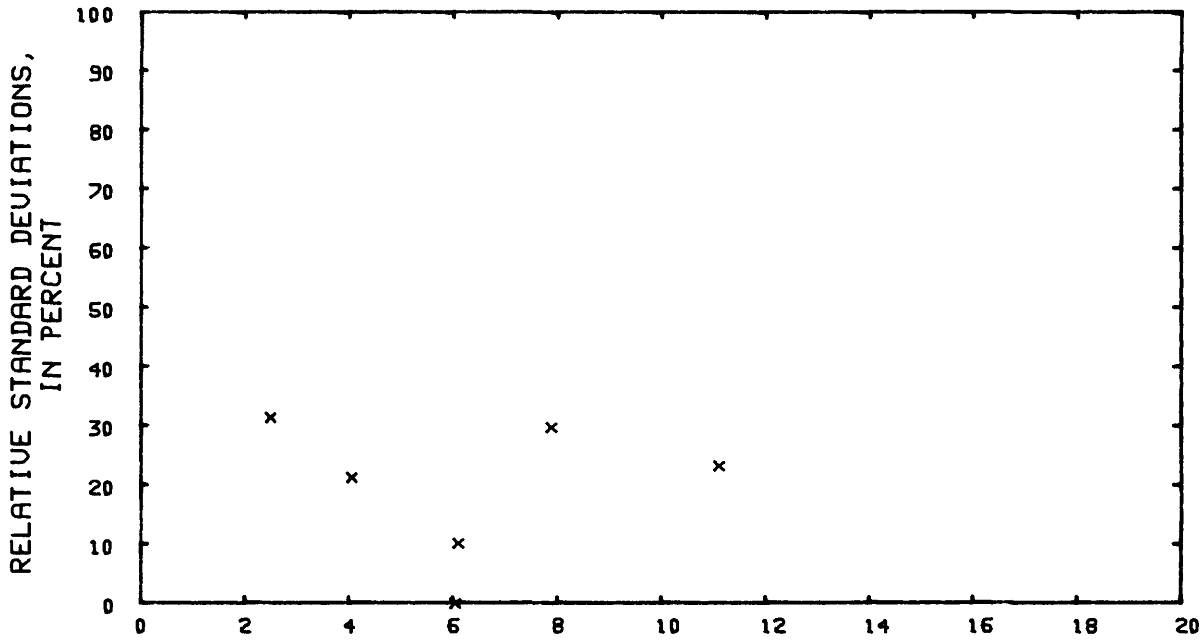

Figure 181--Precision data for molybdenum, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

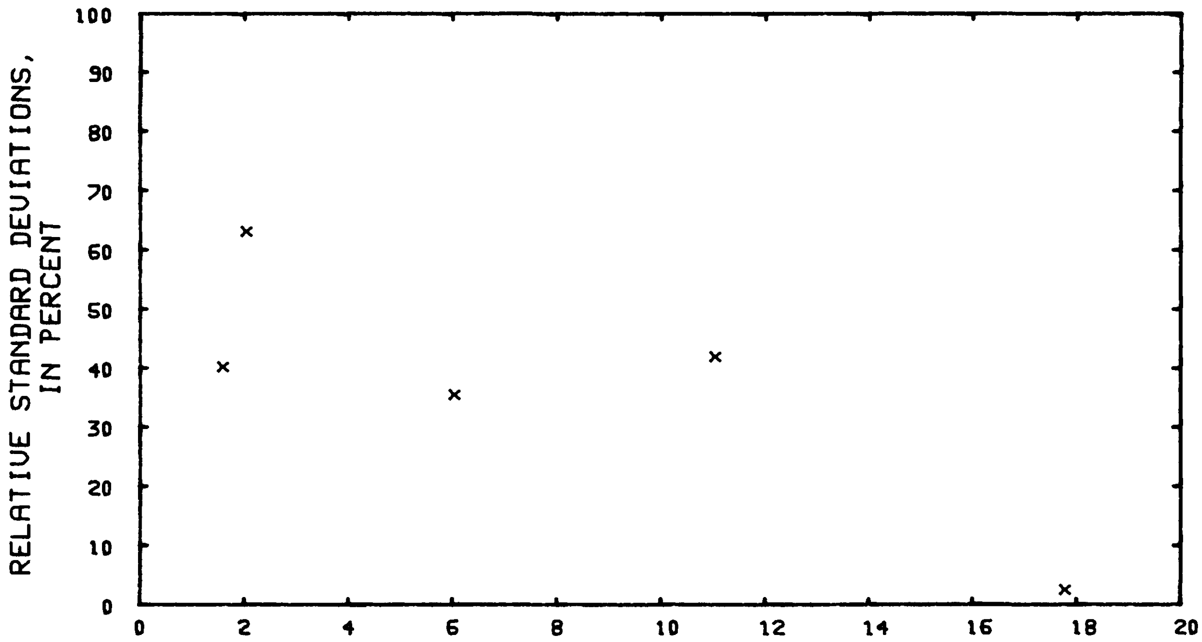

Figure 182--Precision data for molybdenum, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

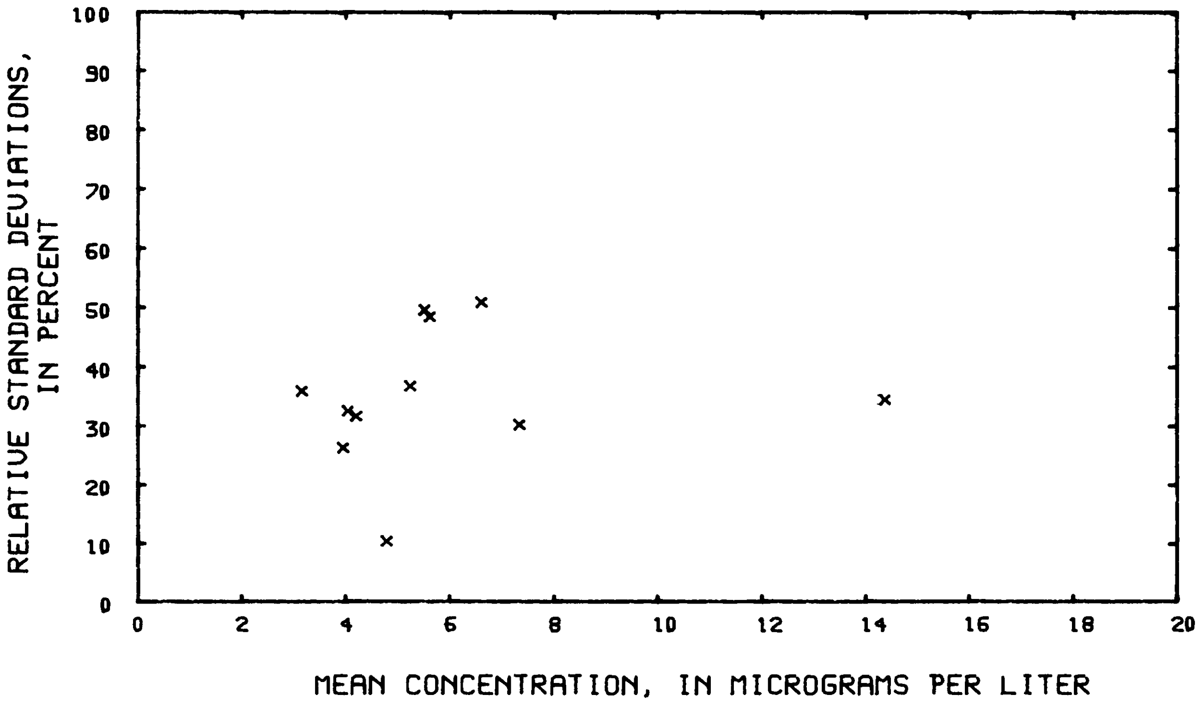

Figure 183--Precision data for nickel, dissolved, at the Atlanta laboratory.

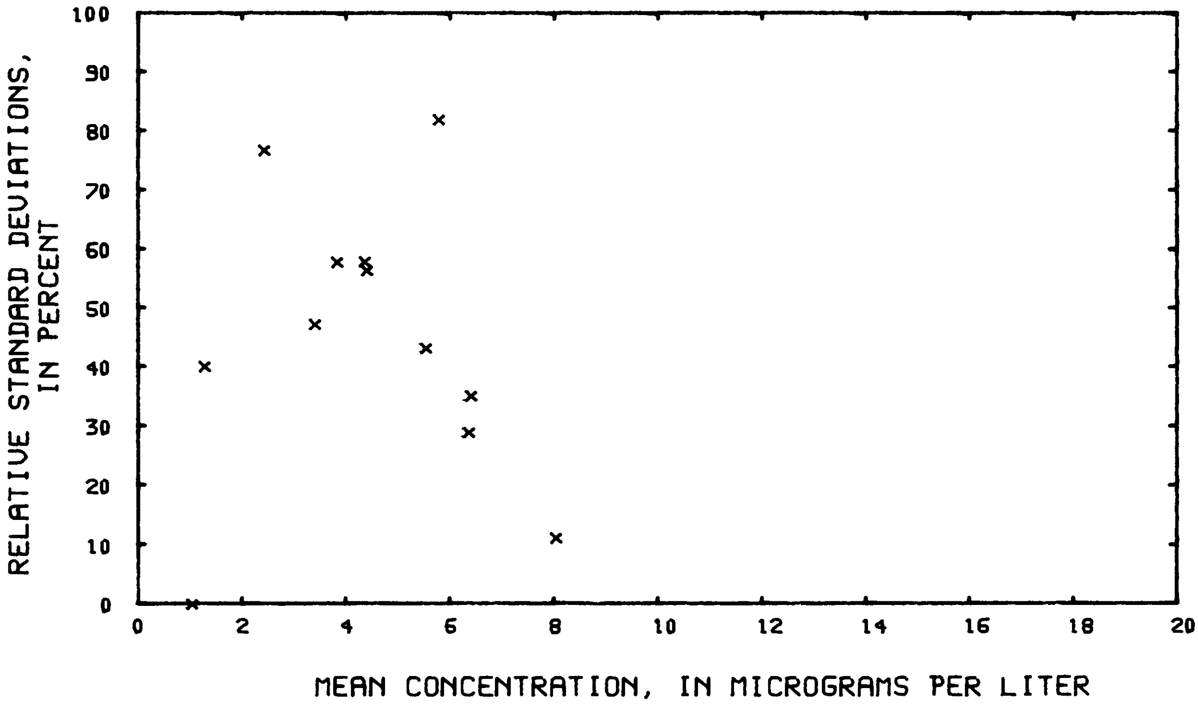

Figure 184--Precision data for nickel, dissolved, at the Denver laboratory.

