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Study of Water Quality of Utah Lake Tributaries and the Jordan River Outlet for the Calibration of the Utah Lake Water Salinity Model (LKSIM)

Gordon Killarney Liljenquist

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

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April 2012

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ABSTRACT

Study of Water Quality of Utah Lake Tributaries and the Jordan River Outlet for the Calibration of the Utah Lake Water Salinity Model (LKSIM)

Gordon Killarney Liljenquist
Department of Civil and Environmental Engineering, BYU
Master of Science

The water quality of Utah Lake is of great importance to agriculture, recreation, and wildlife. The Utah Lake Simulation Model (LKSIM) was created to accurately predict changes in water quality parameters. However, a potential limitation of LKSIM is the age of the underlying data which was gathered from 1930 to 1980. New sample data were collected from March 2009 through May 2011. Samples were taken from 13 tributaries, the Jordan River Outlet, and various wastewater treatment plants (WWTP). Upon dividing the collected data points into seasons and plotting them in Microsoft Excel, trendline equations were produced. These equations correlated TDS and ion concentrations with flow and their respective times of the year. The new equations were compared with the old LKSIM equations by plotting them both against the collected, sample data points. The new trendline equations and mean values proved their worth by generating more accurate predictions of TDS and ion concentrations according to the sample data. However, further studies on the other tributaries of Utah Lake to determine their effect on the water quality may be of value. Also, future sampling from the tributaries of this study may be beneficial in gauging the accuracy of the equations and mean values that were found.

Keywords: utah lake, LKSIM

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1 INTRODUCTION

1.1 Site Description

Utah Lake, in the lowest part of the Utah Valley, occupies about a fourth of the valley's area. The surface area of Utah Lake is about 95,000 acres (Miller, 1980). Utah Lake is the largest freshwater lake in the state of Utah and the second largest west of the Great Lakes. It is fed by approximately 52 tributaries (Rice, 1999). The location of many of these tributaries and their respective sampling areas in relation to Utah Lake can be seen in Figure 1.1-1. Also, Table 1.1-1 displays the GPS coordinates of the major tributaries sampled in this study.

The Jordan River, located at the northwestern corner of the lake, is the only natural, surface outflow. It carries water 40 miles north before discharging into the Great Salt Lake (Miller, 1980).

The water in Utah Lake serves many purposes. A substantial portion of the water going into Utah Lake and coming out through the Jordan River is used for irrigation. Economic losses would result if this water quality deteriorated (Brimhall, 1981).

In addition to agricultural uses, the water from Utah Lake supports a host of recreational uses and wildlife. Among the wildlife that depends on Utah Lake is an endangered, endemic species of fish, the June Sucker, Chasmistes liorus. Such endangered wildlife and recreational uses are also dependent on the proper maintenance of the lake's water quality (Marelli, 2010).

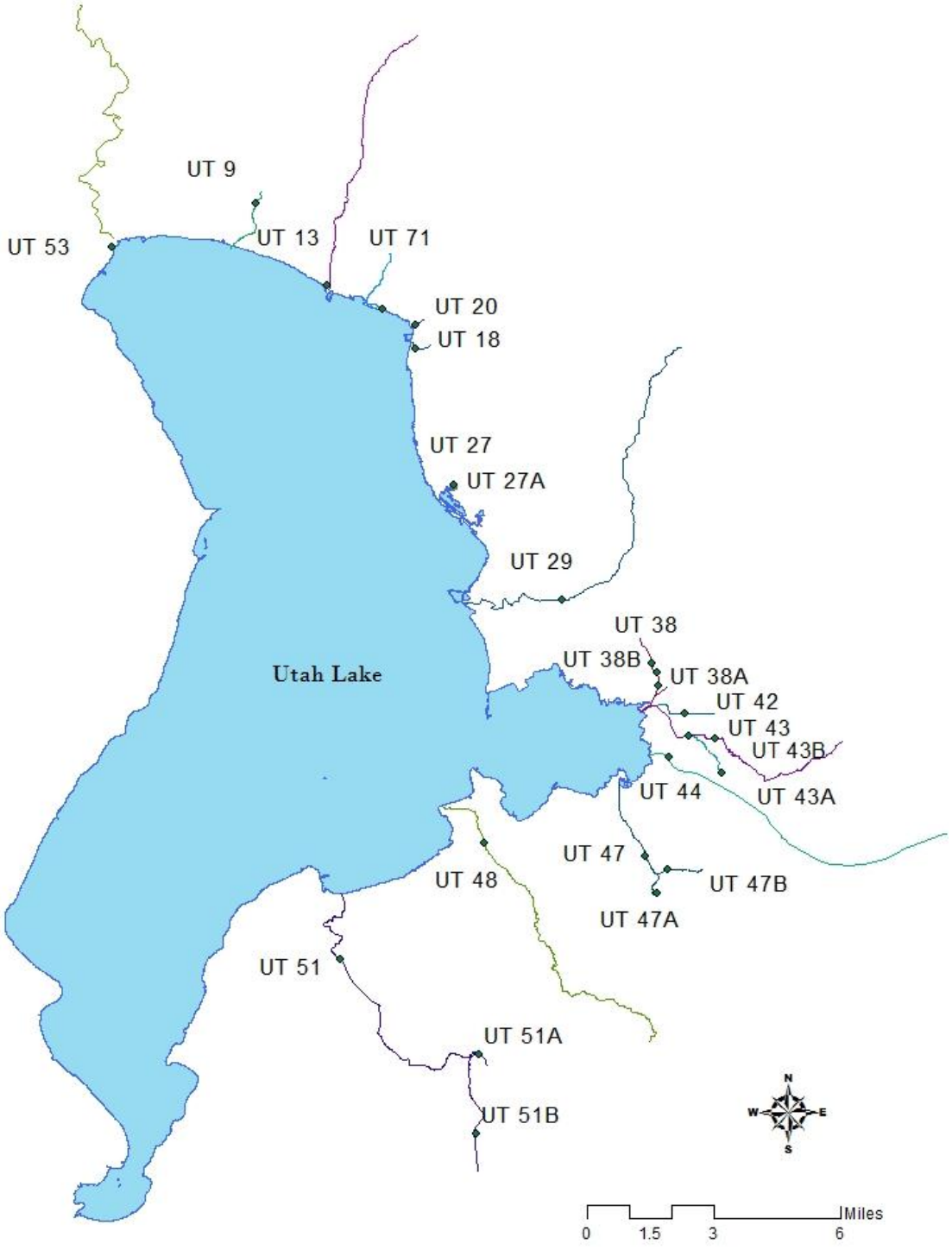

Figure 1-1: Sampling Locations for Utah Lake Tributaries

Table 1-1: GPS Coordinates and Code Numbers for Tributary Locations

Name of Tributary	Code ID	GPS Coordinates	
		N	E
Spring Creek Lehi	UT 9	40.37281389	-111.8339767
American Fork River	UT 13	40.34486972	-111.8017094
Lindon Cannery Drain	UT 18	40.33176722	-111.7631764
Geneva Steel	UT 20	40.312	-111.7495944
Powell's Slough	UT 27	40.27704833	-111.7445806
Provo River	UT 29	40.23808806	-111.6951694
Millrace	UT 38	40.216465	-111.6549206
Steel Mill Drain	UT 42	40.199315	-111.6399047
Spring Creek Springville	UT 43	40.19167139	-111.6384572
Hobble Creek	UT 44	40.18418306	-111.6472019
Dry Creek Spanish Fork	UT 47	40.15861222	-111.6639419
Spanish Fork River	UT 48	40.15462333	-111.7295561
Benjamin Slough	UT 51	40.11426944	-111.7932964
Jordan River at Utah Lake Outlet	UT 53	40.35731167	-111.8987117
Timpanogos WWTP Ponds	UT 71	40.34763611	-111.7795528
Orem WWTP	UT 27A	40.27601944	-111.7435333
Provo WWTP	UT 38A	40.21317222	-111.6525611
Springville WWTP	UT 43A	40.17811111	-111.6000972
Spanish Fork WWTP	UT 47A	40.13763611	-111.6519444
Payson WWTP	UT 51A	40.05495	-111.732175

1.2 Purpose

Since the water quality of Utah Lake is of great importance, a salinity model called the Utah Lake Simulation Model, or ***LKSIM*** for short, was constructed to help simulate and predict concentration levels of total dissolved solids (TDS) and a variety of ions for the lake water. The TDS concentration levels in LKSIM are targeted to be within 50 mg/l of the actual concentrations (Marelli, 2010).

One of the potential limitations of the LKSIM model is the age of the underlying data. The data used by LKSIM were taken over a fifty year period from 1930 to 1980. Since the land use in the Utah Valley and related runoff into Utah Lake has changed greatly since 1980, new sample data could show how much the quality might have changed as compared to the old data set. With new information, LKSIM could be updated with new equations and therefore become more accurate in simulating and predicting the water quality of Utah Lake. Further, better decisions can be made as to the quantity and frequency of additional data that might be needed in the future to continually support robust LKSIM simulations.

Further, this study is part of a two-part project. Another function of LKSIM is to predict the flow rates of the tributaries based on historical precipitation values and trends. Thus, the correlations between precipitation and the flow rates of the tributaries are significant since this study will use flow rates to predict total dissolved solids (TDS) and seven ion concentrations (Blankenstein, 1992).

In this study, eight parameters of LKSIM are updated. These parameters include; total dissolved solids (TDS), bicarbonate (HCO_3), sulfate (SO_4), calcium (Ca), chloride (Cl), magnesium (Mg), potassium (K), and sodium (Na). Two variables are considered in finding correlations with these parameters: months of the year grouped into seasons, and the flow rates of the various tributaries.

2 METHODOLOGY

2.1 Raw Data Acquisition

From March 2009 to May 2011, monthly water samples were collected at 18 different sites from Utah Lake tributaries and the Jordan River. During periods of high flow from April to June of each year, water samples were taken twice a month.

Of the 14 sites, four were located downstream from WWTPs. Beginning in October 2009 to May 2011, additional data were collected upstream from these WWTPs. Also, field measurements of factors such as water temperature, pH levels, conductivity, turbidity, and dissolved oxygen were taken and recorded using the Hach HydroLab DS 5 water probe and surveyor. Weather conditions were also noted. The water samples that were taken at each site were sent to the Unified State Laboratory in Taylorsville, Utah where TDS and ion concentrations were measured.

Flow rates of the various tributaries were measured simultaneously with the water samples that were collected. The units for the flow measurements were in cubic feet per second. The flow rates for the Provo River and Hobble Creek for the relevant sample dates and times were taken from the United States Geological Survey which monitors gaging stations for these tributaries. Furthermore, the flow rates of the Jordan River for the relevant sample dates were provided by the Jordan River/Utah Lake Commissioner (Dye, 2012).

Flow measurements were calculated by measuring the depth and velocity of the tributaries at two to four subsections within the total cross section. The velocity was measured using a Flo-Mate Model 2000 Portable Flow Meter, manufactured by Marsh-McBinney, Inc. The velocity sensor was set to 0.4 (from the bottom) of the surface depth to obtain the average of the velocity profile at each subsection. Multiplying the area of the sub-cross section by the average velocity gives the flow rate for each subsection. The total tributary flow rate is the sum of the subsection flows (Dye, 2012).

From November 2009 to May 2011, data for the various wastewater treatment plants (WWTP) and the Geneva Steel Site (UT 20) were acquired directly from the State of Utah. Prior to November 2009, the values for the flow rates and ion concentrations at the Geneva Steel Site were obtained by the study team.

2.2 Data Analysis

The data received from the Unified State Laboratory were entered into the Microsoft Excel program. In Excel, they were divided according to their respective site locations. Next, the flow measurements that were taken for each site were matched to the concentration data sets that were collected on the same date. Using the Excel functions, the averages and standard deviations were calculated for each set of sample concentrations. Also, the maximum and minimum values for each data set were found and recorded. All outliers that were found were removed from the data sets.

The data sets were then separated by seasons along with their respective flow measurements. Past projects characterized the seasons by dividing the year in different ways (O'Neill, 1992). However, the seasons in this study were defined by dividing the year into only

three seasons and grouping them into the following months: March through June were spring months, July through September were summer months, and October through February were winter months. For the collected sample data in this study, this definition of the seasons produced the most logical and consistent results.

Each TDS and ion concentration set was plotted with its respective flow measurements. TDS and ion concentrations were plotted on the y-axis and flow measurements were plotted on the x-axis for each season. In order to fit diverse data distributions, Excel has a variety of trendline types which include; linear, exponential, power, logarithmic, and polynomial. The type of trendline chosen for each data set depended largely on what produced the best coefficient of determination (r^2). However, the number of available data points was limited. Therefore, if a trendline produced a high r^2 value, but did not realistically project values that went beyond those of the available data points, the trendline was not selected. The objective in choosing a trendline was to have high correlations among sample concentrations and flows and to enhance predictions of ion and TDS concentrations according to flows beyond those which were measured.

The equations that described the trendlines were displayed for each season with "x" representing the variable flow. However, any r^2 value that was less than 0.4 was deemed unacceptable in order to maintain consistency with similar studies of the past (Marelli, 2010). Therefore, if a value of less than 0.4 was the best coefficient of determination that one of these trendline equations could produce, then the equation was discarded.

If an equation could not be found to accurately predict TDS and ion concentrations, then mean values were used. In similar past reports, both overall mean values and seasonal mean values were used to predict TDS and ion concentrations. Likewise, in this study, seasonal and

overall mean values were calculated and used to predict TDS and ion concentrations, if no reliable trendline equation could be determined.

For trendline equations that did produce r^2 values greater than 0.4, TDS and ion concentration values were calculated as functions of the measured flow rates. These values were plotted along with the LKSIM values generated by the existing LKSIM equations. Additionally, the actual concentration values were plotted so accuracy among the values produced by the new equations and the LKSIM values could be visually compared.

LKSIM calculates concentrations and flows from WWTPs separately from their respective tributaries as if the effluent from these plants went straight into Utah Lake. Realistically, however, the effluent of most WWTPs is carried to Utah Lake by various tributaries. For this reason, the tributaries which carried WWTP effluent are analyzed in a different manner in this study than those without WWTP effluent.

In this study, there are four tributaries that carry WWTP effluent: Millrace (UT 38B), Spring Creek (UT 43), Dry Creek (UT 47), and Benjamin Slough (UT 51). The effluent flow rates from these WWTPs were obtained directly from the plant operators. However, the flow rate for the Salem WWTP (UT 51C) was assumed to be constant at 1.2 cfs. This was justified since the effluent from this WWTP is discharged from ponds with small fluctuations. The Timpanogos WWTP Ponds (UT 71) and Orem WWTP (UT 27A) both discharge directly into Utah Lake. As mentioned earlier, beginning in October of 2009, monthly measurements were acquired upstream from the WWTP points of discharge into these four tributaries.

For Millrace, Spring Creek, and Dry Creek the water quality data upstream from the WWTP are available to LKSIM with the flow rate values downstream from the WWTP minus the WWTP discharge flow rates. It was assumed that the water quality upstream for these

tributaries would be the same downstream if the WWTP effluent was not taken into account. If the WWTP discharge was not available, then the seasonal mean discharge was used instead. This assumption was made since the difference in flow rates between the upstream measurements and the downstream measurements without the WWTP effluent were within a range of 3 cubic feet per second (cfs).

However, Benjamin Slough (UT 51) sustained a much greater difference in its upstream and downstream flow rates than the other three tributaries. Therefore, the influence of the Payson WWTP (UT 51A) and Salem WWTP (UT 51C) on UT 51 was removed using a mass balance equation.

2.3 Limitations

In similar studies in the past, statistical programs such as Minitab were used to analyze the data. The trendline equations that were produced by such statistical programs generated very high r^2 values, often greater than 0.9. On average, the r^2 values found by the Excel program were about 0.6. Since the collected data for this study only span a 26 month period, it would be misleading if a large quantity of the trendline equations had r^2 values greater than 0.9. For this reason, the statistical functions of the Excel program, although simple in comparison to such programs as Minitab, were found to be sufficient for this data analysis.

It should be noted that the equations and averages might be considerably different for some of the sites, if data had also been collected during average and low runoff years, instead of the three high runoff years of 2009 - 2011. For example, the 47 year average flow rate of the Provo River measured at the Woodland station is 211 cfs, whereas the average flow rate at this station for the past three years is 257 cfs. Also, the 83 year average flow rate of the Spanish Fork River

measured at the Castilla station is 237 cfs, whereas the average flow rate for the past three years at that location is 287 cfs.

Likewise, the average precipitation for the past 30 years measured at the Provo/BYU station is 20.13 inches, whereas the average precipitation for the past three years at that same station is 23.14 inches. Further, the average Spanish Fork precipitation for the past 30 years is 21.55 inches, whereas the average at the same location for the past three years is 25.74 inches. This must be kept in mind in the ultimate use of the data in trying simulate a full range of high to low runoff years.

The trendline equations likely work best at predicting TDS and ion concentrations when the flow rates are within the maximum and minimum flow rates that were measured in the 26 month period. Beyond these flow rates, the predicted concentration values may be significantly inaccurate.

In the case that a good trendline equation cannot be found, mean values are used to predict the behavior of a TDS or ion concentration. However, mean values only work well at forecasting concentrations when variations among the sample concentrations are small. If variations among concentration values are large, then a mean value may not produce an accurate prediction.