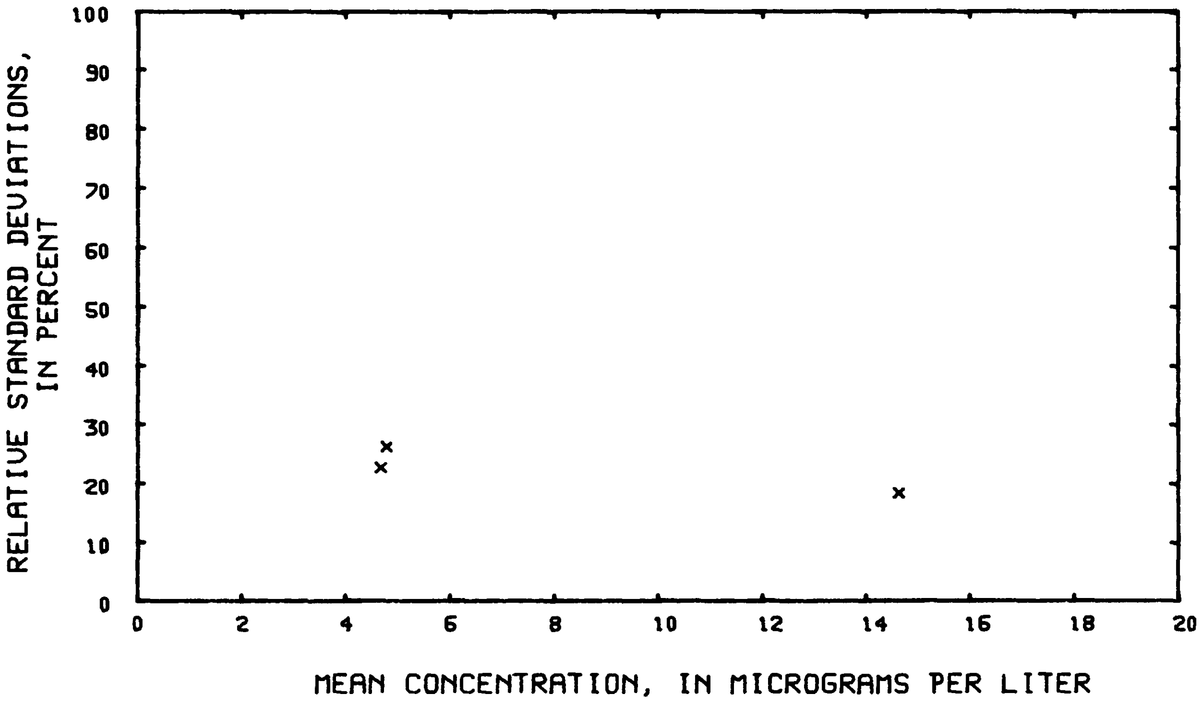

Figure 185--Precision data for nickel, total recoverable, at the Atlanta laboratory.

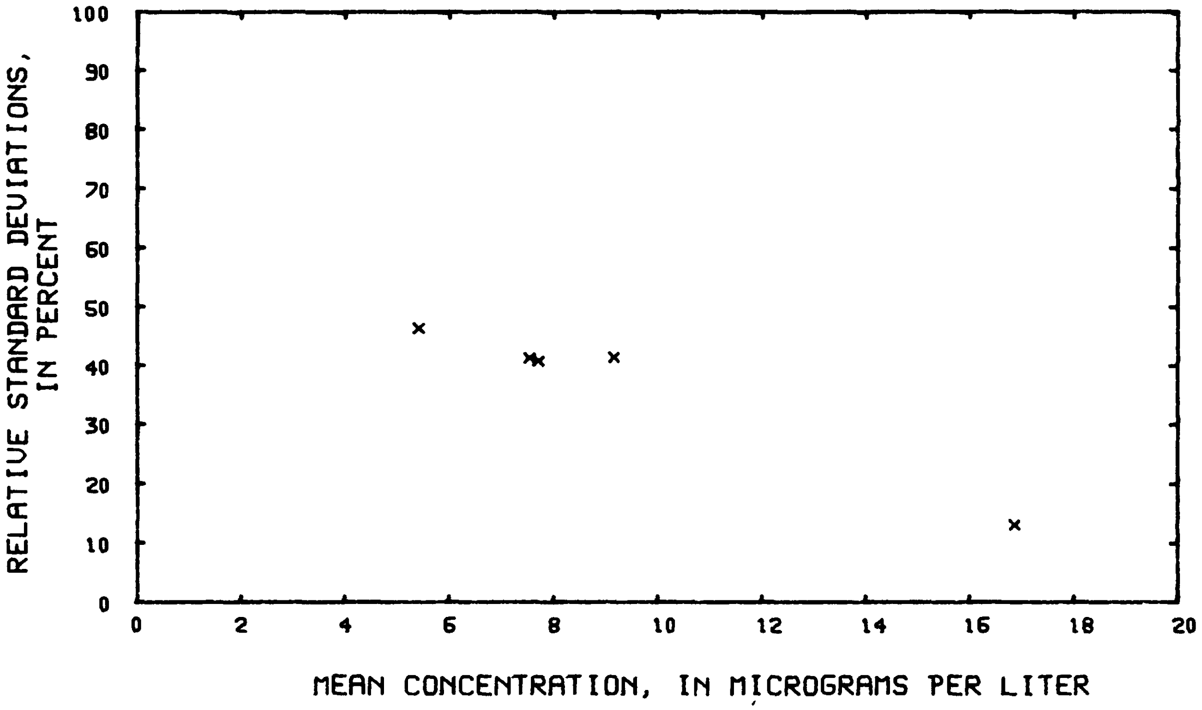

Figure 186--Precision data for nickel, total recoverable, at the Denver laboratory.

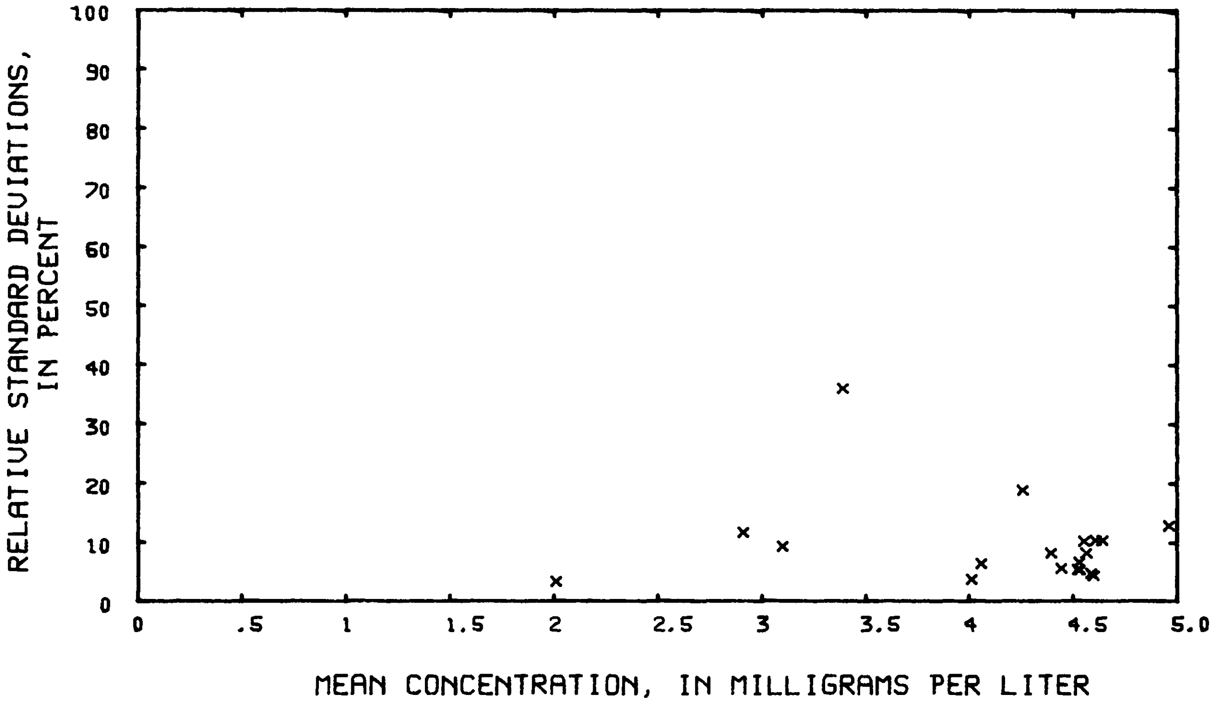

Figure 187--Precision data for potassium, dissolved, at the Atlanta laboratory.

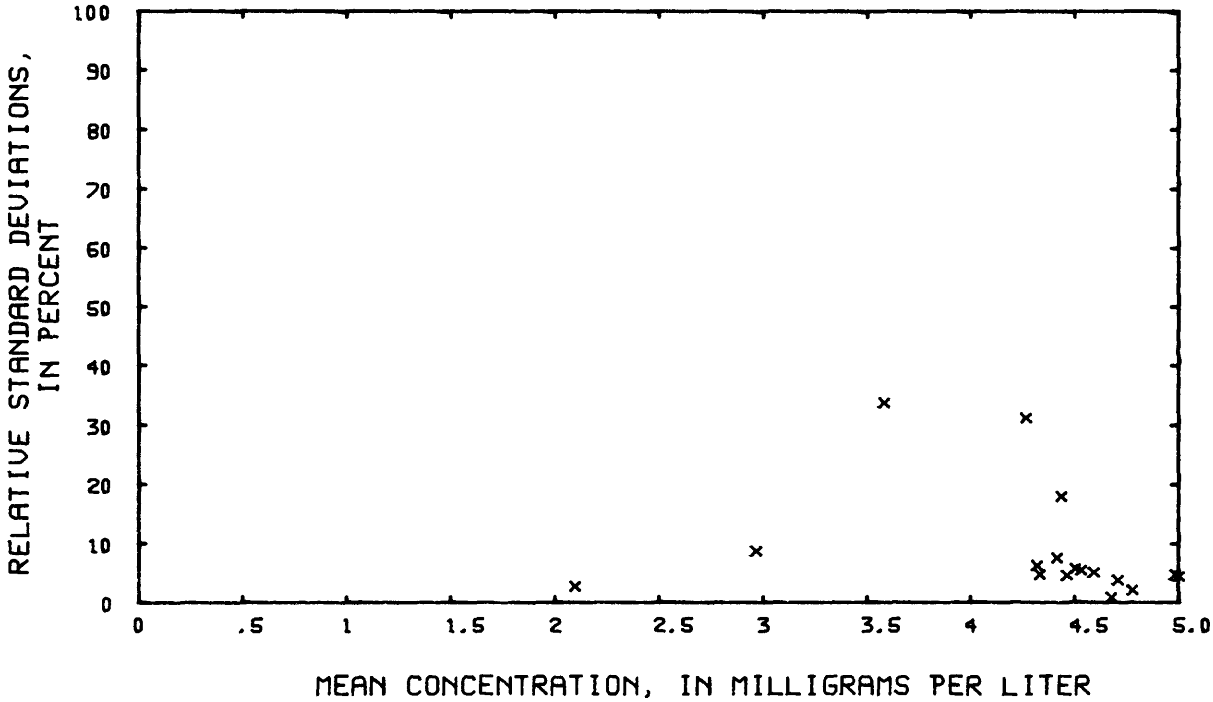

Figure 188--Precision data for potassium, dissolved, at the Denver laboratory.

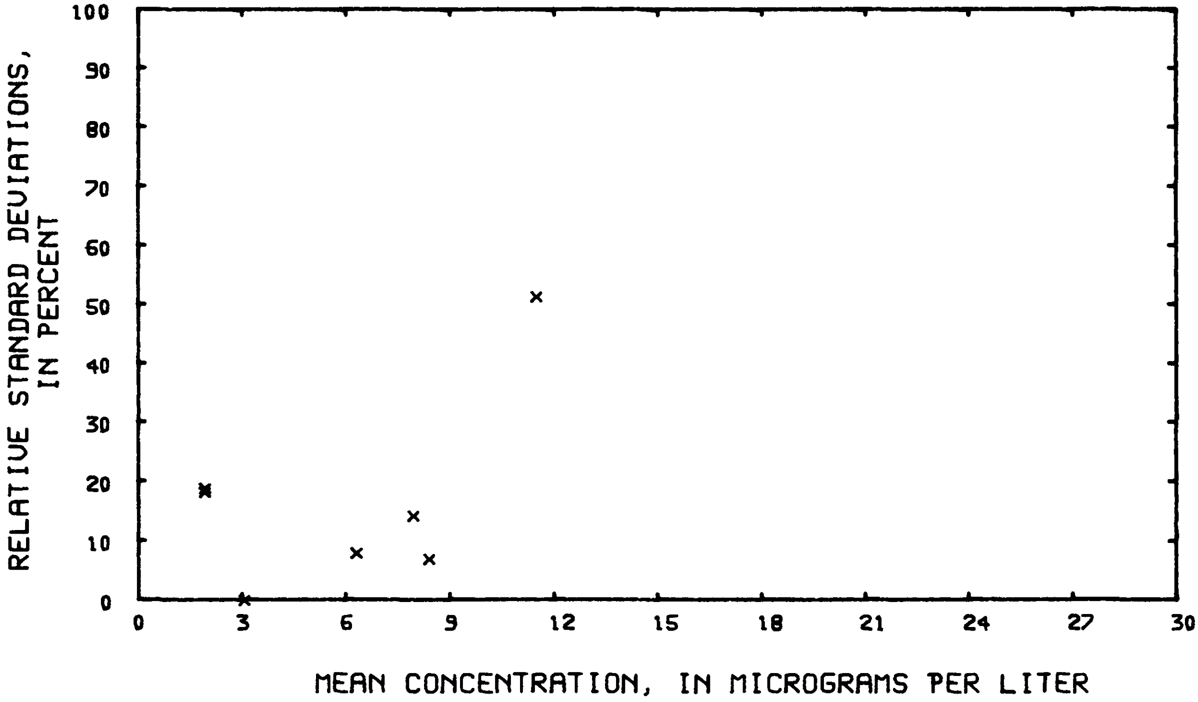

Figure 189--Precision data for selenium, dissolved, at the Atlanta laboratory.

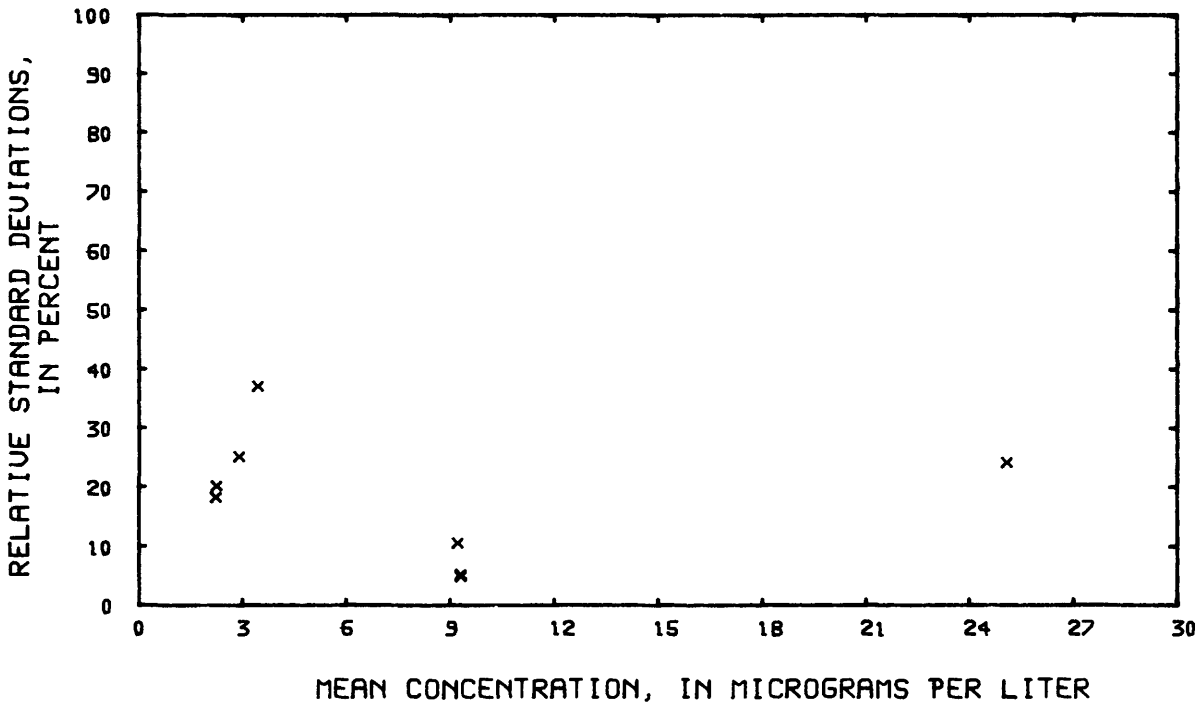

Figure 190--Precision data for selenium, dissolved, at the Denver laboratory.

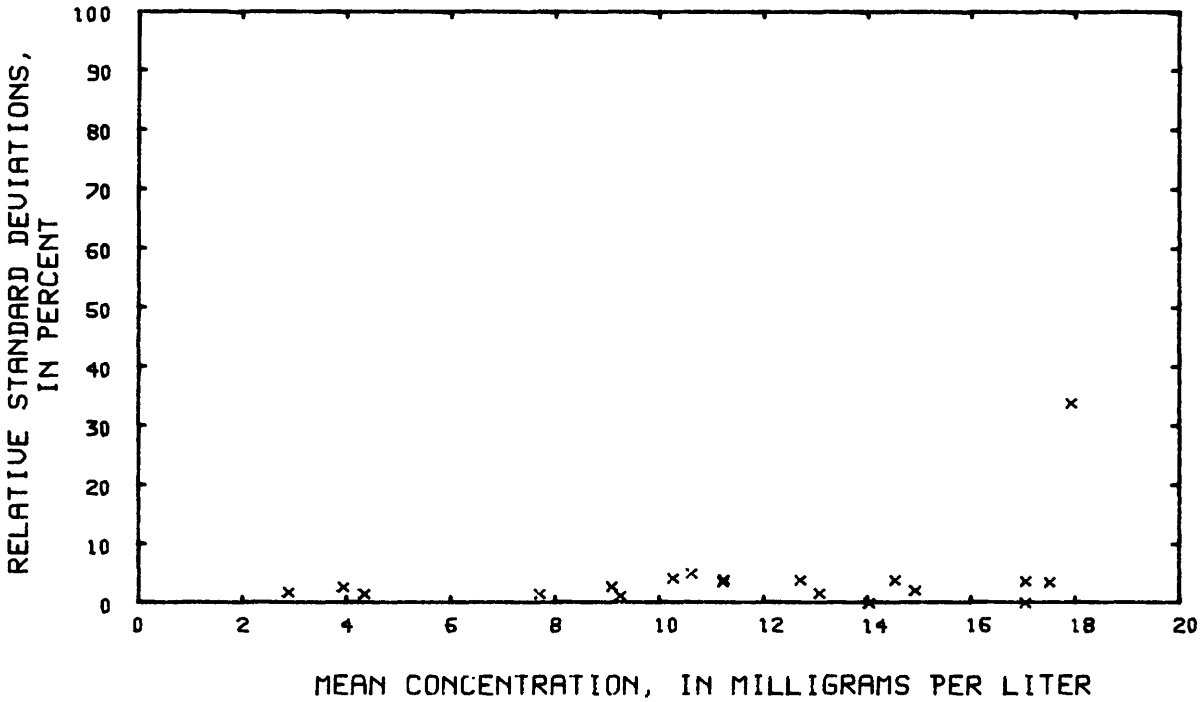

Figure 191--Precision data for silica, dissolved, at the Atlanta laboratory.