3 RESULTS

3.1 Trendline Equations and Seasonal Mean Values

The trendline equations that were produced by the Excel program to predict the concentrations for each tributary and the Jordan River Outlet are displayed in Table 3.1-1. The units for "flow" should be in cubic feet per second (cfs). The seasons of winter, spring, and summer are represented either by the integer 0 or 1 depending on the time of year. If an equation has a single value multiplied with a season, then the single value represents the seasonal mean. The annual mean concentrations for TDS and the various ions of the tributaries can be found in the subsequent section called "Graphs."

As mentioned earlier, there are four tributaries that carry WWTP effluent. The flow rates for these tributaries were calculated by subtracting the flow rate of the WWTP discharge from the flow rate downstream of the WWTP. These flow values were used in the analysis of the four tributaries. For Millrace, Spring Creek, and Dry Creek, the TDS and ion concentrations upstream from their respective WWTPs were measured. These water quality measurements were used in analysis for Millrace, Spring Creek, and Dry Creek. However, the TDS and ion concentrations for Benjamin Slough were obtained by calculating out Payson WWTP (UT 51A) and Salem WWTP (UT 51C) using a mass balance equation. For this reason, these four

tributaries that carry WWTP effluent will have an asterisk (*****) next to them indicating that the effect of the WWTP effluents was factored out.

Table 3-1: Equations and Seasonal Mean Values

Station	Parameter	Equation
UT 9	TDS	{winter * $392.26e^{0.0144 * flow}$} + {summer * $541.26e^{-0.058}$} + {spring * [(0.0326 * $flow^3$) - (1.0824 * $flow^2$) + (3.6272 * flow) + 518.43]}
	HCO_3	{winter * [(-0.3317 * $flow^3$) + (12.505 * $flow^2$) - (152.06 * flow) + 923.37]} + {summer * [(1.5191 * $flow^2$) - (28.731 * flow) + 421.79]} + {spring * [(0.0881 * $flow^3$) - (4.0798 * $flow^2$) + (54.526 * flow) + 83.987]}
	Ca	{winter * [(0.136 * $flow^2$) - (3.5299 * flow) + 106.11]} + {summer * $85.722e^{-0.009 * flow}$} + {spring * [(0.0142 * $flow^3$) - (0.6769 * $flow^2$) + (9.5302 * flow) + 37.032]}
	Cl	{winter * [(-0.2338 * $flow^3$) + (9.4021 * $flow^2$) - (117.88 * flow) + 495.61]} + {summer * [(-0.1827 * $flow^3$) + (4.7449 * $flow^2$) - (38.824 * flow) + 145.39]} + {spring * [(-0.0218 * $flow^3$) + (1.0648 * $flow^2$) - (15.725 * flow) + 117.47]}
	Mg	{winter * 39.2} + {summer * 40.7} + {spring * 38.8}
	K	{winter * [(0.0158 * $flow^2$) - (0.3577 * flow) + 5.3165]} + {summer * [(-0.0174 * $flow^3$) + (0.4426 * $flow^2$) - (3.5509 * flow) + 12.648]} + {spring * [(0.0026 * $flow^3$) - (0.1202 * $flow^2$) + (1.7001 * flow) - 4.1544]}
	Na	{winter * 30.8} + {summer * 30.6} + {spring * 29.6}
	SO_4	{winter * 101} + {summer * 88.8} + {spring * 89.6}
UT 13	TDS	{winter * [(1.5345 * $flow^2$) - (25.664 * flow) + 412.12]} + {summer * [(0.3556 * $flow^2$) - (10.267 * flow) + 379.11]} + {spring * [(0.0027 * $flow^2$) - (1.2563 * flow) + 305.84]}
	HCO_3	{winter * [276.12 * $flow^{-0.12}$]} + {summer * [(-0.2436 * $flow^2$) - (0.3147 * flow) + 245.79]} + {spring * $194.94e^{-7E-04 * flow}$}
	Ca	{winter * [(0.2029 * $flow^2$) - (3.7619 * flow) + 86.816]} + {summer * [(-0.3604 * $flow^2$) + (3.9898 * flow) + 66.687]} + {spring * $62.712e^{-0.001 * flow}$}
	Cl	{winter * 19.062 * $flow^{-0.263}$} + {summer * [(-0.4993 * $flow^2$) + (5.5447 * flow) + 10.128]} + {spring * 11.502 * $flow^{-0.025}$}
	Mg	{winter * [(0.092 * $flow^2$) - (1.5785 * flow) + 27.426]} + {summer * [(-0.1863 * $flow^2$) + (1.9211 * flow) + 20.327]} + {spring * [(0.0001 * $flow^2$) - (0.0705 * flow) + 19.812]}

Table 3-1: Continued

	K	{winter * [(0.0236 * flow^2) - (0.3922 * flow) + 2.5677]} + {summer * [(-0.0194 * flow^3) + (0.3267 * flow^2) - (1.6031 * flow) + 4.1646]} + {spring * [1.4248 * flow$^{-0.079}$]}
	Na	{winter * [(0.0934 * flow^2) - (1.694 * flow) + 15.408]} + {summer * [(-0.2548 * flow^2) + (2.8258 * flow) + 8.2376]} + {spring * [-1.087 * LN(flow) + 10.193]}
	SO_4	{winter * [(-0.3395 * flow^2) + (7.4526 * flow) + 69.061]} + {summer * [(-0.3655 * flow^2) + (3.3381 * flow) + 51.437]} + {spring * 103.67 * flow$^{-0.252}$}
UT 18	TDS	{winter * [(2.0795 * flow^2) - (63.375 * flow) + 1082.3]} + {summer * [4558.5 * flow$^{-0.668}$]} + {spring * [1489.5 * flow$^{-0.32}$]}
	HCO_3	{winter * [(0.6819 * flow^2) - (22.161 * flow) + 521.97]} + {summer * [(0.6673 * flow^2) - (33.1 * flow) + 692.58]} + {spring * 857.96 * flow$^{-0.331}$}
	Ca	{winter * [(0.2274 * flow^2) - (7.9192 * flow) + 165.51]} + {summer * [(0.1219 * flow^2) - (6.7559 * flow) + 176.64]} + {spring * [-19.46 * LN(flow) + 147.2]}
	Cl	{winter * [(0.761 * flow^2) - (23.262 * flow) + 222.56]} + {summer * [(0.1624 * flow^2) - (8.3312 * flow) + 143.24]} + {spring * 161.88 * flow$^{-0.322}$}
	Mg	{winter * [(0.1681 * flow^2) - (5.5174 * flow) + 87.333]} + {summer * [(0.0535 * flow^2) - (3.1024 * flow) + 78.64]} + {spring * 126.27 * flow$^{-0.391}$}
	K	{winter * [(0.033 * flow^2) - (0.8158 * flow) + 9.69]} + {summer * [(0.0142 * flow^2) - (0.8485 * flow) + 16.799]} + {spring * [7.7128 * flow$^{-0.108}$]}
	Na	{winter * [(0.0942 * flow^2) - (0.0183 * flow) + 23.282]} + {summer * [(0.0725 * flow^2) - (4.5392 * flow) + 101.55]} + {spring * 104.52 * flow$^{-0.259}$}
	SO_4	{winter * [(0.5296 * flow^2) - (15.159 * flow) + 258.99]} + {summer * [(0.22 * flow^2) - (15.137 * flow) + 349.84]} + {spring * 458.34 * flow$^{-0.392}$}
UT 20	TDS	{winter * [(-95.683 * flow^2) + (769.45 * flow) - 650.21]} + {summer * 1169.4 * flow$^{-0.412}$} + {spring * 961.86e$^{-0.049 * flow}$}
	HCO_3	{winter * [(-53.449 * flow^2) + (520.2 * flow) - 956.38]} + {summer * [(-1.7087 * flow^2) + (27.906 * flow) + 109.49]} + {spring * [(0.2315 * flow^3) - (8.5538 * flow^2) + (85.442 * flow) + 19.048]}
	Ca	{winter * [(-20.008 * flow^2) + (193.45 * flow) - 367.08]} + {summer * [(-0.4063 * flow^2) + (6.5194 * flow) + 41.091]} + {spring * [(0.0293 * flow^3) - (1.1533 * flow^2) + (10.515 * flow) + 59.286]}

Table 3-1: Continued

	Cl	{winter * $1948.1e^{-0.549}$ * flow} + {summer * [(-0.8341 * $flow^3$) + (26.903 * $flow^2$) - (281.12 * flow) + 1002.1]} + {spring * [(0.0483 * $flow^3$) - (1.3482 * $flow^2$) + (5.0638 * flow) + 124.05]}
	Mg	{winter * [(-22.477 * $flow^2$) + (219.16 * flow) - 474.15]} + {summer * 42.378 * $flow^{-0.163}$} + {spring * [(0.031 * $flow^3$) - (1.09 * $flow^2$) + (9.7211 * flow) + 24.96]}
	K	{winter * [(-10.829 * $flow^2$) + (104.36 * flow) - 223.01]} + {summer * [(0.0944 * $flow^2$) - (2.0342 * flow) + 22.255]} + {spring * 56.62 * $flow^{-0.52}$}
	Na	{winter * [(-21.875 * flow) + 171.67]} + {summer * 50.096 * $flow^{-0.212}$} + {spring * $80.832e^{-0.056 * flow}$}
	SO_4	{winter * [(-65.376 * $flow^2$) + (633.92 * flow) - 1338.7]} + {summer * [(0.6723 * $flow^2$) - (14.633 * flow) + 175.25]} + {spring * [-74.81 * LN(flow) + 313.57]}
UT 27	TDS	{winter * [(-2.5394 * $flow^3$) + (38.621 * $flow^2$) - (164.57 * flow) + 580.31]} + {summer * [(-3.4352 * $flow^2$) + (42.676 * flow) + 288.66]} + {spring * [(2.3788 * $flow^3$) - (46.324 * $flow^2$) + (290.86 * flow) - 159.61]}
	HCO_3	{winter * [(-0.9258 * $flow^2$) + (12.336 * flow) + 261.44]} + {summer * [(-3.3251 * $flow^2$) + (38.189 * flow) + 185.23]} + {spring * [(-3.5679 * $flow^3$) + (61.885 * $flow^2$) - (343.09 * flow) + 889.86]}
	Ca	{winter * 80.2} + {summer * 72.4} + {spring * 77.4}
	Cl	{winter * 23.9} + {summer * 24.3} + {spring * 25.9}
	Mg	{winter * 29.2} + {summer * 29.9} + {spring * 29.9}
	K	{winter * 7.35} + {summer * 7.65} + {spring * 7.23}
	Na	{winter * 21.5} + {summer * 21.9} + {spring * 21.6}
	SO_4	{winter * 94.1} + {summer * 73.7} + {spring * 88.5}
UT 27A	TDS	{winter * 608} + {summer * 598} + {spring * 596}
	HCO_3	{winter * $107.26e^{0.0558 * flow}$} + {summer * [(-10.039 * $flow^2$) + (281.59 * flow) - 1739.2]} + {spring * [(14.671 * $flow^2$) - (407.77 * flow) + 3051.9]}
	Ca	{winter * [(3.2988 * $flow^2$) - (78.762 * flow) + 527.97]} + {summer * [(0.3819 * $flow^2$) + (9.8141 * flow) + 125.79]} + {spring * [(0.8501 * $flow^2$) - (22.671 * flow) + 214.21]}
	Cl	{winter * 159} + {summer * 156} + {spring * 153}
	Mg	{winter * [(1.401 * $flow^2$) - (33.662 * flow) + 222.42]} + {summer * [(0.1724 * $flow^2$) - (4.3674 * flow) + 49.461]} + {spring * [(0.4144 * $flow^3$) - (17.169 * $flow^2$) + (236.05 * flow) - 1054.5]}

Table 3-1: Continued

	K	{winter * [(0.6025 * flow^2) - (14.24 * flow) + 97.623]} + {summer * [(0.1442 * flow^2) - (3.9764 * flow) + 40.919]} + {spring * [(-0.4041 * flow^2) + (11.814 * flow) - 70.546]}
	Na	{winter * 114} + {summer * 111} + {spring * 110}
	SO_4	{winter * 82.3} + {summer * 74.1} + {spring * 82.5}
UT 29	TDS	{winter * [(-0.0005 * flow^2) + (0.3423 * flow) + 195.23]} + {summer * [(0.0097 * flow^2) - (2.5149 * flow) + 359.85]} + {spring * 409.28 * flow$^{-0.089}$]}
	HCO_3	{winter * [(-3E-07 * flow^3) + (0.0003 * flow^2) - (0.0719 * flow) + 187.38]} + {summer * [417.04 * flow$^{-0.207}$]} + {spring * 284.79 * flow$^{-0.085}$}
	Ca	{winter * [(-1E-05 * flow^2) + (0.0258 * flow) + 50.223]} + {summer * [(0.0011 * flow^2) - (0.3133 * flow) + 71.043]} + {spring * [(2E-08 * flow^3) - (6E-05 * flow^2) + (0.0326 * flow) + 52.403]}
	Cl	{winter * 15.5} + {summer * 15.7} + {spring * 16.4}
	Mg	{winter * [(-3E-05 * flow^2) + (0.0153 * flow) + 12.526]} + {summer * [(0.0002 * flow^2) - (0.0714 * flow) + 16.979]} + {spring * [(-2E-06 * flow^2) - (0.0001 * flow) + 13.953]}
	K	{winter * 1.99} + {summer * 2.33} + {spring * 2.00}
	Na	{winter * [(-4E-07 * flow^3) + (0.0003 * flow^2) - (0.0491 * flow) + 13.935]} + {summer * [(0.0003 * flow^2) - (0.0635 * flow) + 16.659]} + {spring * [-1.077 * LN(flow) + 18.721]}
	SO_4	{winter * 45.1} + {summer * 36.9} + {spring * 40.8}
UT 38B*	TDS	{winter * [(1.0329 * flow^2) - (11.666 * flow) + 580.62]} + {summer * [(-140 * flow) + 1022]} + {spring * 664.15e$^{-0.049 * flow}$}
	HCO_3	{winter * [(-3.1764 * flow^2) + (23.07 * flow) + 363.32]} + {summer * [(-3.4348 * flow) + 382.33]} + {spring * 413.17e$^{-0.033 * flow}$}
	Ca	{winter * [(-0.8171 * flow^2) + (5.7677 * flow) + 94.156]} + {summer * [(-0.486 * flow^2) + 3.8745 * flow) + 89.451]} + {spring * [(-0.1229 * flow^2) + (0.7723 * flow) + 93.806]}
	Cl	{winter * [-5.236 * LN(flow) + 99.033]} + {summer * 83.966e$^{0.0147 * flow}$} + {spring * 134.08e$^{-0.105 * flow}$}
	Mg	{winter * [(-0.3735 * flow^2) + (2.3685 * flow) + 38.938]} + {summer * 39.622e$^{-0.01 * flow}$} + {spring * 47.789e$^{-0.063 * flow}$}
	K	{winter * [(-0.0528 * flow^2) + (0.4086 * flow) + 5.515]} + {summer * 6.0535e$^{-0.013 * flow}$} + {spring * 6.9406e$^{-0.069 * flow}$}
	Na	{winter * [(0.5127 * flow^2) - (4.7755 * flow) + 53.361]} + {summer * 51.128 * flow$^{-0.08}$} + {spring * 60.259e$^{-0.085 * flow}$}

Table 3-1: Continued

	SO_4	{winter * [(-0.6367 * flow^2) + (3.2493 * flow) + 69.051]} + {summer * 56.386e$^{-0.003 * flow}$} + {spring * 66.847e$^{-0.051 * flow}$}
UT 38A	TDS	{winter * [(3.1099 * flow^2) - (127.95 * flow) + 1816.8]} + {summer * [(-10.686 * flow^2) + (500.13 * flow) - 5220.5]} + {spring * 919.95e$^{-0.022 * flow}$}
	HCO_3	{winter * [(1.1669 * flow^2) - (41.896 * flow) + 535.7]} + {summer * [100.4 * LN(flow) - 111.73]} + {spring * 26.532 * flow$^{0.6443}$}
	Ca	{winter * 35.047e$^{0.0296 * flow}$} + {summer * [(-0.5652 * flow^2) + (26.444 * flow) - 230.73]} + {spring * [(0.2545 * flow^2) - (9.7779 * flow) + 163.42]}
	Cl	{winter * 100} + {summer * 122} + {spring * 128}
	Mg	{winter * [(0.1197 * flow^2) - (4.4735 * flow) + 62.364]} + {summer * [(-0.3374 * flow^2) + (15.874 * flow) - 160.46]} + {spring * [(0.0888 * flow^2) - (3.6577 * flow) + 60.61]}
	K	{winter * [(-0.0066 * flow^2) + (0.2681 * flow) + 7.9124]} + {summer * [(0.0331 * flow^2) - (1.652 * flow) + 31.223} + {spring * 19.614e$^{-0.029 * flow}$}
	Na	{winter * [(0.3491 * flow^2) - (12.119 * flow) + 174.7]} + {summer * 25.039 * flow$^{0.3949}$} + {spring * [(0.1506 * flow^2) - (10.163 * flow) + 228.73]}
	SO_4	{winter * [(0.3639 * flow^2) - (11.675 * flow) + 139.52]} + {summer * [(-4.7786 * flow^2) + (224.45 * flow) - 2544.4]} + {spring * [(-0.2861 * flow^2) + (14.915 * flow) - 128.92]}
UT 42	TDS	{winter * 960} + {summer * 972} + {spring * 969}
	HCO_3	{winter * [(-1.1033 * flow^2) + (27.936 * flow) + 113.73]} + {summer * [(-0.0805 * flow^2) + (1.1444 * flow) + 262.65]} + {spring * [(-0.1797 * flow^3) + (7.3177 * flow^2) - (99.103 * flow) + 724.73]}
	Ca	{winter * 167} + {summer * 173} + {spring * 168}
	Cl	{winter * [(-1.3688 * flow^2) + (33.576 * flow) - 127.51]} + {summer * [(-0.3794 * flow^2) + (9.3109 * flow) + 13.177]} + {spring * [(0.1997 * flow^2) - (5.938 * flow) + 114.23]}
	Mg	{winter * [(-0.0538 * flow^3) + (1.5338 * flow^2) - (13.026 * flow) + 85.223]} + {summer * [(-0.0419 * flow^2) + (1.0282 * flow) + 48.58]} + {spring * [(-0.0566 * flow^3) + (2.278 * flow^2) - (30.896 * flow) + 195.12]}
	K	{winter * [(-0.0456 * flow^3) + (1.3708 * flow^2) - (12.878 * flow) + 43.846]} + {summer * [(0.0046 * flow^3) - (0.1494 * flow^2) + (1.5624 * flow) + 0.3896]} + {spring * [(0.1174 * flow^2) - (3.3607 * flow) + 30.051]}