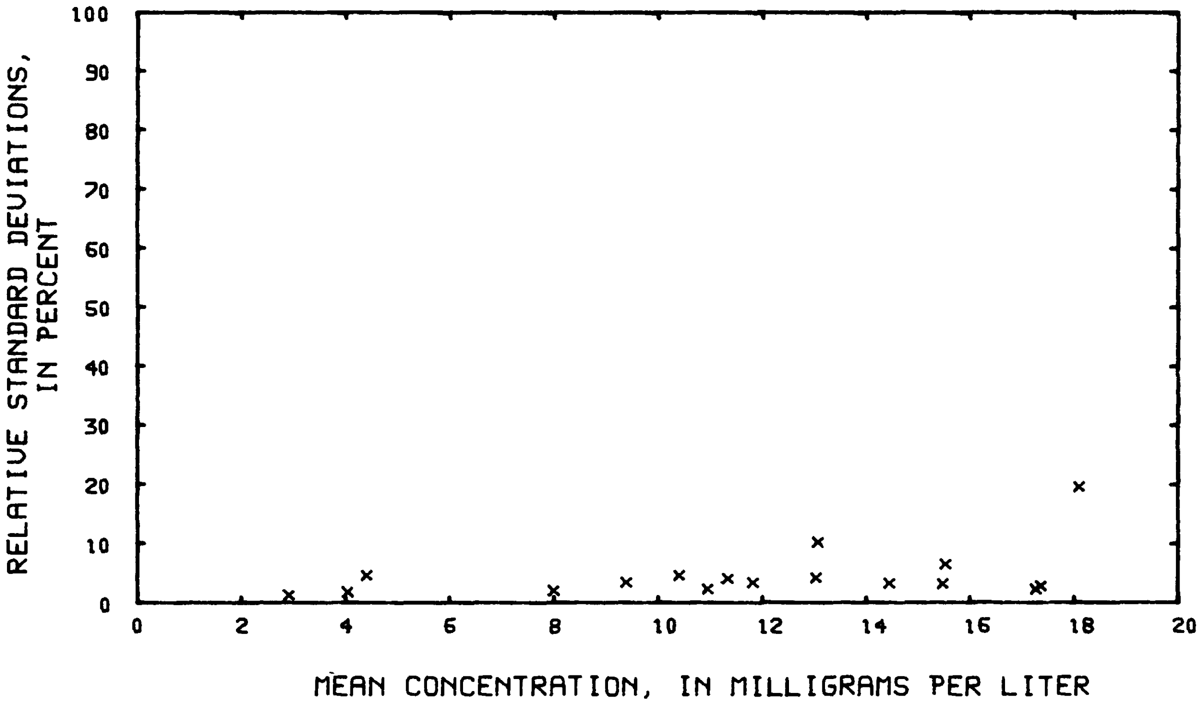

Figure 192--Precision data for silica, dissolved, at the Denver laboratory.

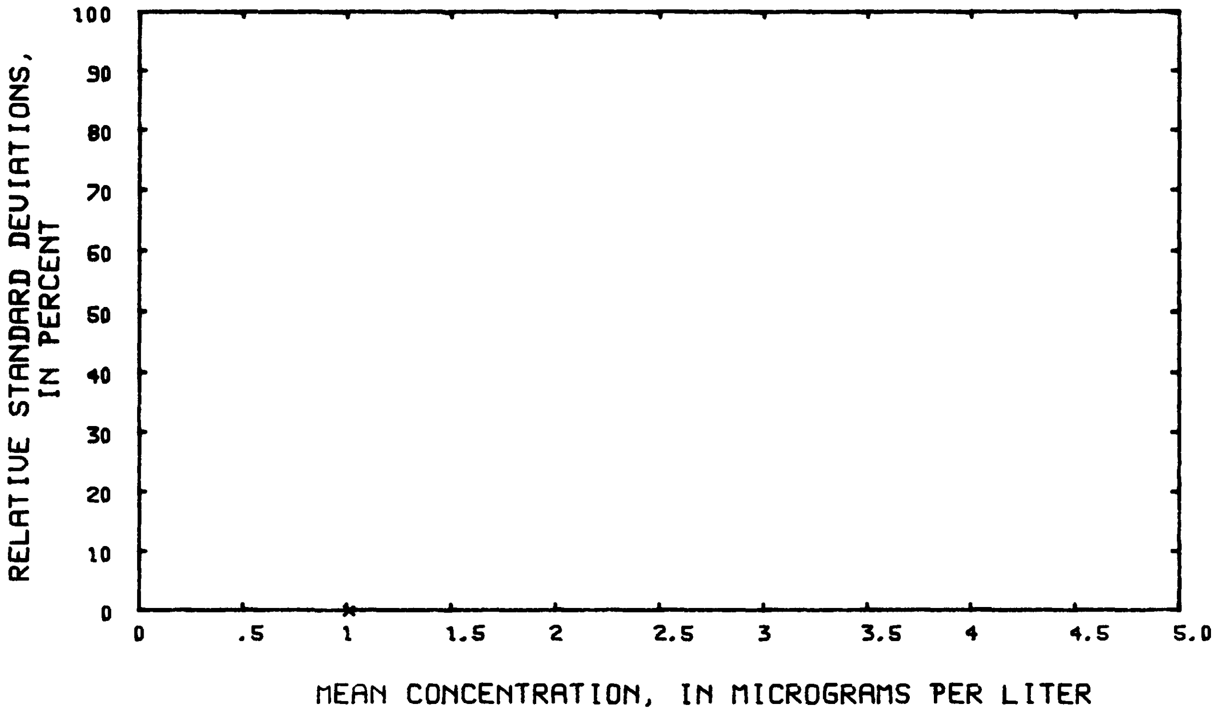

Figure 193--Precision data for silver, dissolved, at the Atlanta laboratory.

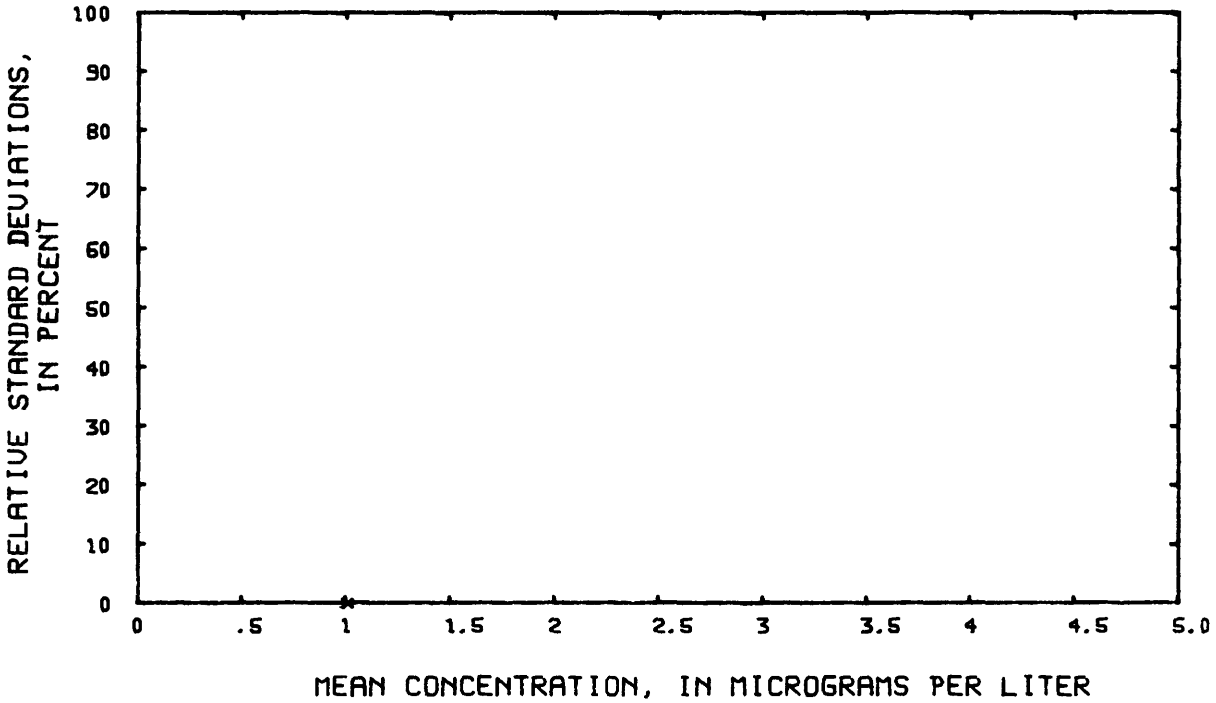

Figure 194--Precision data for silver, dissolved, at the Denver laboratory.

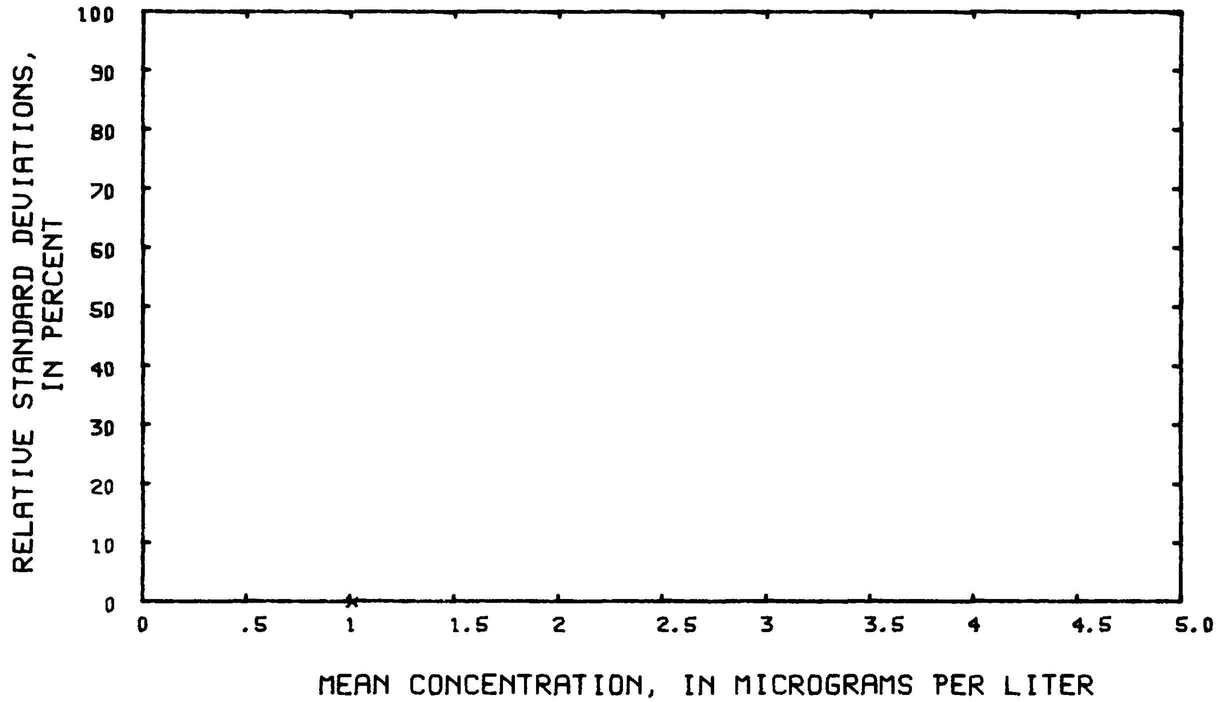

Figure 195--Precision data for silver, total recoverable, at the Atlanta laboratory.