Table 3-1: Continued

	Na	{winter * [(-0.2049 * flow^3) + (6.2019 * flow^2) - (58.434 * flow) + 216.45]} + {summer * [(0.0296 * flow^3) - (0.8927 * flow^2) + (8.2861 * flow) + 22.152]} + {spring * [-18.64 * LN(flow) + 94.671]}
	SO_4	{winter * 422} + {summer * 401} + {spring * 410}
UT 43*	TDS	{winter * [(-4.3162 * flow^2) + (84.458 * flow) + 425.61]} + {summer * [(-8.1633 * flow) + 895.43]} + {spring * [(0.6517 * flow^2) - (28.212 * flow) + 1039.2]}
	HCO_3	{winter * 284} + {summer * 291} + {spring * 273}
	Ca	{winter * [(-0.4354 * flow^2) + (7.6619 * flow) + 121.04]} + {summer * [(-4.3624 * flow) + 178.31]} + {spring * [(-0.0762 * flow^2) + (1.8173 * flow) + 131.94]}
	Cl	{winter * 51.9} + {summer * 51.9} + {spring * 48.9}
	Mg	{winter * [(-0.1256 * flow2) + (2.3262 * flow) + 38.932]} + {summer * [(-1.3758 * flow) + 57.513]} + {spring * [(-0.0495 * flow2) + (1.3948 * flow) + 37.324]}
	K	{winter * 4.76} + {summer * 4.84} + {spring * 4.65}
	Na	{winter * 39.1} + {summer * 38.8} + {spring * 37.8}
	SO_4	{winter * [(-2.0039 * flow^2) + (30.866 * flow) + 231.55]} + {summer * [(2.7693 * flow2) - (51.649 * flow) + 515.8]} + {spring * [(0.3941 * flow^2) - (14.819 * flow) + 393.86]}
UT 43A	TDS	{winter * 587} + {summer * 608} + {spring * 603}
	HCO_3	{winter * 123.8 * flow$^{0.4052}$} + {summer * 206.53e$^{0.0482 * flow}$} + {spring * [(18.394 * flow^2) - (211.96 * flow) + 858.74]}
	Ca	{winter * 26.27 * flow$^{0.4793}$} + {summer * 18.497 * flow$^{0.683}$} + {spring * [(5.2266 * flow^2) - (60.904 * flow) + 237.99]}
	Cl	{winter * [(10.997 * flow^2) - (113.63 * flow) + 411.04]} + {summer * [(5.1207 * flow) + 92.126]} + {spring * [(22.895 * flow^2) - (249.71 * flow) + 801.58]}
	Mg	{winter * [(-6.8504 * flow^2) + (82.166 * flow) - 219.89]} + {summer * 12.931 * flow$^{0.3717}$} + {spring * [(0.8629 * flow^2) - (8.7299 * flow) + 45.943]}
	K	{winter * [(1.6842 * flow^2) - (17.797 * flow) + 60.977]} + {summer * [-23.31 * LN(flow) + 59.417]} + {spring * [(-0.1991 * flow^2) + (2.0109 * flow) + 10.024]}
	Na	{winter * 27.401 * flow$^{0.743}$} + {summer * 136.68 * flow$^{-0.141}$} + {spring * [(-1.8009 * flow^2) + (18.112 * flow) + 57.811]}

Table 3-1: Continued

	SO_4	{winter * [(-58.978 * flow^2) + (696.07 * flow) - 1976.2]} + {summer * [-280.6 * LN(flow) + 582.18]} + {spring * 17.84e$^{0.1879 * flow}$}
UT 44	TDS	{winter * [(-0.0865 * flow^2) + (5.0825 * flow) + 228.75]} + {summer * [(-20.353 * flow^3) + (188.21 * flow^2) - (525.99 * flow) + 694.01]} + {spring * 258e$^{-0.001 * flow}$}
	HCO_3	{winter * [(0.03 * flow^2) - (2.8018 * flow) + 303.2]} + {summer * [(-2.4807 * flow^3) + (31.151 * flow^2) - (109.03 * flow) + 326.46]} + {spring * 216.16e$^{-0.001 * flow}$}
	Ca	{winter * [(0.0146 * flow^2) - (1.0332 * flow) + 91.049]} + {summer * [(0.9532 * flow^3) + (6.9071 * flow^2) - (11.96 * flow) + 68.404]} + {spring * 65.443e$^{-0.001 * flow}$}
	Cl	{winter * [4.2444 * flow$^{0.3033}$]} + {summer * [(-1.222 * flow^3) + (6.769 * flow^2) - (6.2046 * flow) + 13.913]} + {spring * 11.373 * flow$^{-0.02}$}
	Mg	{winter * [(-0.0011 * flow^3) + (0.1042 * flow^2) - (3.1721 * flow) + 49.147]} + {summer * [(-0.4024 * flow^3) + (2.6227 * flow^2) - (4.5759 * flow) * 21.927]} + {spring * 15.604e$^{-0.002 * flow}$}
	K	{winter * [(0.0009 * flow^2) - (0.0598 * flow) + 2.5098]} + {summer * [(-0.2427 * flow^2) + (1.3643 * flow) + 0.4744]} + {spring * [(7E-06 * flow^2) - (0.0038 * flow) + 1.4712]}
	Na	{winter * [(0.0057 * flow^2) - (0.3873 * flow) + 18.902]} + {summer * [(-0.6252 * flow^2) + (3.7568 * flow) + 11.112]} + {spring * [(6E-05 * flow^2) - (0.0418 * flow) + 11.739]}
	SO_4	{winter * [(0.0448 * flow^2) - (2.5453 * flow) + 83.637]} + {summer * [(-3.3449 * flow^3) + (21.826 * flow^2) - (33.541 * flow) + 49.393]} + {spring * 35.699e$^{-0.001 * flow}$}
UT 47*	TDS	{winter * 670} + {summer * 615} + {spring * 618}
	HCO_3	{winter * [(-0.1161 * flow^2) + (10.014 * flow) + 332.15]} + {summer * 346.19e$^{0.0104 * flow}$} + {spring * [(-0.7341 * flow^2) + (20.075 * flow) +323.4]}
	Ca	{winter * [(-0.1186 * flow^2) + (4.4792 * flow) + 47.944]} + {summer * 69.514e$^{0.0124 * flow}$} + {spring * [(-0.1406 * flow^2) + (3.4185 * flow) + 60.642]}
	Cl	{winter * 81.1} + {summer * 50.5} + {spring * 71.1}
	Mg	{winter * 34.965e$^{0.0222 * flow}$} + {summer * 44.079e$^{-0.011 * flow}$} + {spring * [(-0.1273 * flow^2) + (3.166 * flow) + 28.683]}
	K	{winter * [(0.0224 * flow^2) - (0.224 * flow) + 6.7234]} + {summer * [-6.17 * LN(flow) + 22.527} + {spring * [(-0.0232 * flow^2) + (0.6497 * flow) + 5.703]}

Table 3-1: Continued

	Na	{winter * [(0.2548 * flow^2) - (2.0304 * flow) + 46.649]} + {summer * [-16.26 * LN(flow) + 89.151]} + {spring * [(0.0301 * flow^3) - (1.5306 * flow^2) + (23.607 * flow) - 16.66]}
	SO_4	{winter * [(7.4354 * flow) - 15.447]} + {summer * [-18.92 * LN(flow) + 114.75]} + {spring * [(0.3337 * flow^2) + (10.599 * flow) + 27.073]}
UT 47A	TDS	{winter * 883} + {summer * 885} + {spring * 898}
	HCO_3	{winter * 403} + {summer * 368} + {spring * 401}
	Ca	{winter * [-53.62 * LN(flow) + 177.64]} + {summer * [(7.3955 * flow) + 34.833]} + {spring * [(-7.7805 * flow^2) + (111.65 * flow) - 318.45]}
	Cl	{winter * 1273.4e$^{-0.264 * flow}$} + {summer * [(-169.71 * flow^2) + (2356.8 * flow) - 7969.8]} + {spring * [(-51.975 * flow^2) + (711.39 * flow) - 2200]}
	Mg	{winter * [(38.917 * flow^2) - (533.21 * flow) + 1859.3]} + {summer * [(4.7686 * flow^2) - (63.663 * flow) + 248.7]} + {spring * [(-1.1679 * flow^2) + (19.939 * flow) - 45.51]}
	K	{winter * 15.6} + {summer * 15.5} + {spring * 16.0}
	Na	{winter * 177} + {summer * 169} * {spring * 185}
	SO_4	{winter * [(504.33 * flow^2) - (6874.6 * flow) + 23510]} + {summer * [-393.4 * LN(flow) + 903.11]} * {spring * 20.687 * flow$^{0.9343}$}
UT 48	TDS	{winter * [(0.0372 * flow^2) - (11.21 * flow) + 1230.7]} + {summer * [(0.0219 * flow^2) - (5.1242 * flow) + 566.98]} + {spring * 396.61e$^{-3E-04 * flow}$}
	HCO_3	{winter * [(0.0246 * flow^2) - (7.4076 * flow) + 809.53]} + {summer * [(0.0109 * flow^2) - (2.487 * flow) + 352.83]} + {spring * [(5E-07 * flow^3) - (0.0008 * flow^2) + (0.3004 * flow) + 253]}
	Ca	{winter * 68.6} + {summer * 60.4} + {spring * 64.7}
	Cl	{winter * 47.2} + {summer * 35.3} + {spring * 39.0}
	Mg	{winter * [(0.0013 * flow^2) - (0.3697 * flow) + 51.003]} + {summer * [(0.0008 * flow^2) - (0.1991 * flow) + 32.351]} + {spring * [(4E-08 * flow^3) - (7E-05 * flow^2) + (0.0232 * flow) + 23.814]}
	K	{winter * 3.44} + {summer * 3.51} + {spring * 2.91}
	Na	{winter * [(0.0041 * flow^2) - (1.1916 * flow) + 131.92]} + {summer * [-11.58 * LN(flow) + 87.98]} + {spring * 43.541e$^{-6E-04 * flow}$}
	SO_4	{winter * [(0.0032 * flow^2) - (0.9015 * flow) + 146.67]} + {summer * [(0.0042 * flow^2) - (0.9367 * flow) + 96.975]} + {spring * 67.851e$^{-7E-04 * flow}$}

Table 3-1: Continued

UT 51*	TDS	{winter * [214.44 * LN(flow) - 180.28]} + {summer * 955.87e$^{-0.014 * flow}$} + {spring * [-194.6 * LN(flow) + 1530.9}
	HCO_3	{winter * 274.64 * flow$^{0.1245}$} + {summer * 577.33e$^{-0.014 * flow}$} + {spring * [-128.21 * LN(flow) + 943.13]}
	Ca	{winter * [(-0.0028 * flow^2) + (0.3287 * flow) + 69.389]} + {summer * 54.839 * flow$^{0.0941}$} + {spring * [-14.78 * LN(flow) + 131.76}
	Cl	{winter * [53.96 * LN(flow) - 119.93]} + {summer * 21.784 * flow$^{0.5123}$} + {spring * [-26.62 * LN(flow) + 222.09]}
	Mg	{winter * [14.104 * LN(flow) - 1.8202]} + {summer * 154.95 * flow$^{-0.357}$} + {spring * [-17.65 * LN(flow) + 129.2]}
	K	{winter * 10.4} + {summer * 9.30} + {spring * 9.65}
	Na	{winter * [50.881 * LN(flow) - 112.27]} + {summer * 132.11e$^{-0.019 * flow}$} + {spring * [-38.07 * LN(flow) + 261.35]}
	SO_4	{winter * [(-0.0162 * flow^2) + (3.4609 * flow) - 4.4505]} + {summer * 598.7 * flow$^{-0.513}$} + {spring * [-43.54 * LN(flow) + 330.71]}
UT 51A	TDS	{winter * 854} + {summer * 845} + {spring * 800}
	HCO_3	{winter * 243} + {summer * 262} + {spring * 247}
	Ca	{winter * [(-90.481 * flow^2) + (380.99 * flow) - 323.02]} + {summer * [-165.6 * LN(flow) + 224.58]} + {spring * [(4.6872 * flow^2) - (17.552 * flow) + 92.465]}
	Cl	{winter * [(-167.61 * flow) + 579.27]} + {summer * [(-187.5 * flow) + 681.25]} + {spring * [(158.89 * flow^2) - (903.37 * flow) + 1465.4]}
	Mg	{winter * 23.304 * flow$^{0.2544}$} + {summer * 78.893e$^{-0.408 * flow}$} + {spring * [(3.1125 * flow^2) - (13.02 * flow) + 41.313]}
	K	{winter * [(-4.8 * flow^2) + (19.203 * flow) - 4.1514]} + {summer * [-16.59 * LN(flow) + 28.925]} + {spring * [(5.4547 * flow^2) - (29.841 * flow) + 53.894]}
	Na	{winter * [(-119.5 * flow^2) + (410.11 * flow) - 154.56]} + {summer * [(-47.368 * flow) + 278.11]} + {spring * [(36.421 * flow^2) - (210.47 * flow) + 444.15]}
	SO_4	{winter * 65.9} + {summer * 67.0} + {spring * 63.2}
UT 51C	TDS	{winter * 706} + {summer * 758} + {spring * 681}
	HCO_3	{winter * 480} + {summer * 477} + {spring * 469}
	Ca	{winter * 72.6} + {summer * 77.6} + {spring * 73.5}
	Cl	{winter * 117} + {summer * 180} + {spring * 176}
	Mg	{winter * 45.7} + {summer * 50.5} + {spring * 47.4}

Table 3-1: Continued

	K	{winter * 13.9} + {summer * 15.1} + {spring * 13.5}
	Na	{winter * 114} + {summer * 130} + {spring * 111}
	SO_4	{winter * 54.7} + {summer * 54.4} + {spring * 50.9}
UT 53	TDS	{winter * 919} + {summer * 856} + {spring * 836}
	HCO_3	{winter * 253} + {summer * 230} + {spring * 236}
	Ca	{winter * 60.8} + {summer * 50.9} + {spring * 55.2}
	Cl	{winter * [(-18.719 * (lake stage above 4400 ft)^2) + (3291.8 * lake stage above 4400 ft) - 144470]} + {summer * [(-23.619 * (lake stage above 4400 ft)^2) + (4154.3 * lake stage above 4400 ft) - 182420]} + {spring * [(-13.246 * (lake stage above 4400 ft)^2) + (2360.4 * lake stage above 4400 ft) - 104930]}
	Mg	{winter * [(-4.6093 * (lake stage above 4400 ft)^2) + (810.2 * lake stage above 4400 ft) + 35546]} + {summer * [(-10.628 * (lake stage above 4400 ft)^2) + (1878.4 * lake stage above 4400 ft) - 82935]} + {spring * [(-0.6944 * (lake stage above 4400 ft)^2) + 119.23 * (lake stage above 4400 ft) - 5058.1]}
	K	{winter * 16.2} + {summer * 16.4} + {spring * 14.1}
	Na	{winter * [(-16.87 * (lake stage above 4400 ft)^2) + (2964.7 * lake stage above 4400 ft) - 130081]} + {summer * [(-37.776 * (lake stage above 4400 ft)^2) + (6674.8 * lake stage above 4400 ft) - 294663]} + {spring * [(-9.6481 * (lake stage above 4400 ft)^2) + (1715.1 * lake stage above 4400 ft) - 76061]}
	SO_4	{winter * [(-16.596 * (lake stage above 4400 ft)^2) + (2899.8 * lake stage above 4400 ft) - 126440]} + {summer * [(-37.94 * (lake stage above 4400 ft)^2) + (6698.2 * lake stage above 4400 ft) - 295424]} + {spring * [(-8.5535 * (lake stage above 4400 ft)^2)] + (1522.8 * lake stage above 4400 ft) - 67583]}
UT 71	TDS	{winter * 732} + {summer * 742} + {spring * 717}
	HCO_3	{winter * 279} + {summer * 289} + {spring * 275}
	Ca	{winter * 71.4} + {summer * 74.0} + {spring * 70.8}
	Cl	{winter * [(-2.6944 * flow^2) + (130.69 * flow) - 1371.2]} + {summer * [(-0.5225 * flow^2) + (28.921 * flow) – 196.95]} + {spring * [(1.2839 * flow^2) - (59.997 * flow) + 896.7]}
	Mg	{winter * [(-0.9528 * flow^2) + (45.353 * flow) - 507.62]} + {summer * [(-0.0346 * flow^2) + (1.697 * flow) + 11.187]} + {spring * [(0.1081 * flow^2) - (4.1991 * flow) + 69.775]}
	K	{winter * 11.2} + {summer * 10.6} + {spring * 10.5}
	Na	{winter * 144} + {summer * 137} + {spring * 133}
	SO_4	{winter * [(-6.3889 * flow^2) + (295.39 * flow) - 3286.3]} + {summer * [(1.0798 * flow^2) - (48.983 * flow) + 648.18]} + {spring * [(1.6516 * flow^2) - (76.237 * flow) + 975.76]}

3.2 Graphs

The graphs displayed in this section show how trendline equations were developed using the new sample data. A trendline equation was produced for each seasonal set of data. Thus, a total of three trendline equations are displayed which model the behavior of the concentrations according to winter, spring, and summer. Also, the values produced by the equations displayed in the previous section are plotted along with the actual sample data points, and the existing LKSIM equations.

The values in the tables of this section depict the maximum, minimum, overall mean, seasonal mean, and the standard deviation values among the sample data. The coefficients of determination are also displayed in the table. These r^2 values correlate the "predicted" values produced by the three trendline equations with the actual, sample data points.

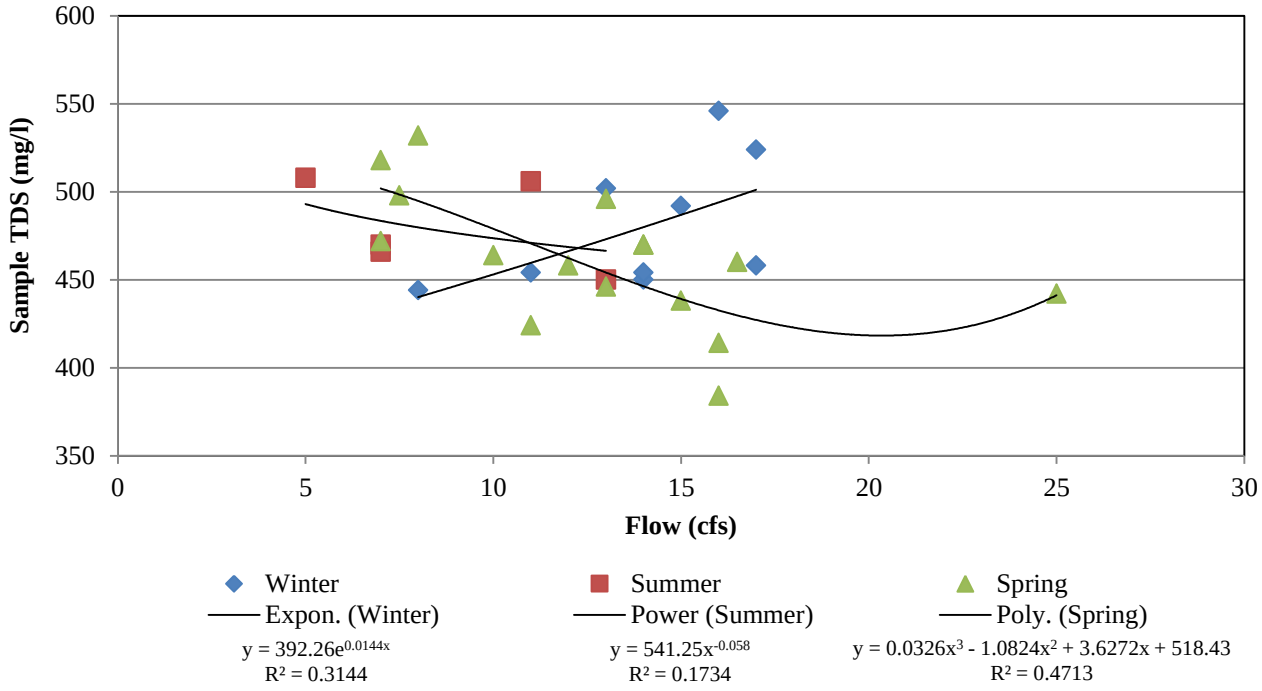

Figure 3-1: UT 9 Trendlines and Equations for TDS

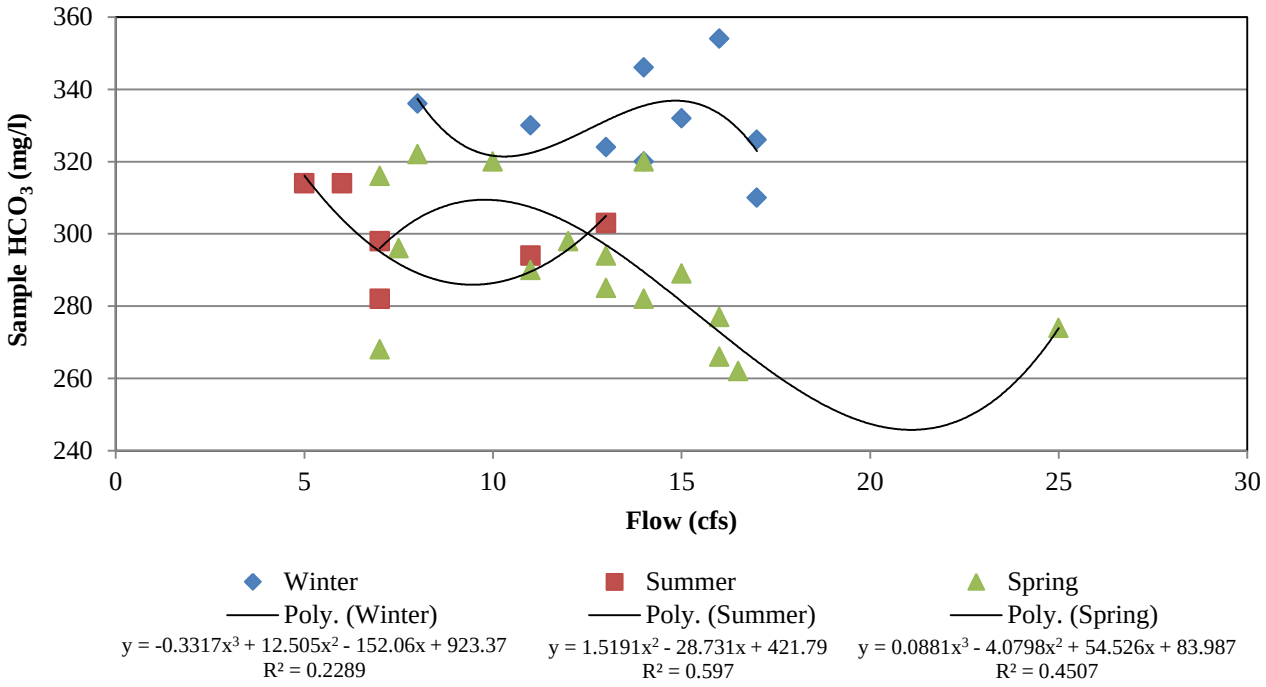

Figure 3-2: UT 9 Trendlines and Equations for HCO_3

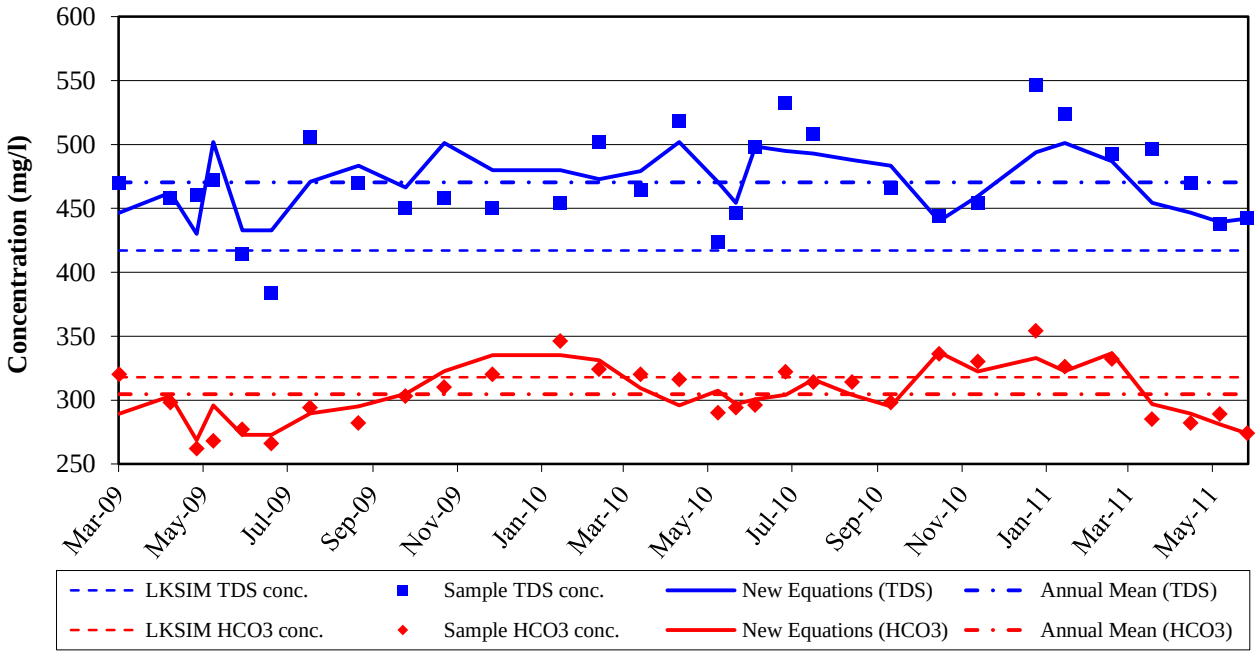

Figure 3-3: UT 9 Measured and Predicted Concentrations for TDS and HCO_3

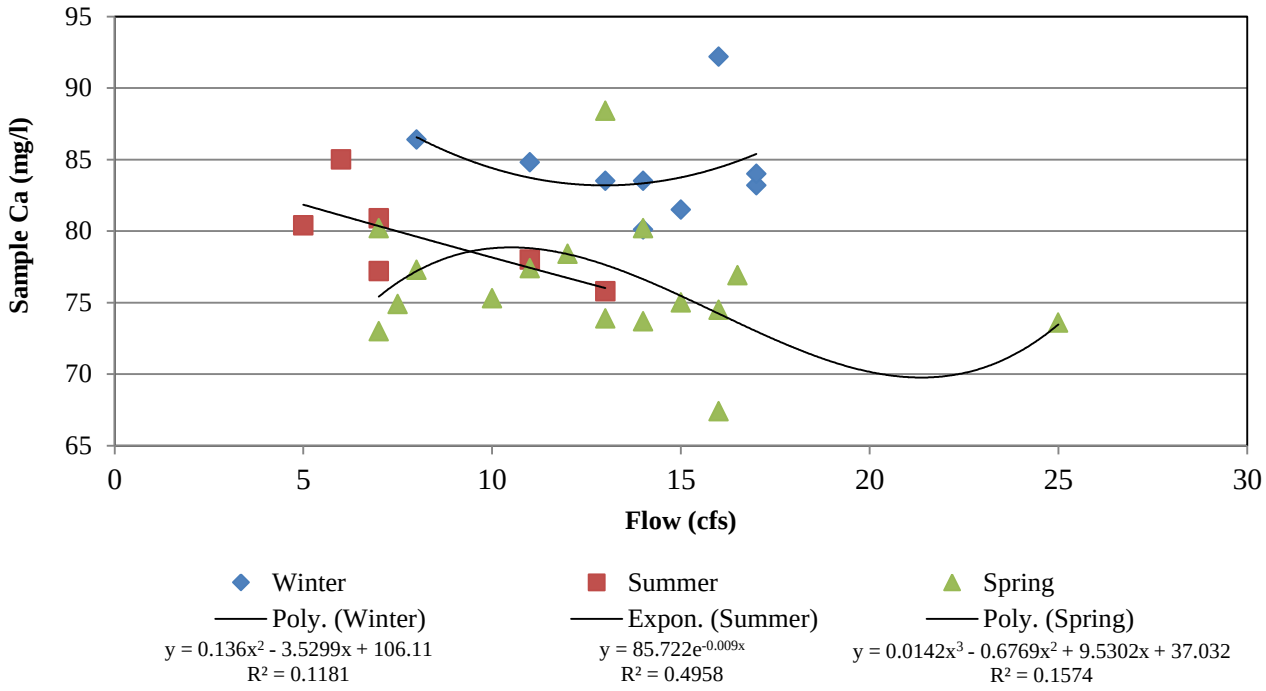

Figure 3-4: UT 9 Trendlines and Equations for Ca

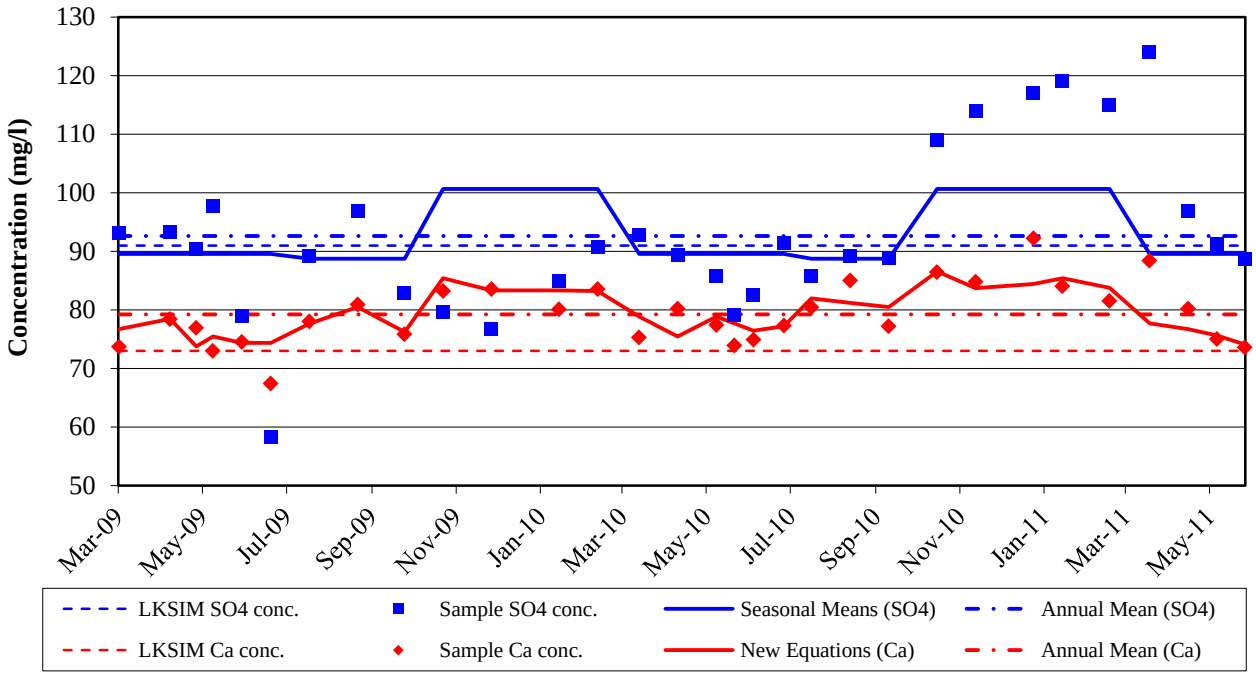

Figure 3-5: UT 9 Measured and Predicted Concentrations for SO_4 and Ca