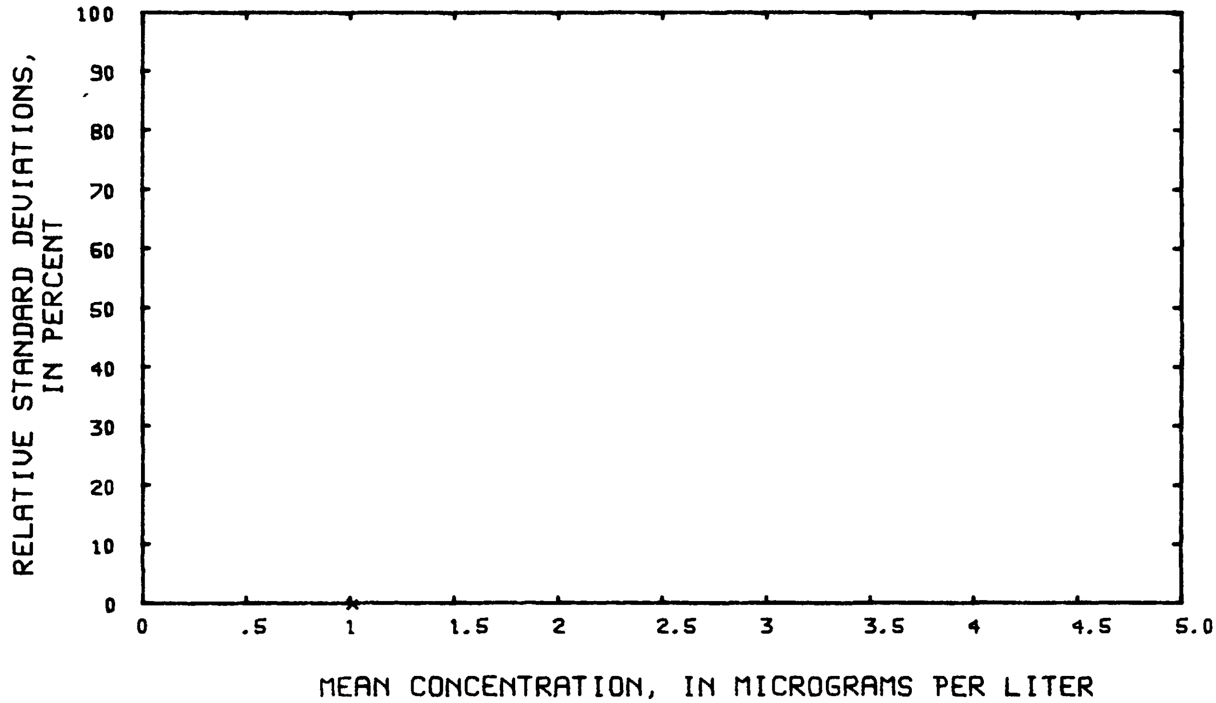

Figure 196--Precision data for silver, total recoverable, at the Denver laboratory.

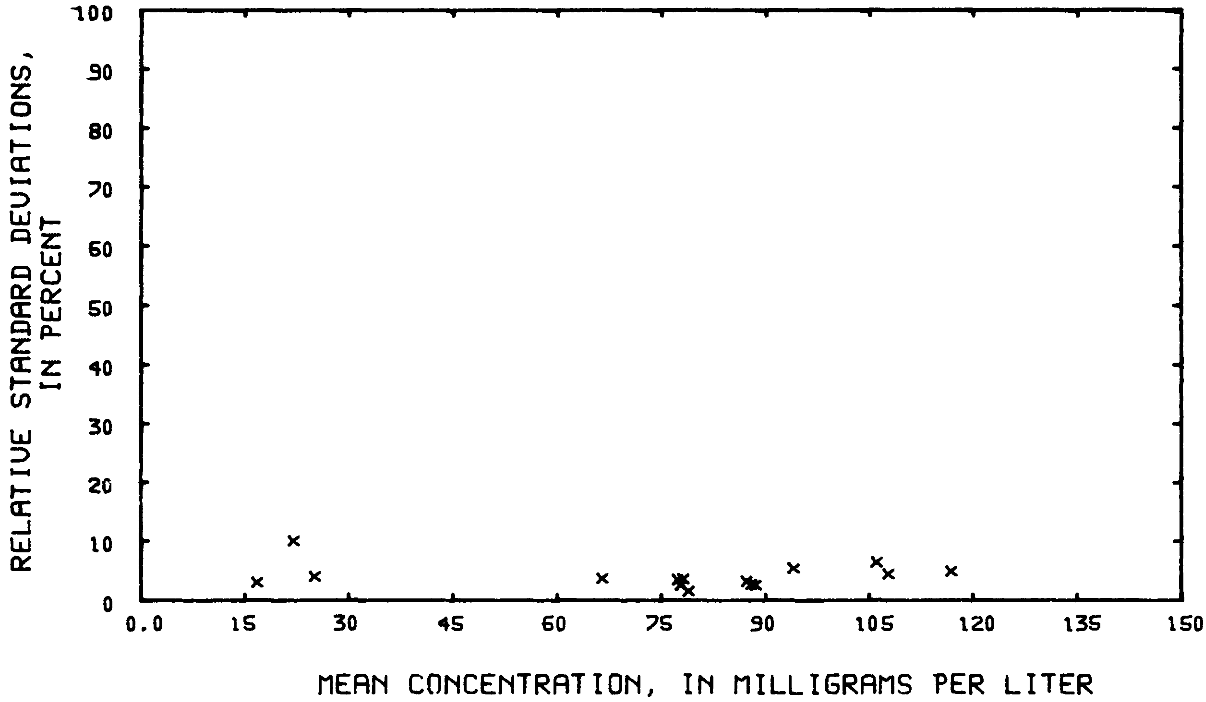

Figure 197--Precision data for sodium, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

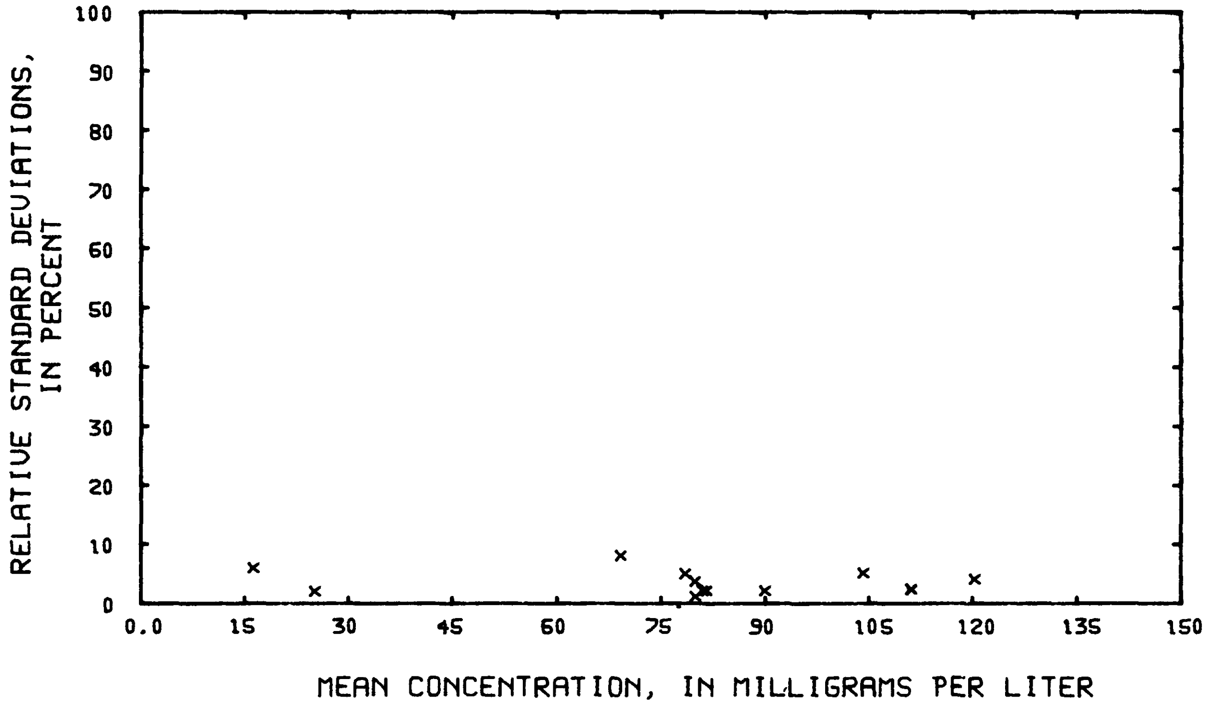

Figure 198--Precision data for sodium, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

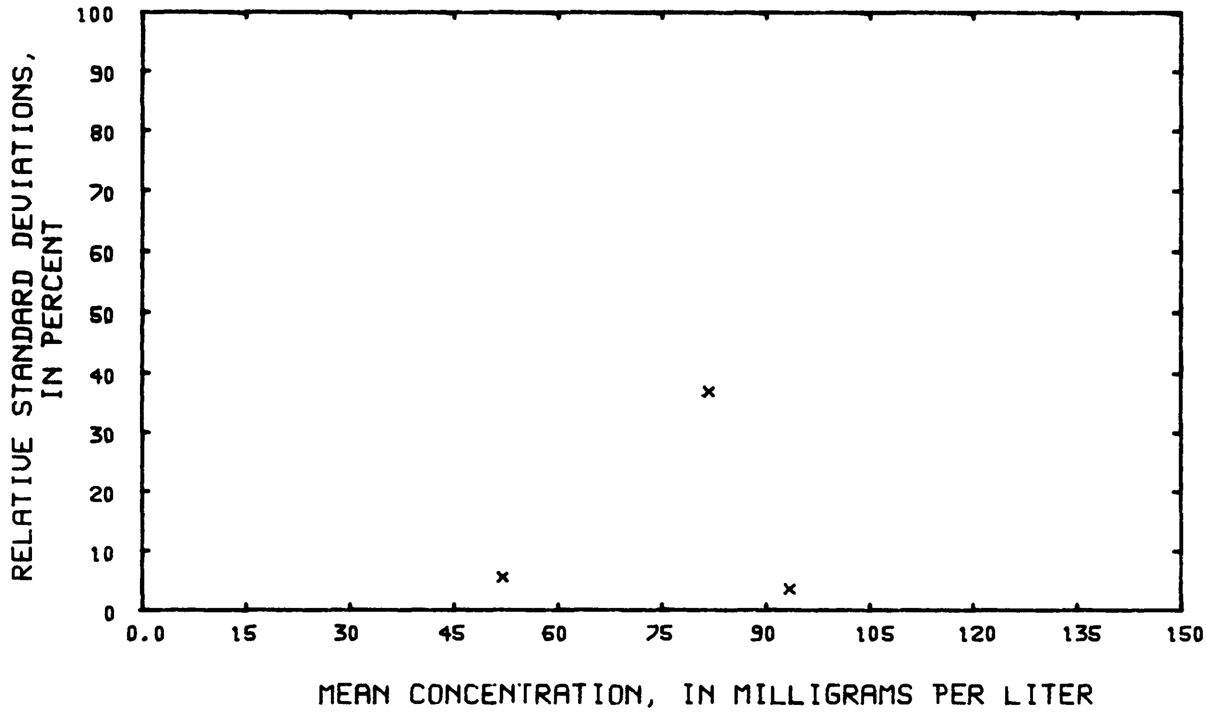

Figure 199--Precision data for sodium, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

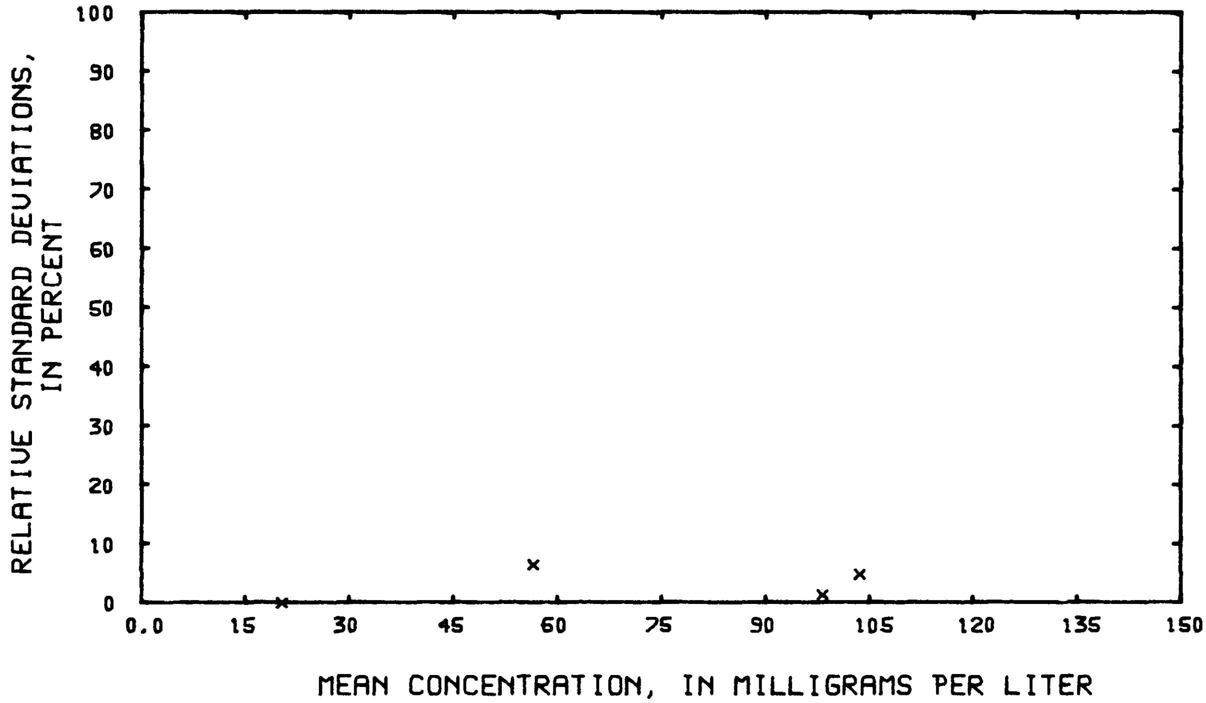

Figure 200--Precision data for sodium, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

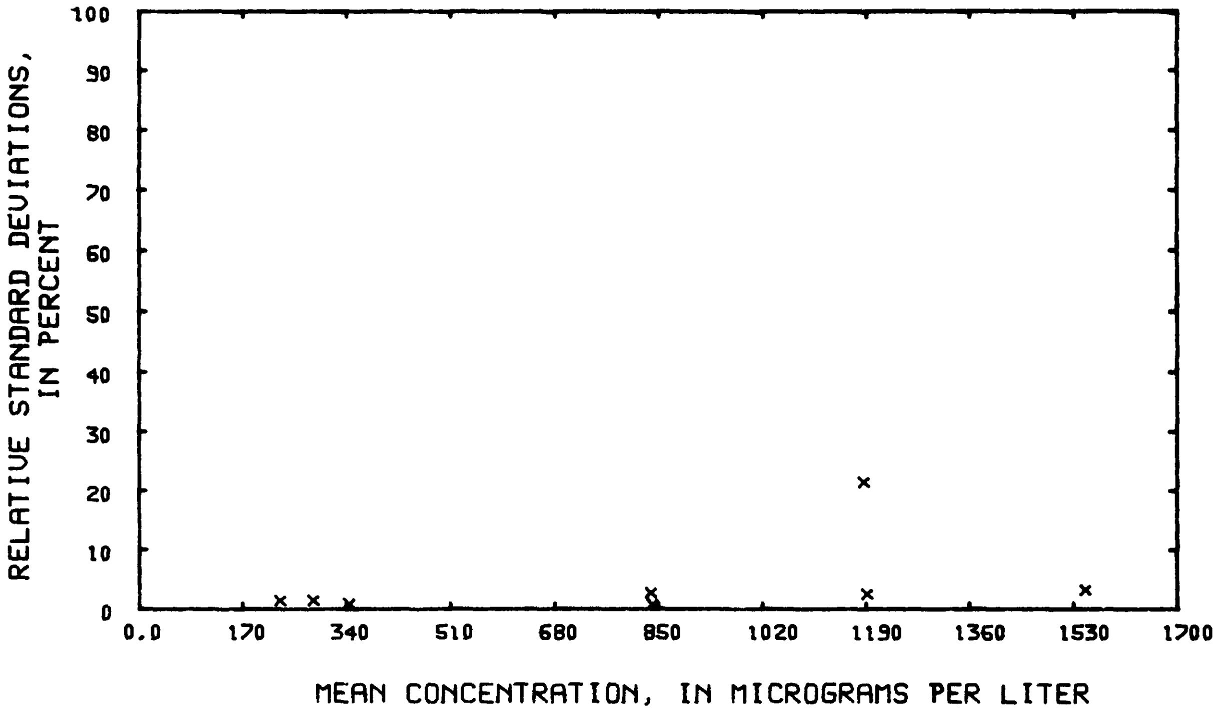

Figure 201--Precision data for strontium, dissolved, at the Atlanta laboratory.

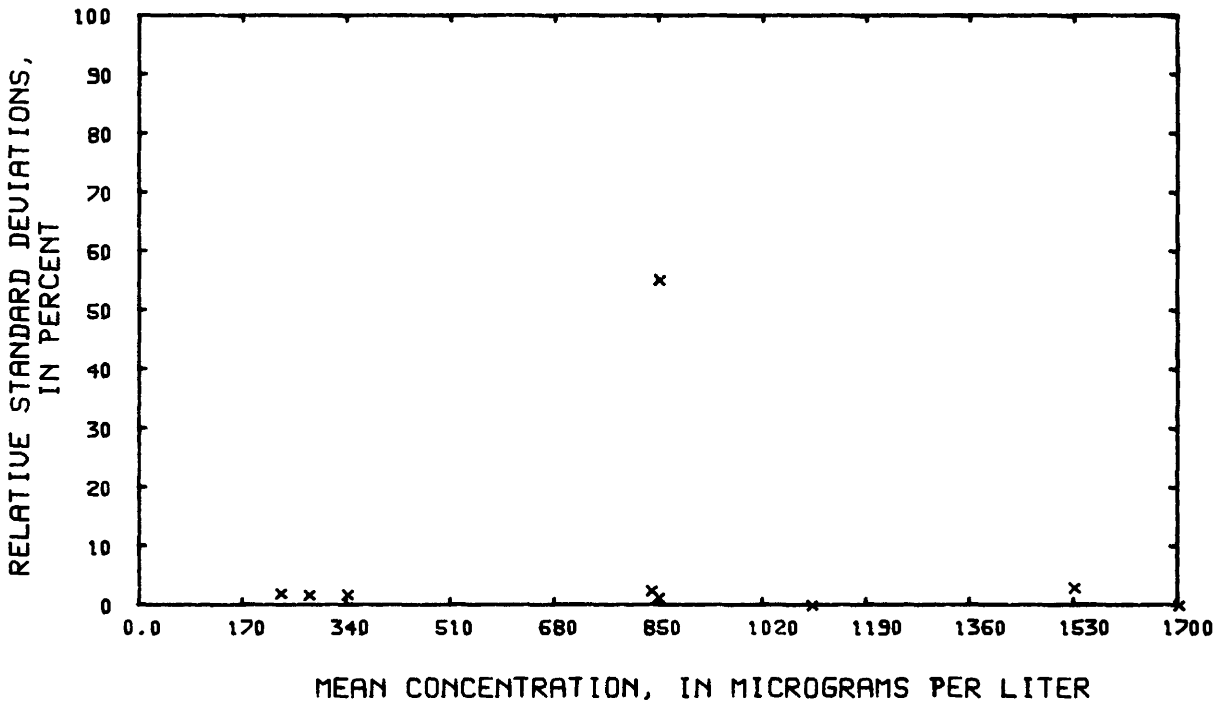

Figure 202--Precision data for strontium, dissolved, at the Denver laboratory.

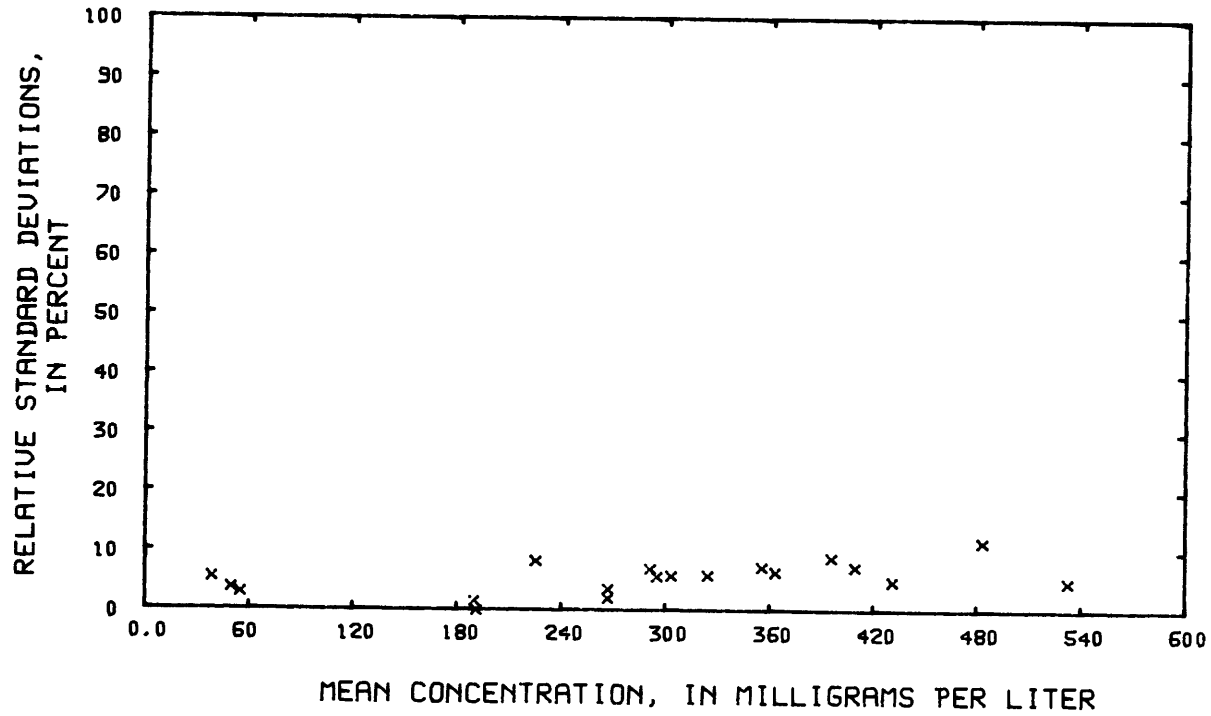

Figure 203--Precision data for sulfate, dissolved, at the Atlanta laboratory.