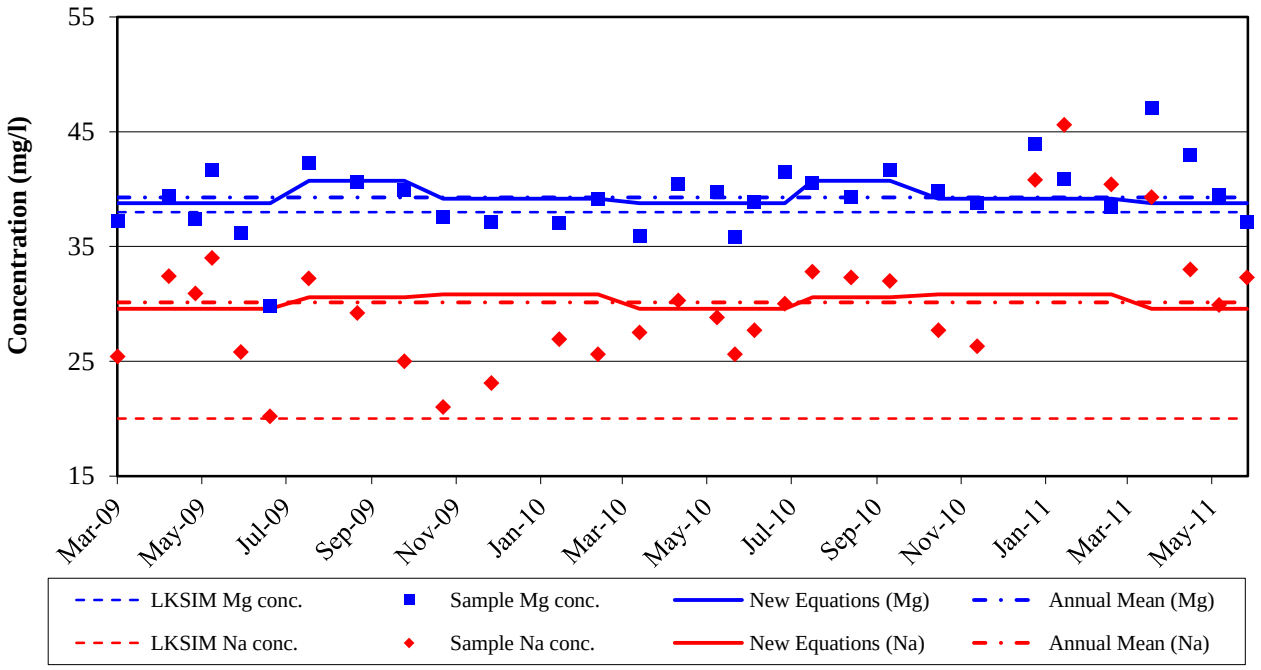

Figure 3-6: UT 9 Measured and Predicted Concentrations for Mg and Na

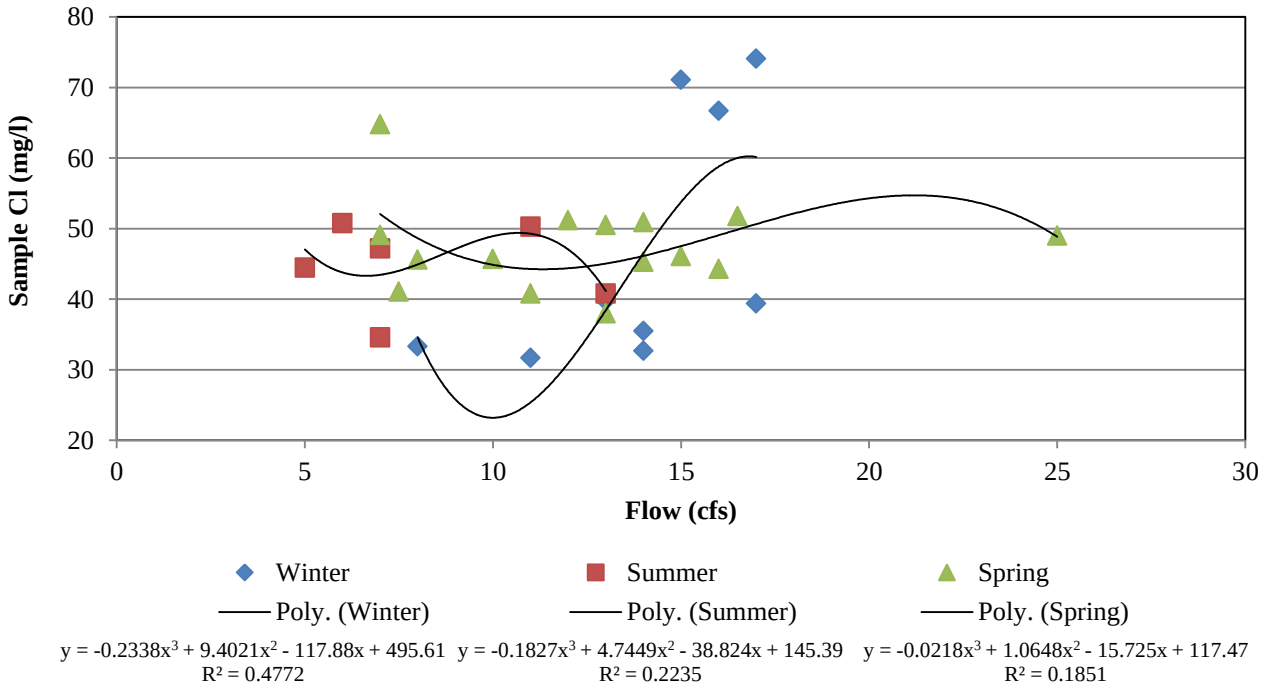

Figure 3-7: UT 9 Trendlines and Equations for Cl

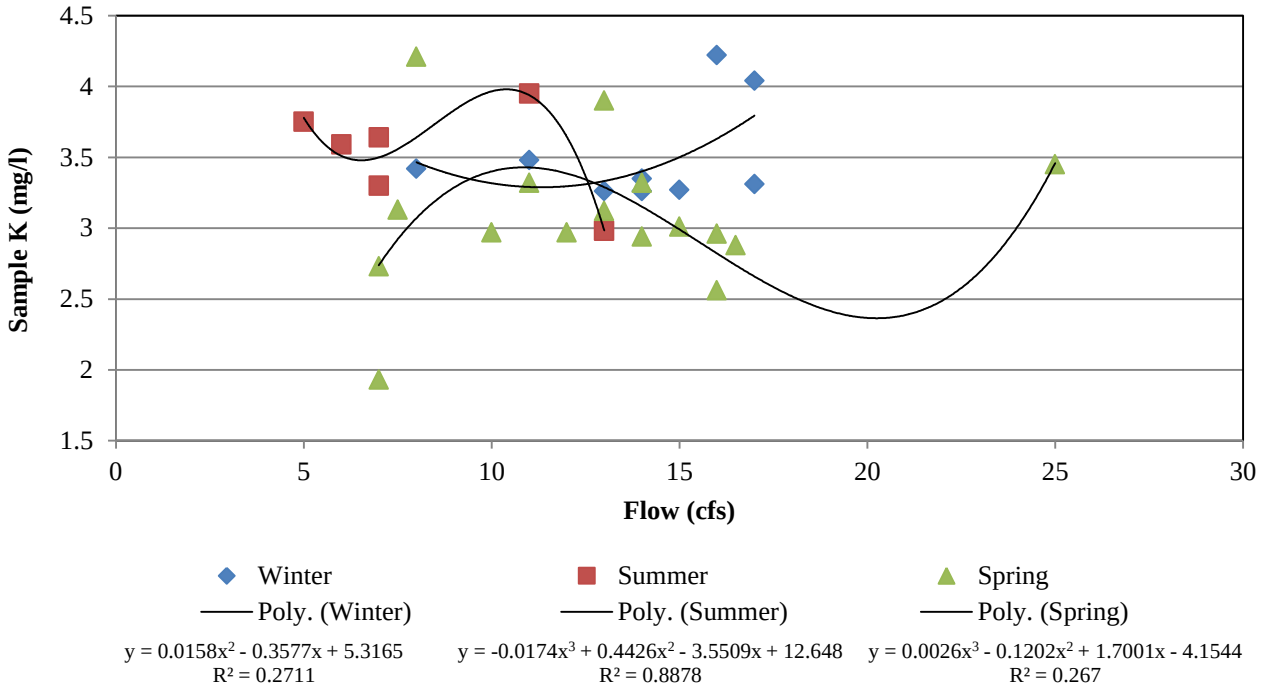

Figure 3-8: UT 9 Trendlines and Equations for K

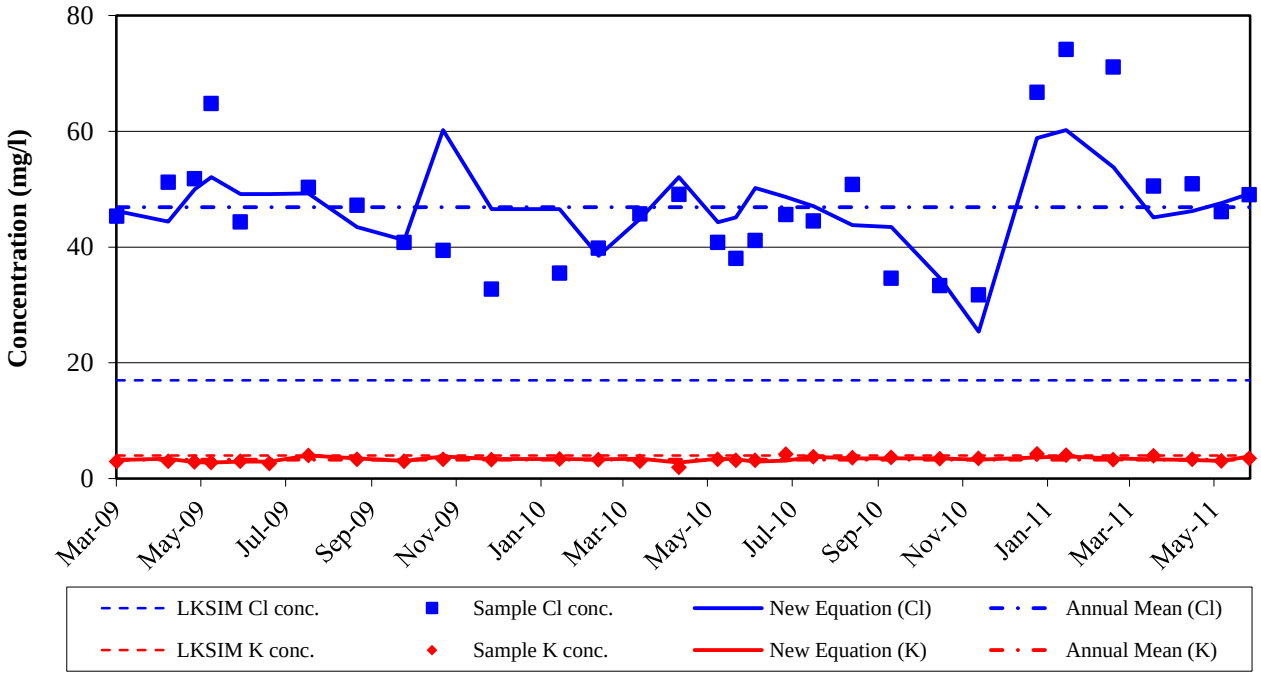

Figure 3-9: UT 9 Measured and Predicted Concentrations for Cl and K

Table 3-2: UT 9 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	546	384	470	480	480	462	36.2	0.44
HCO_3	354	262	305	331	301	291	24.0	0.73
SO_4	124	58.3	92.6	101	88.8	89.6	14.1	-
Ca	92.2	67.4	79.2	84.4	79.6	76.3	5.26	0.55
Mg	47.1	29.8	39.3	39.2	40.7	38.8	3.05	-
Na	45.6	20.2	30.1	30.8	30.6	29.6	5.72	-
Cl	74.1	31.7	46.9	47.1	44.7	47.6	10.8	0.42
K	4.22	1.93	3.30	3.51	3.54	3.09	0.487	0.46