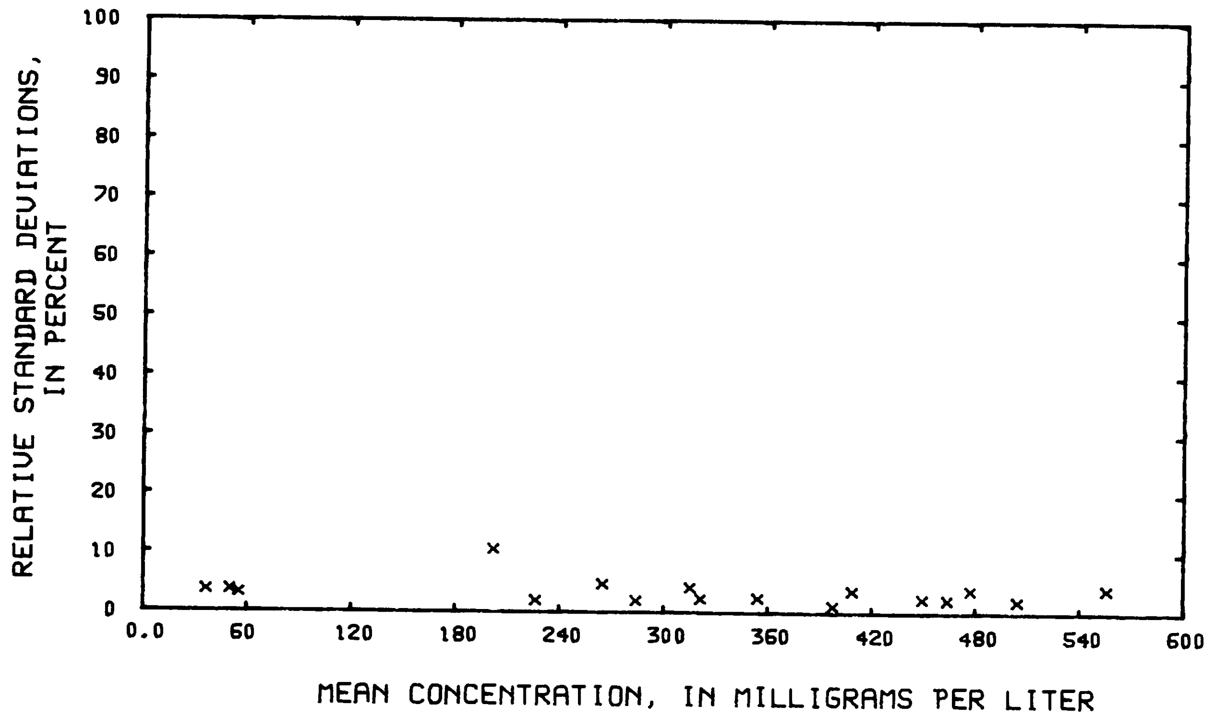

Figure 204--Precision data for sulfate, dissolved, at the Denver laboratory.

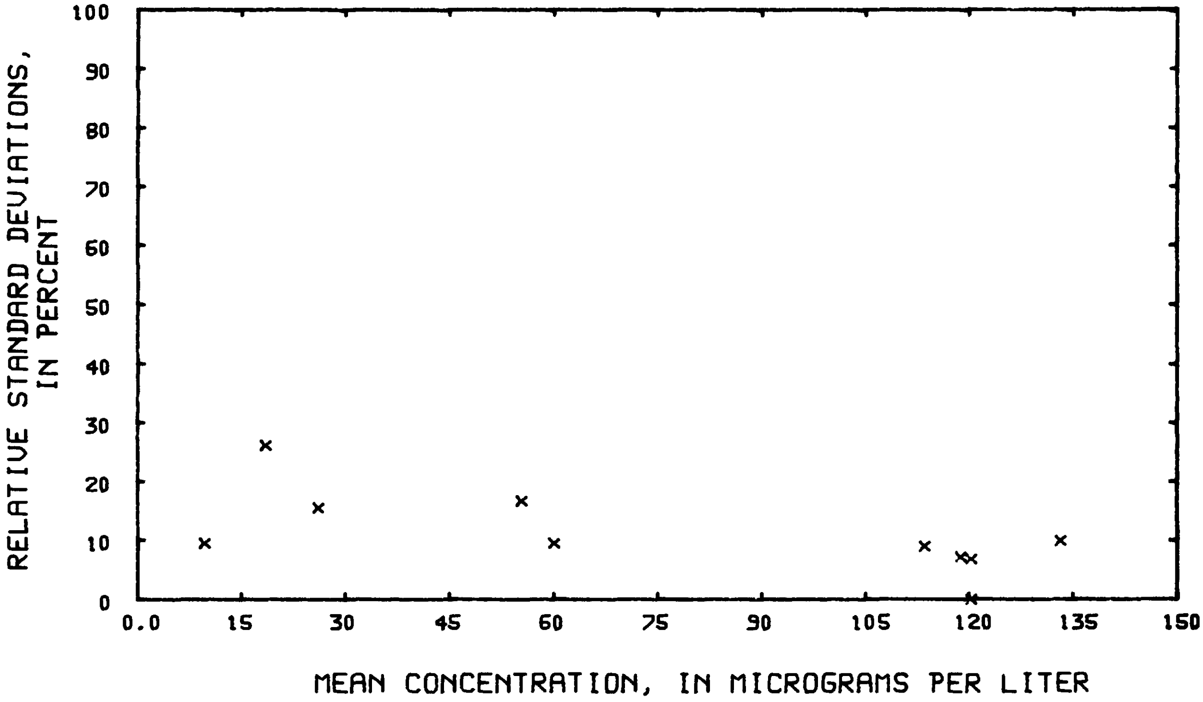

Figure 205--Precision data for zinc, dissolved, (inductively coupled plasma emission spectrometry) at the Atlanta laboratory.

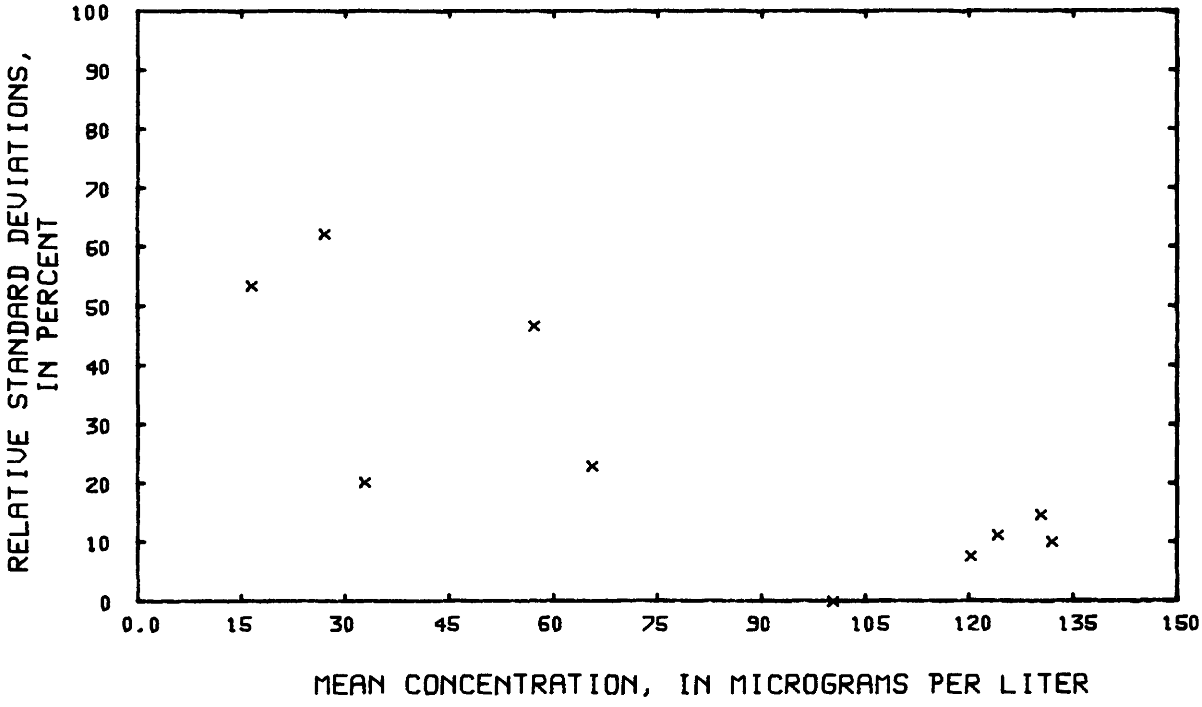

Figure 206--Precision data for zinc, dissolved, (inductively coupled plasma emission spectrometry) at the Denver laboratory.