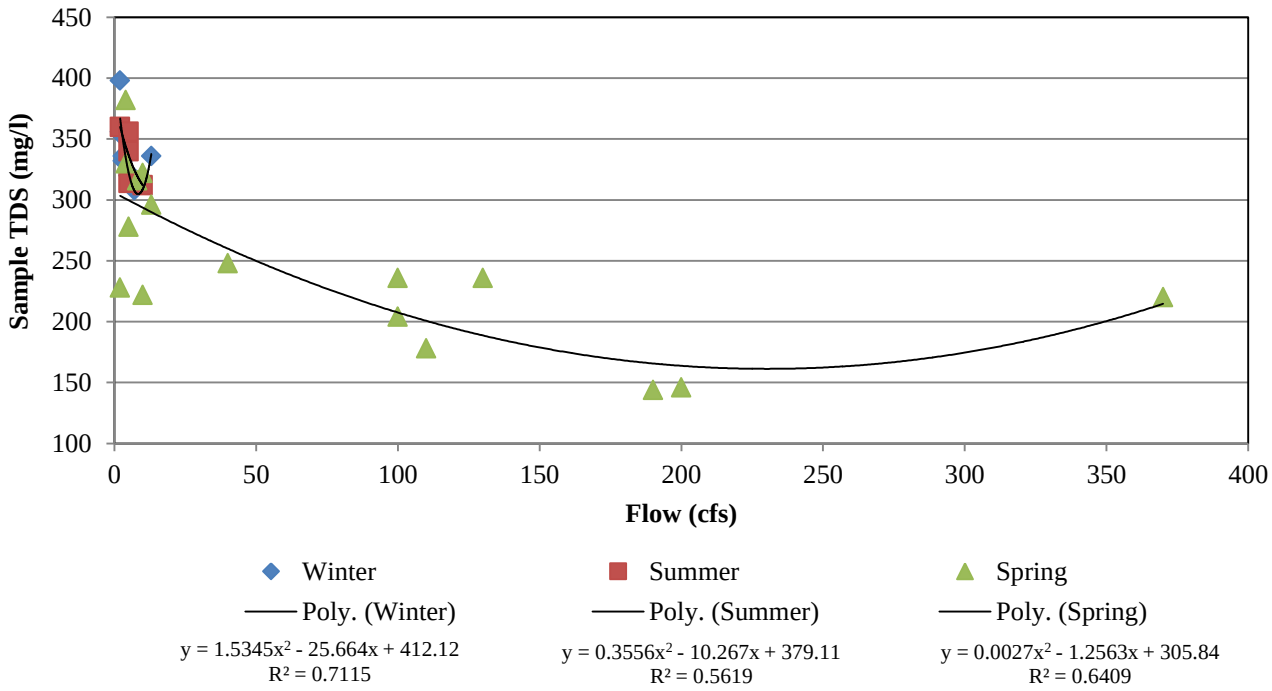

Figure 3-10: UT 13 Trendlines and Equations for TDS

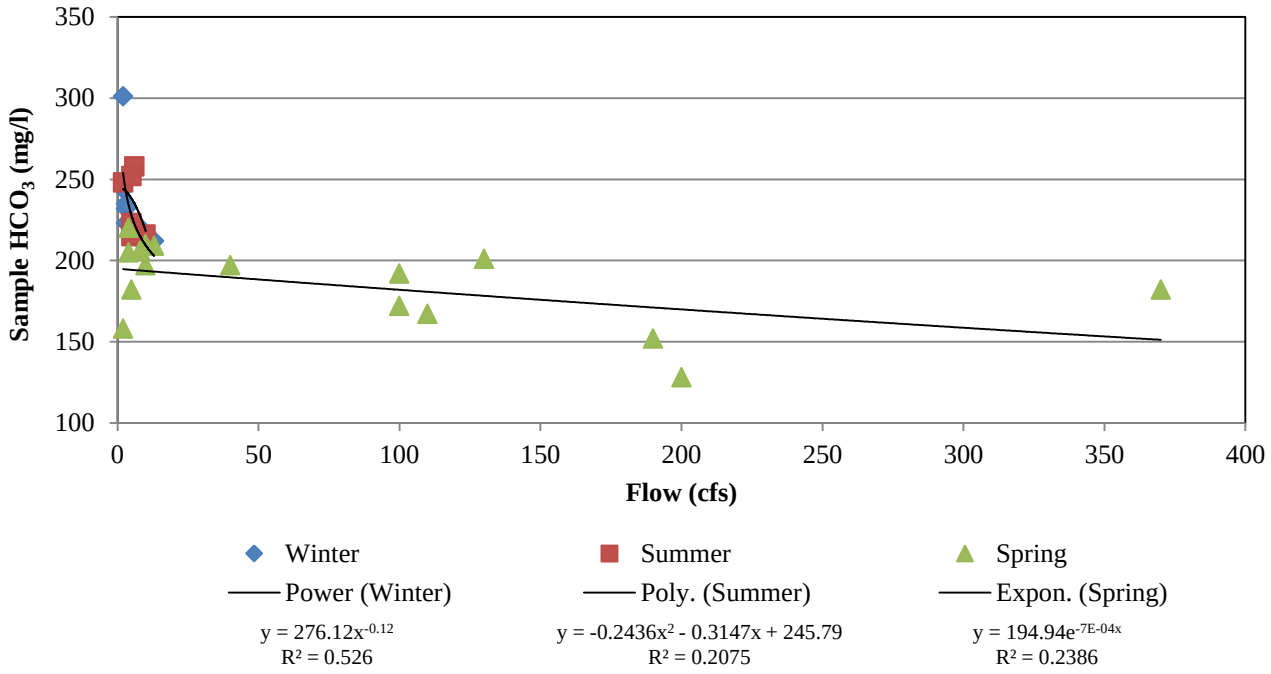

Figure 3-11: UT 13 Trendlines and Equations for HCO_3

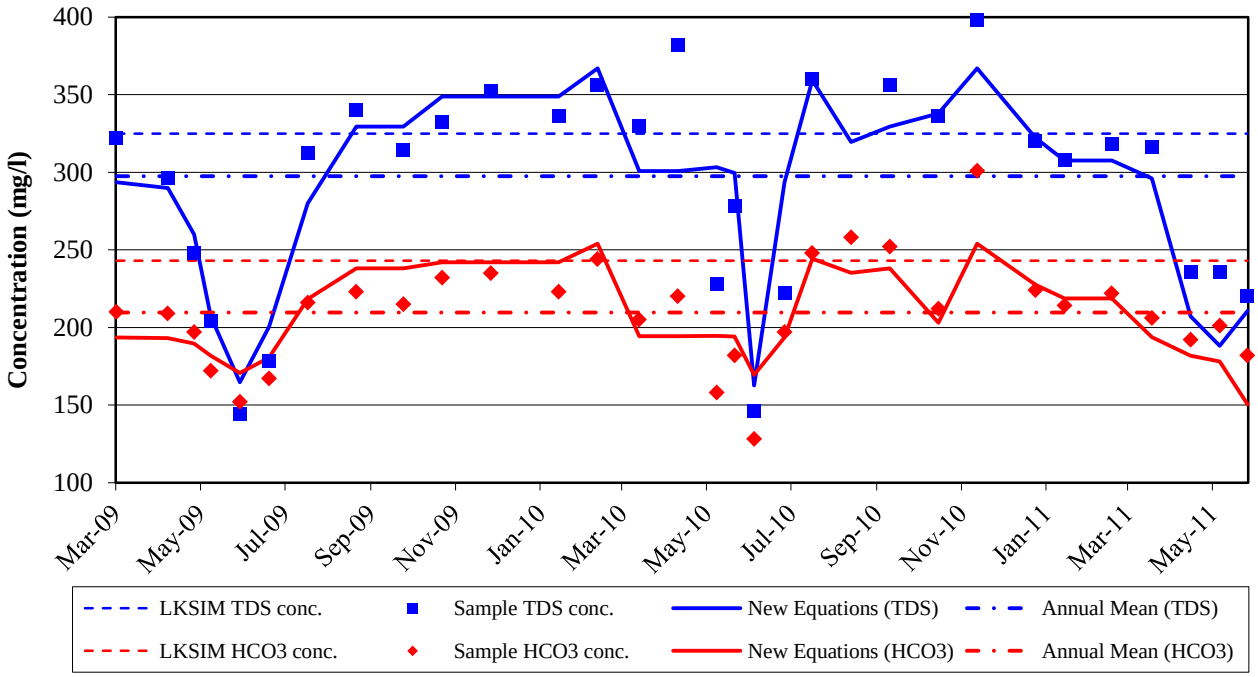

Figure 3-12: UT 13 Measured and Predicted Concentrations for TDS and HCO_3

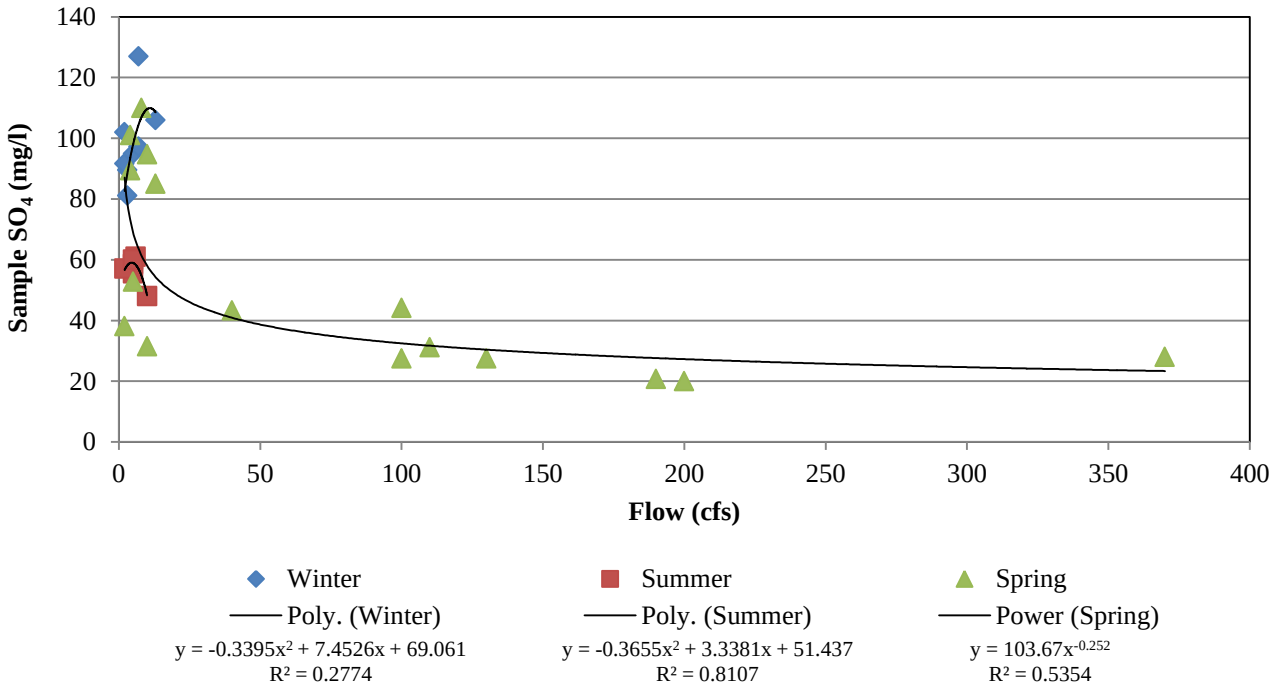

Figure 3-13: UT 13 Trendlines and Equations for SO_4

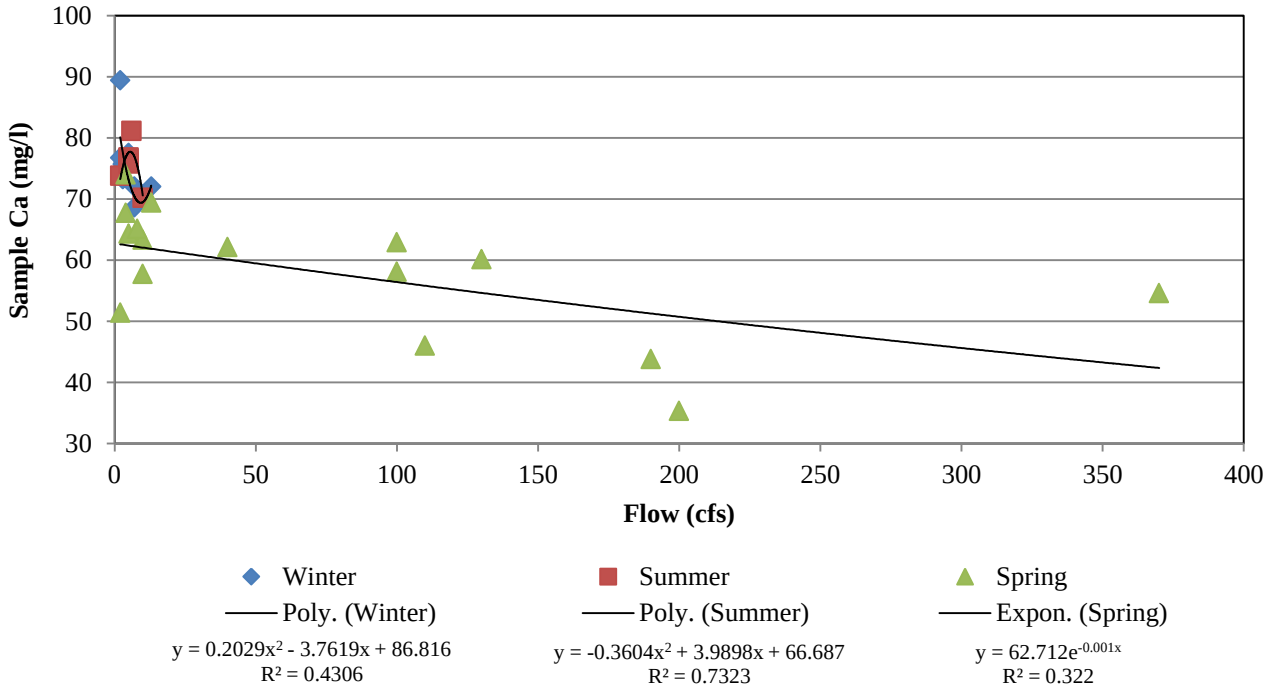

Figure 3-14: UT 13 Trendlines and Equations for Ca

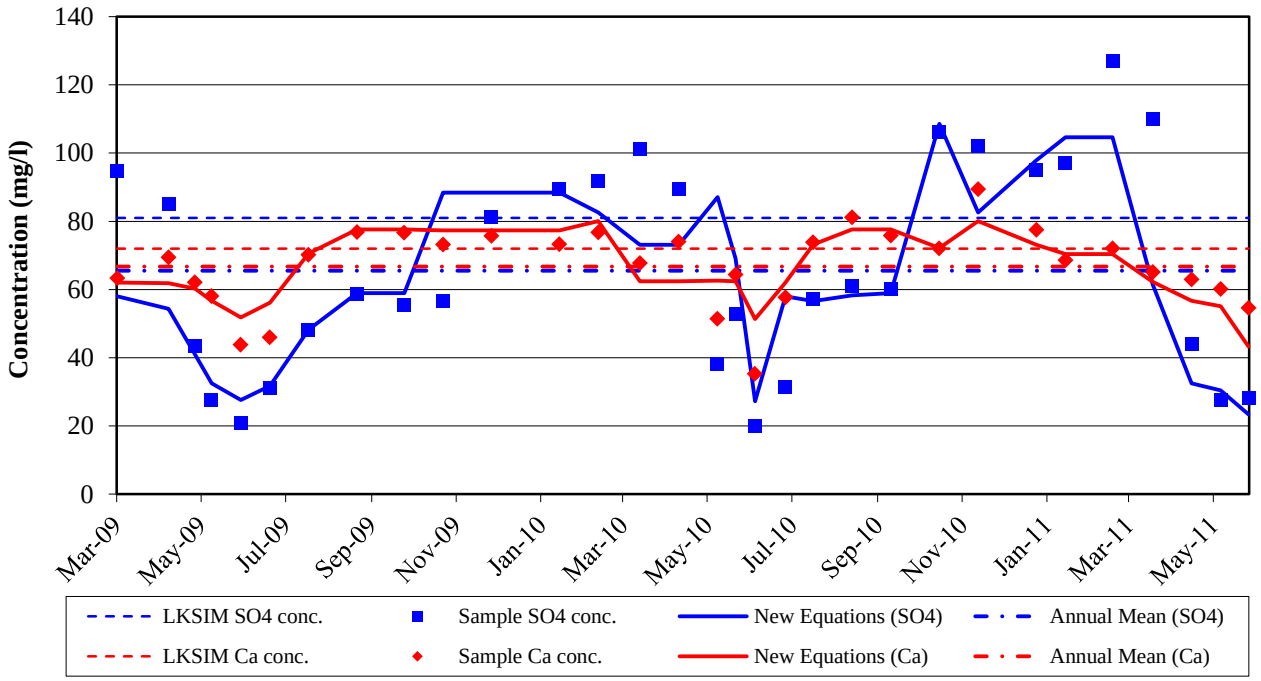

Figure 3-15: UT 13 Measured and Predicted Concentrations for SO_4 and Ca

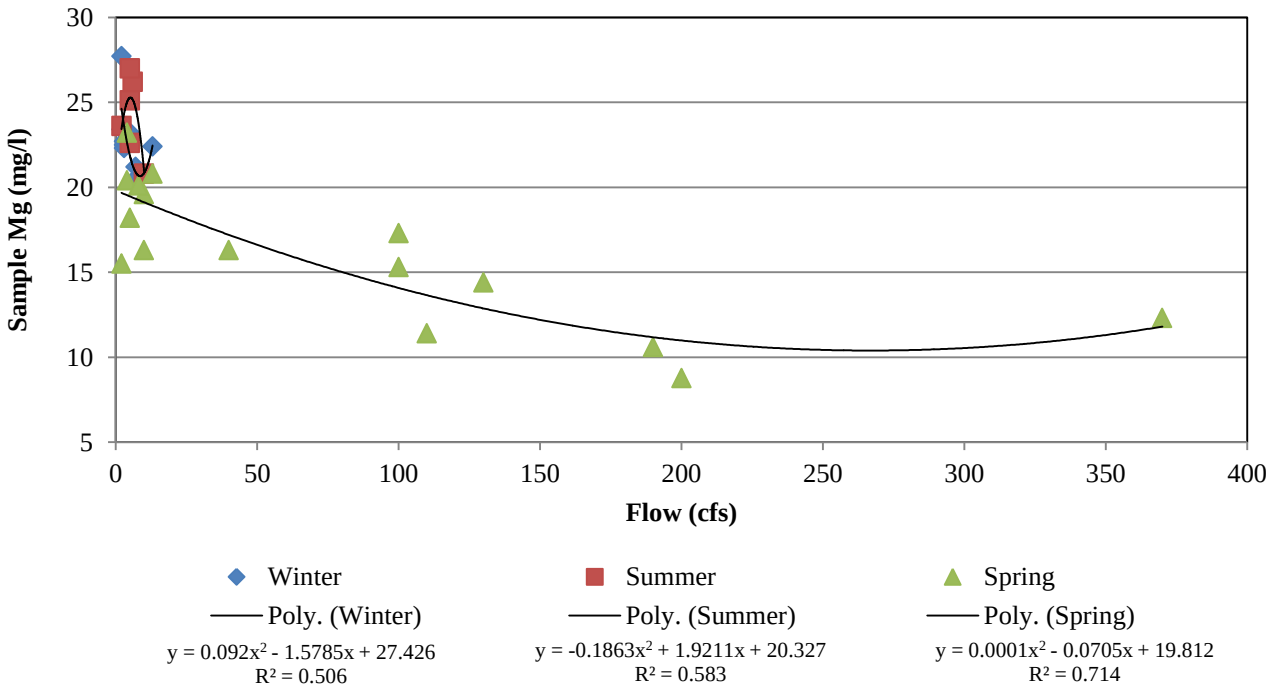

Figure 3-16: UT 13 Trendlines and Equations for Mg

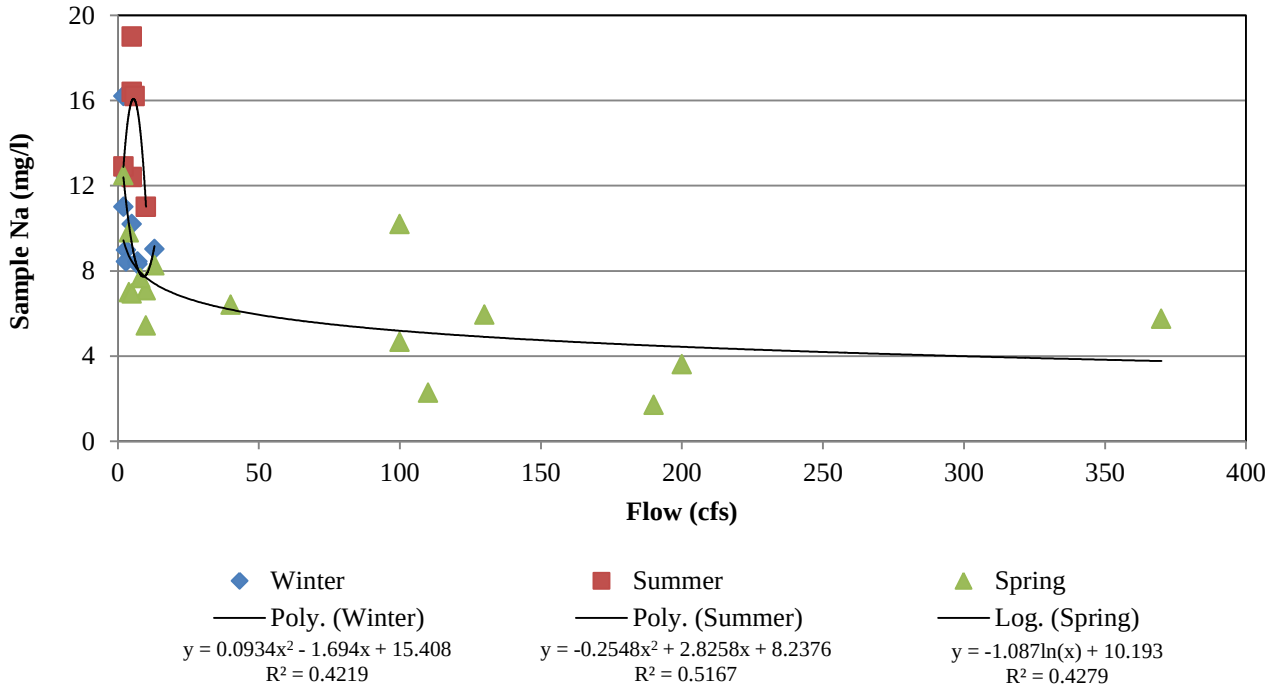

Figure 3-17: UT 13 Trendlines and Equations for Na

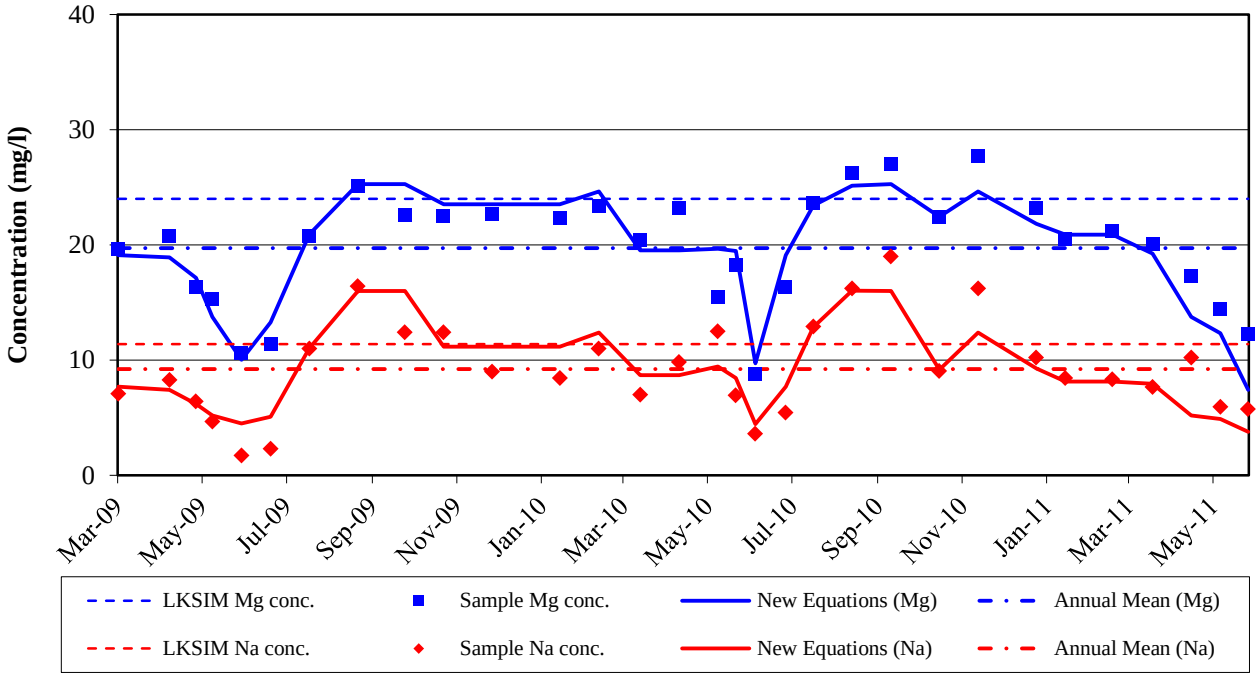

Figure 3-18: UT 13 Measured and Predicted Concentrations for Mg and Na

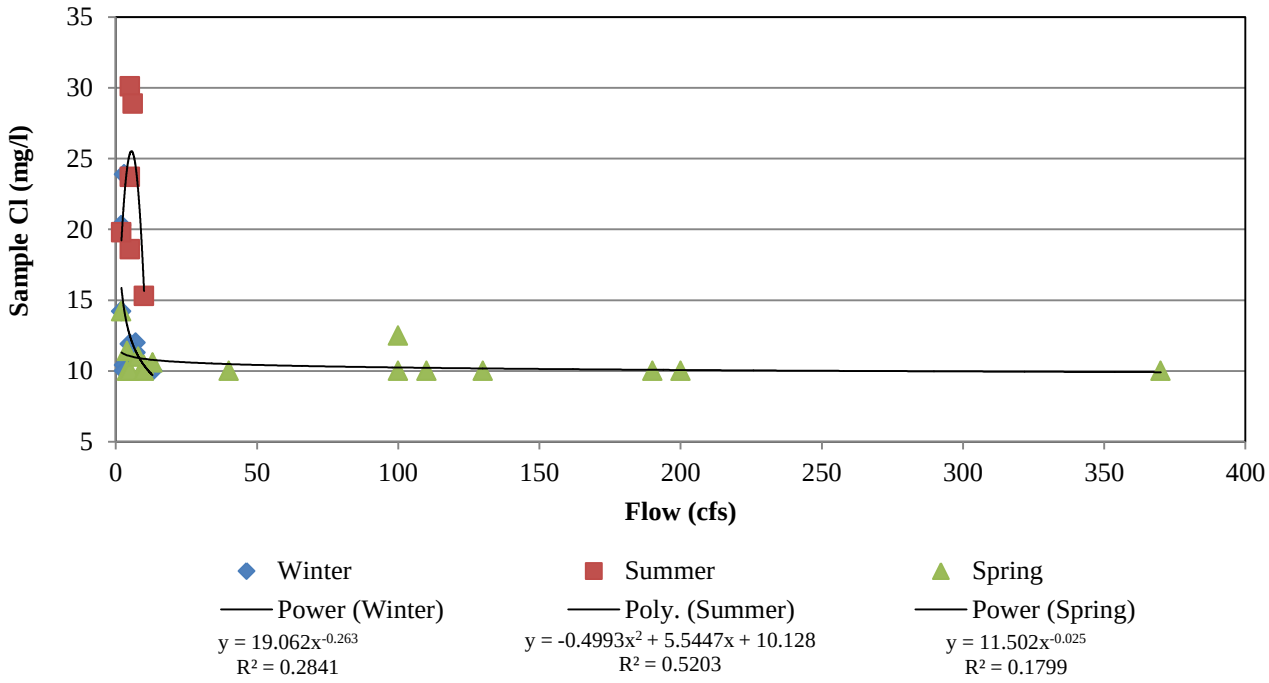

Figure 3-19: UT 13 Trendlines and Equations for Cl

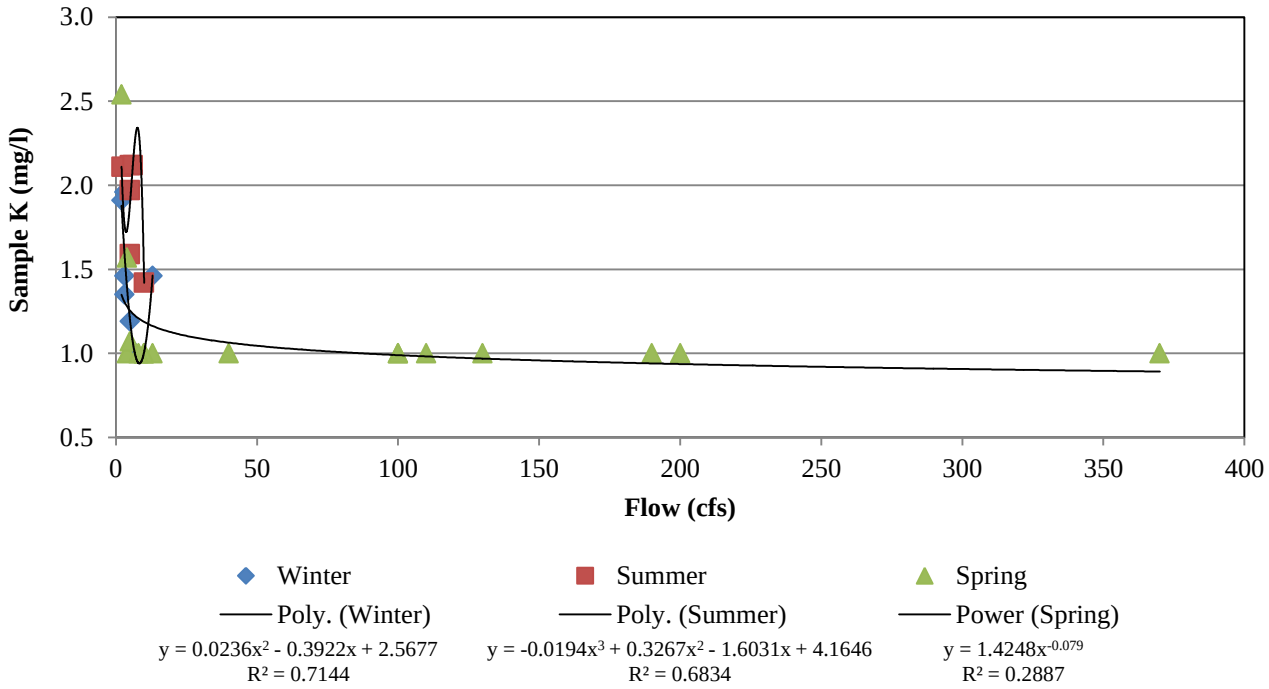

Figure 3-20: UT 13 Trendlines and Equations for K

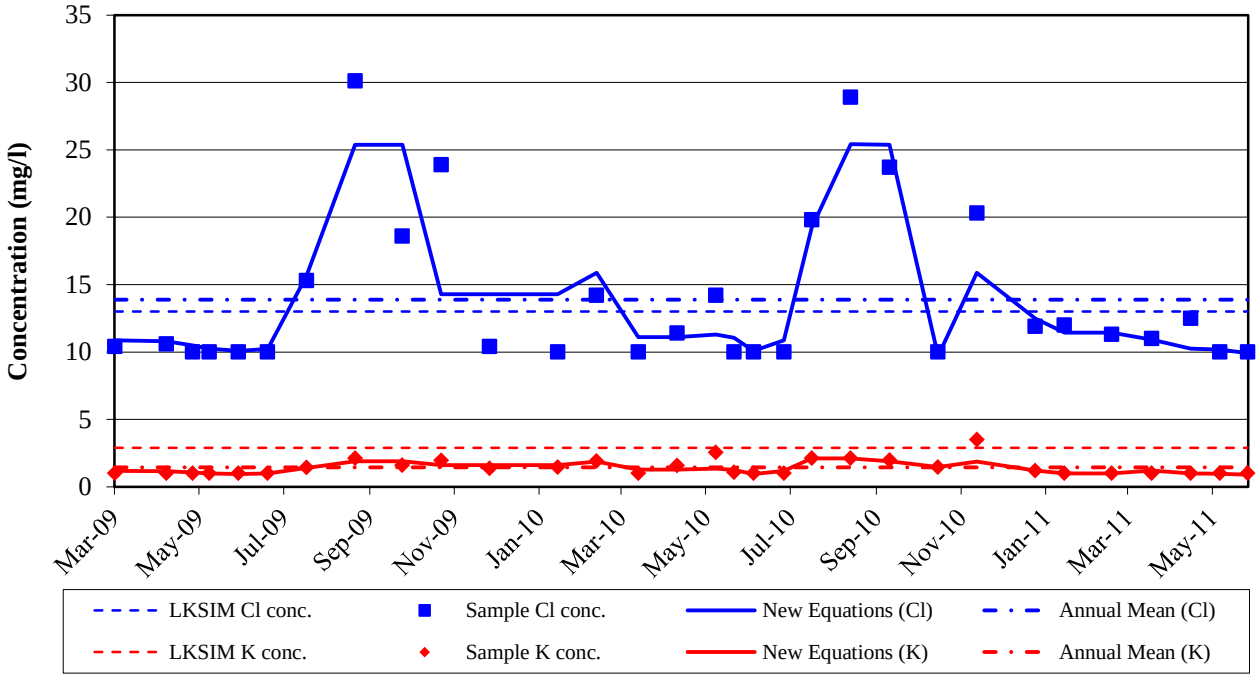

Figure 3-21: UT 13 Measured and Predicted Concentrations for Cl and K

Table 3-3: UT 13 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	500	144	298	340	336	249	77.0	0.79
HCO_3	301	128	210	234	235	186	34.3	0.68
SO_4	127	20.0	65.5	94.0	56.7	52.8	30.8	0.60
Ca	89.4	35.3	66.7	75.4	75.7	58.5	11.8	0.72
Mg	27.7	8.77	19.7	22.9	24.2	16.3	4.86	0.85
Na	19.0	1.71	9.23	10.3	14.7	6.58	4.16	0.77
Cl	30.1	10.0	13.9	13.8	22.7	10.6	5.87	0.76
K	3.49	1.00	1.43	1.42	1.89	1.14	0.597	0.66