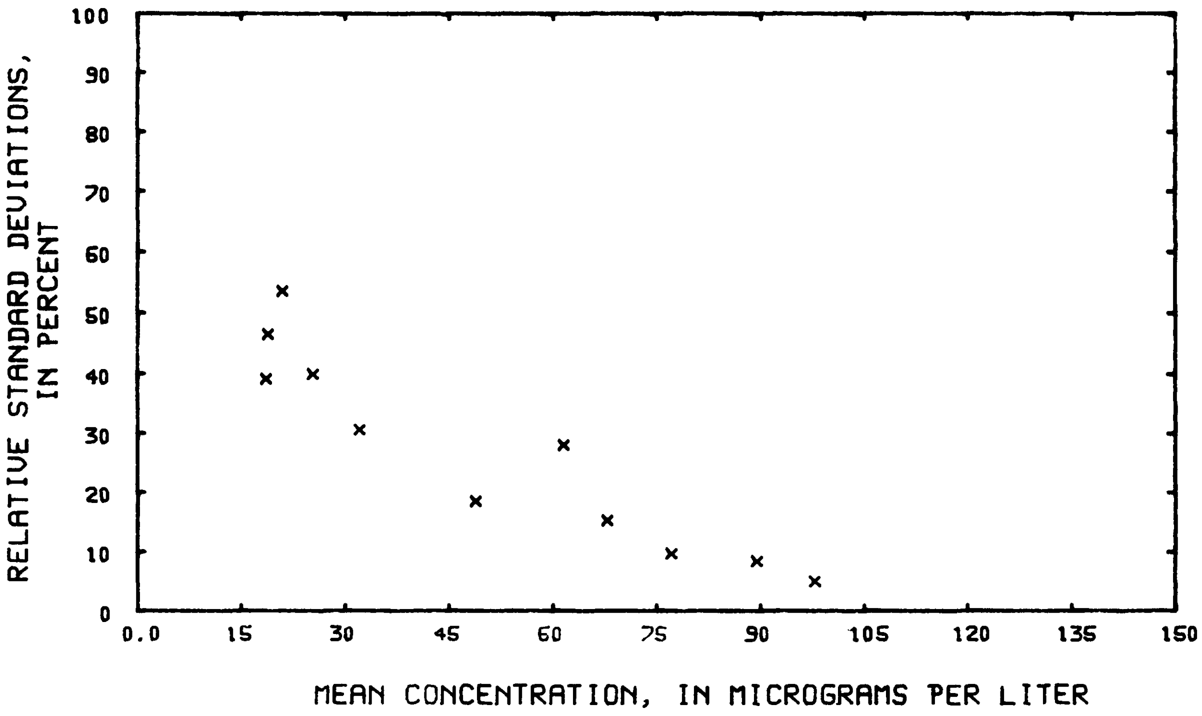

Figure 207--Precision data for zinc, dissolved, (atomic absorption spectrometry) at the Atlanta laboratory.

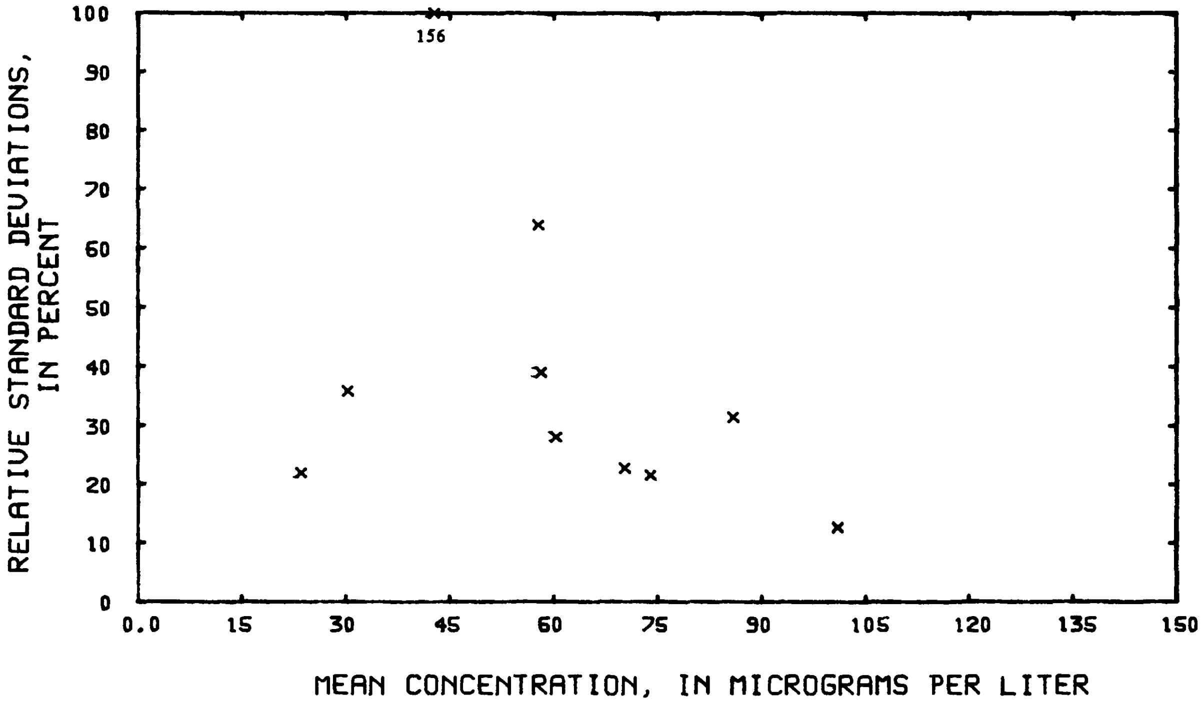

Figure 208--Precision data for zinc, dissolved, (atomic absorption spectrometry) at the Denver laboratory.

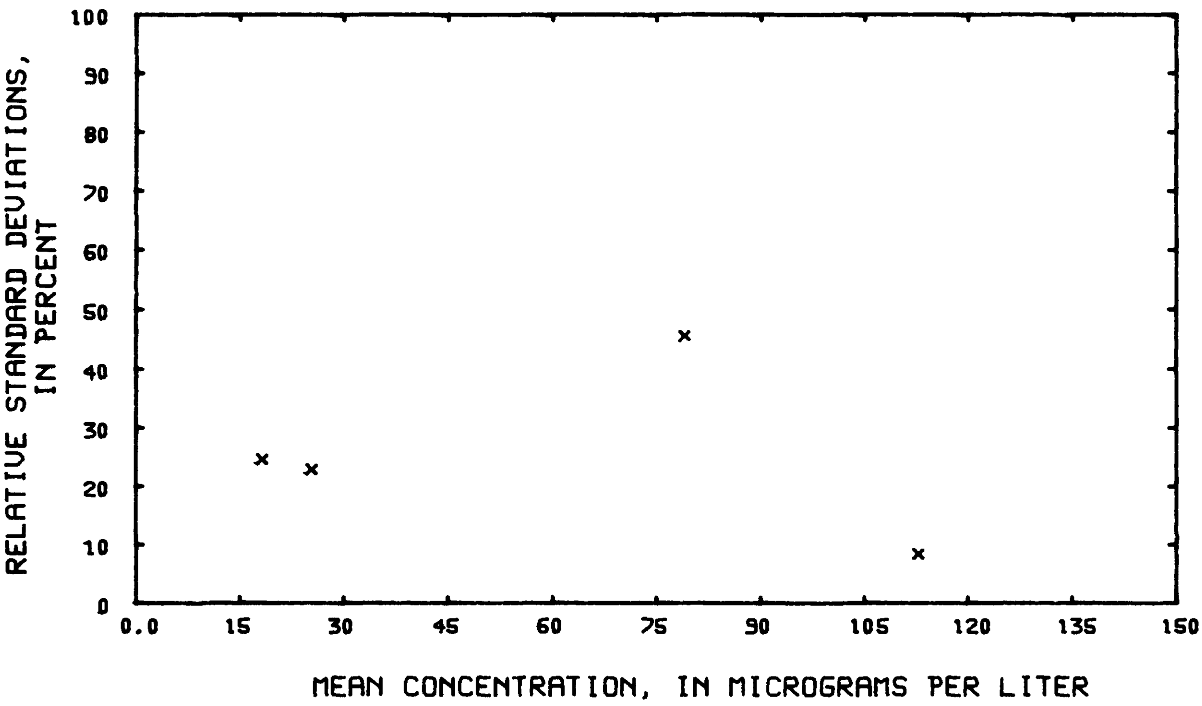

Figure 209--Precision data for zinc, total recoverable, at the Atlanta laboratory.

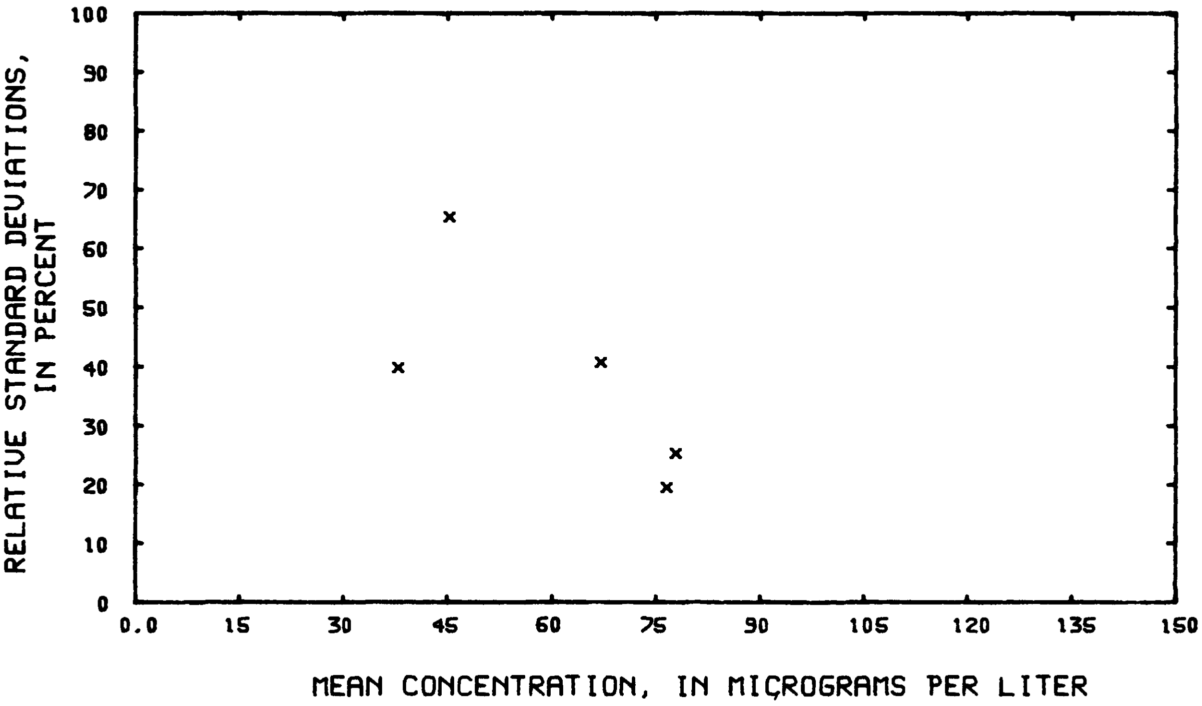

Figure 210--Precision data for zinc, total recoverable, at the Denver laboratory.

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