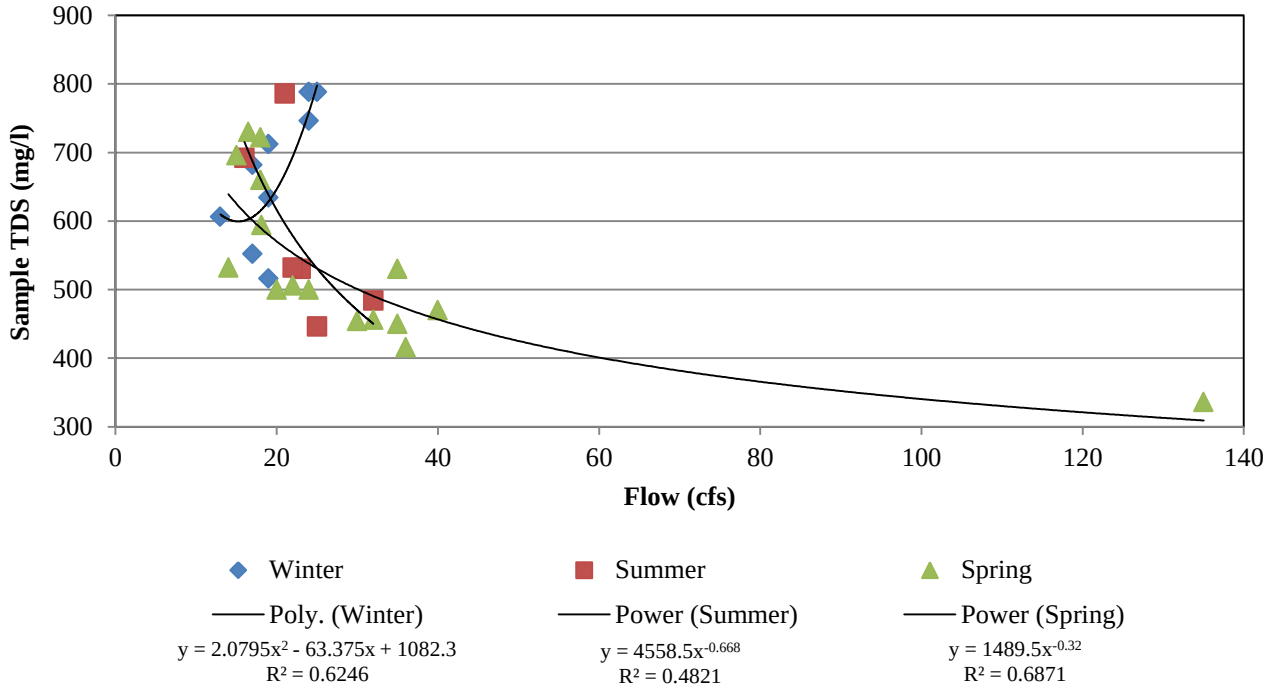

Figure 3-22: UT 18 Trendlines and Equations for TDS

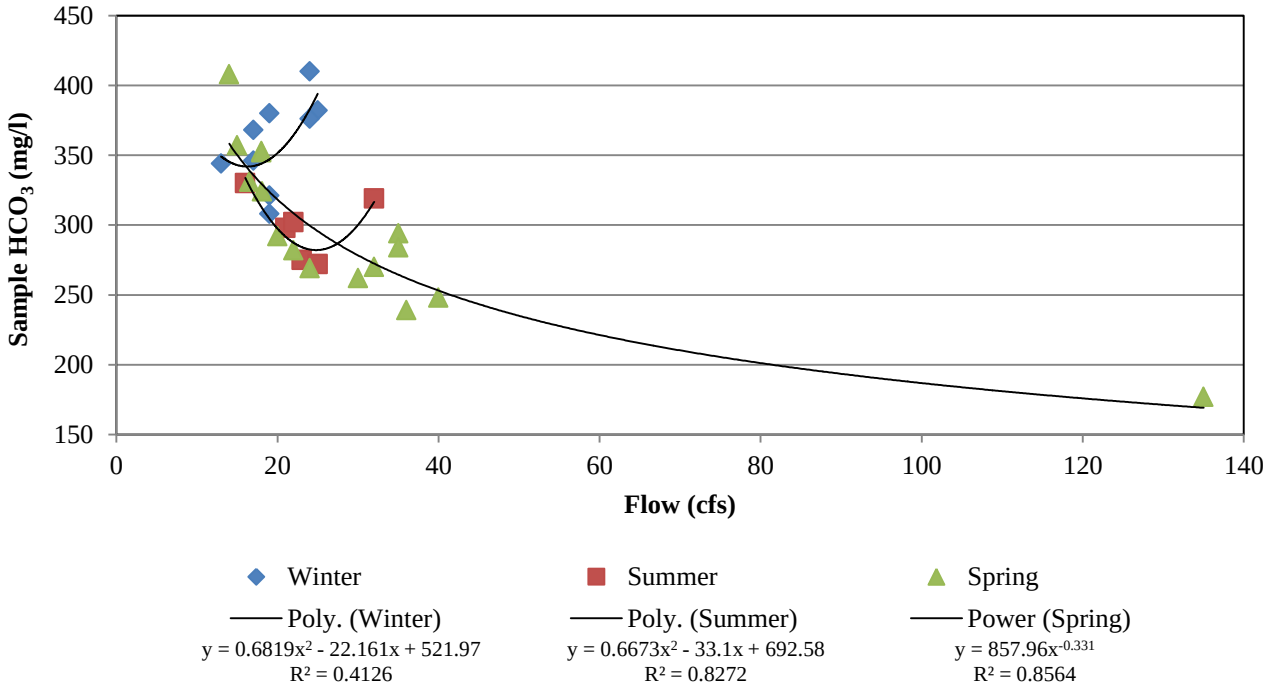

Figure 3-23: UT 18 Trendlines and Equations for HCO_3

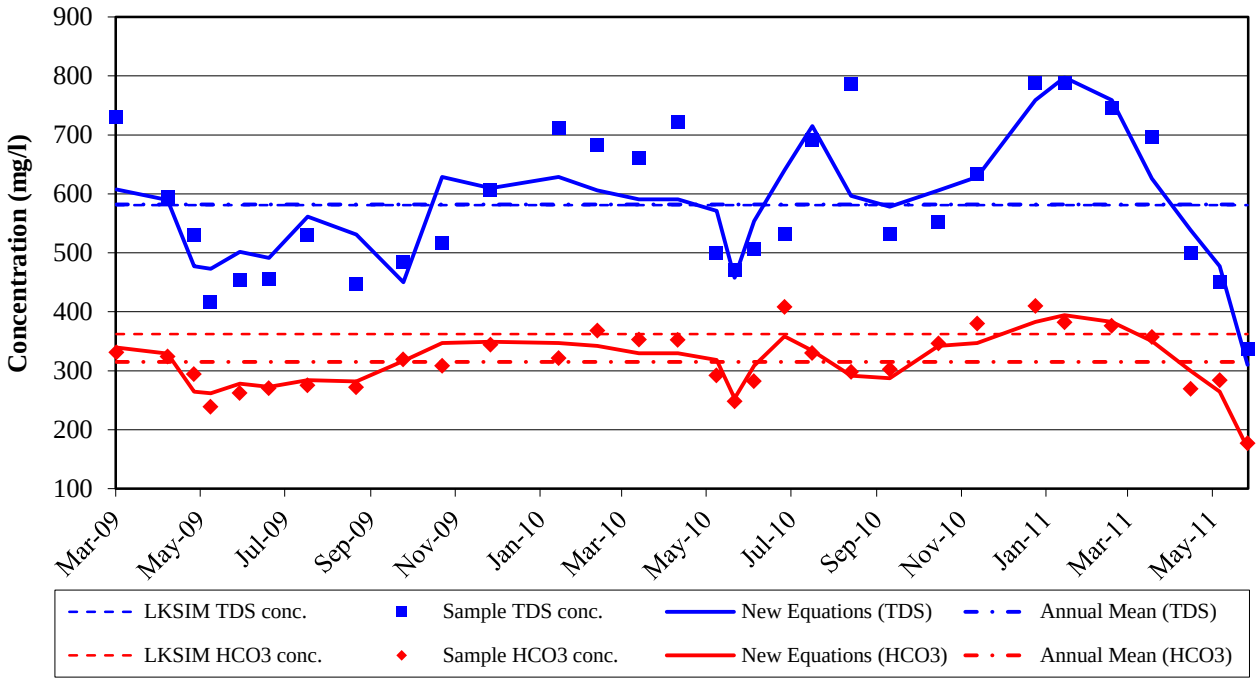

Figure 3-24: UT 18 Measured and Predicted Concentrations for TDS and HCO_3

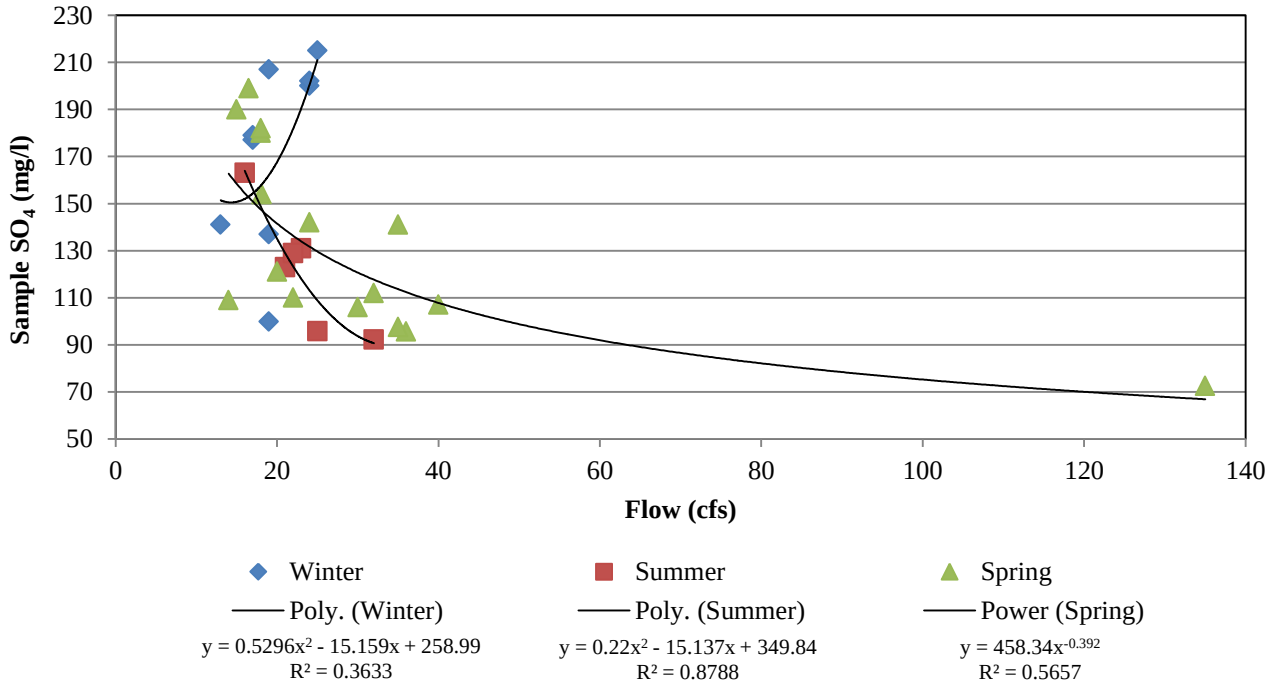

Figure 3-25: UT 18 Trendlines and Equations for SO_4

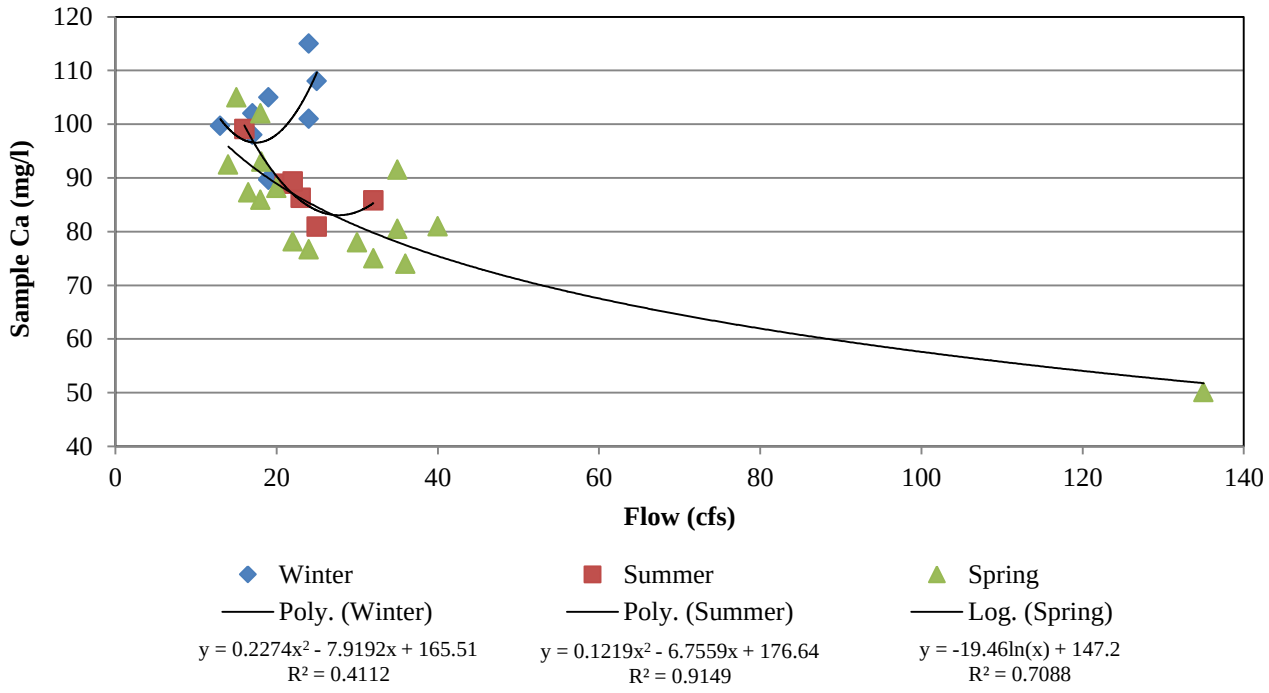

Figure 3-26: UT 18 Trendlines and Equations for Ca

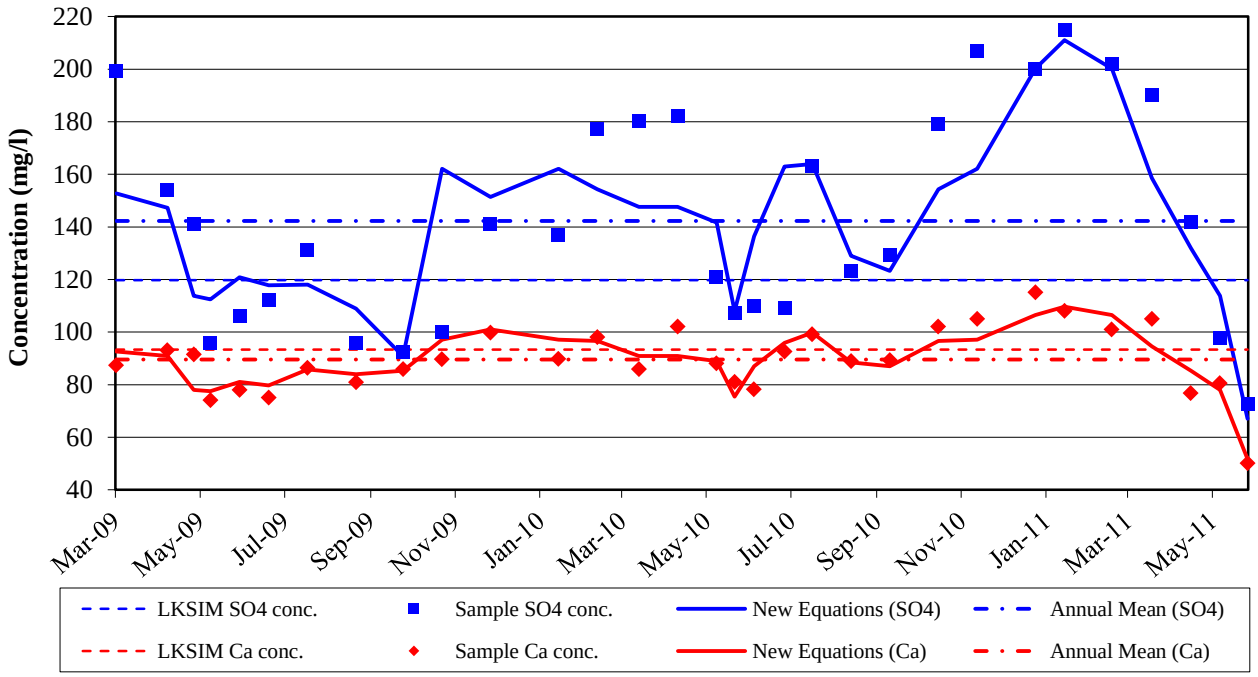

Figure 3-27: UT 18 Measure and Predicted Concentrations for SO_4 and Ca

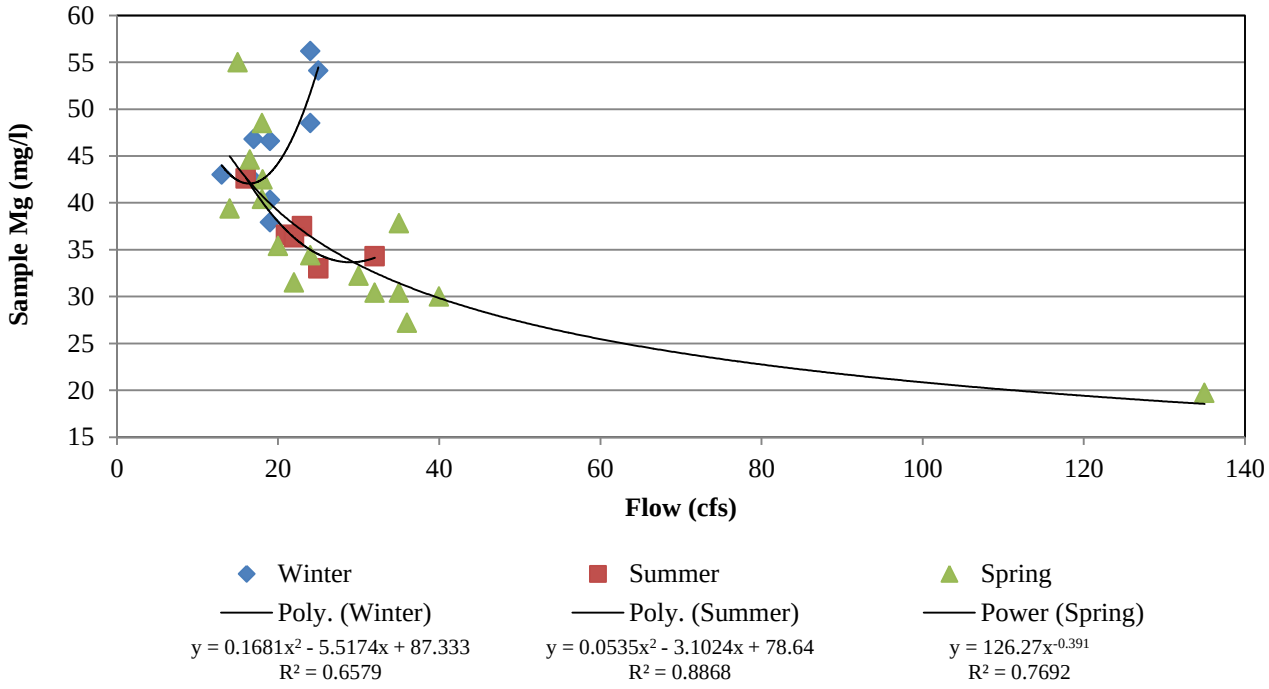

Figure 3-28: UT 18 Trendlines and Equations for Mg

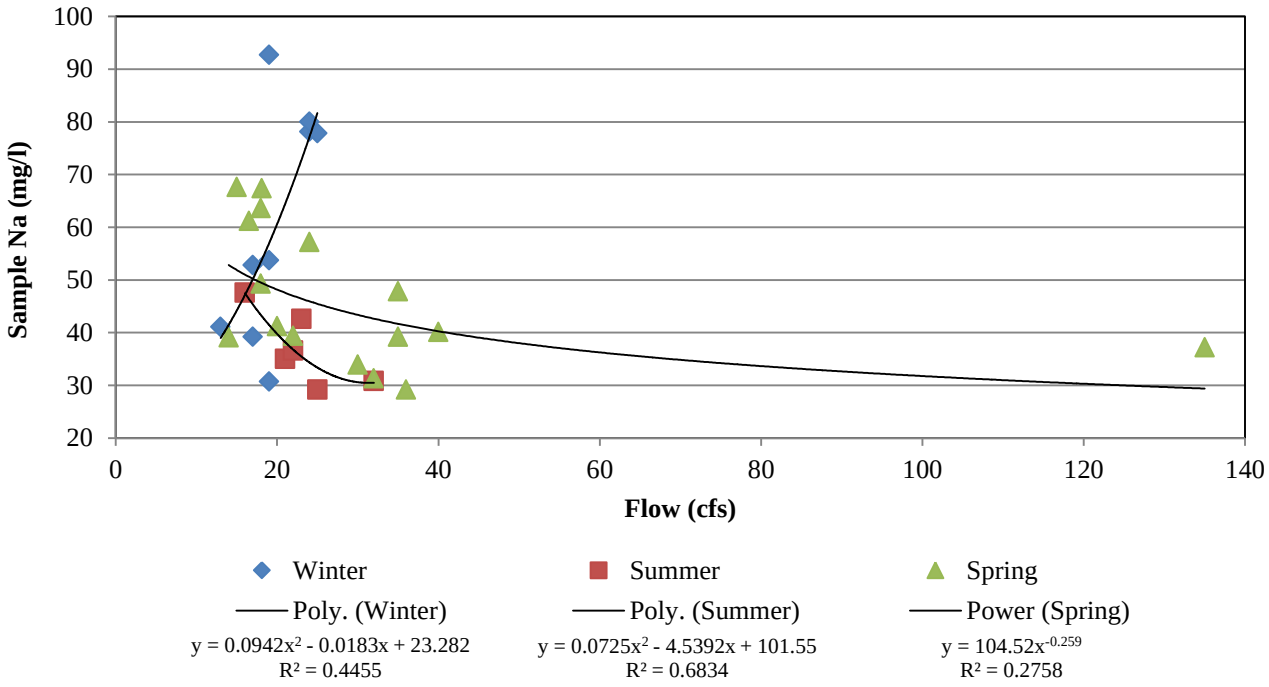

Figure 3-29: UT 18 Trendlines and Equations for Na

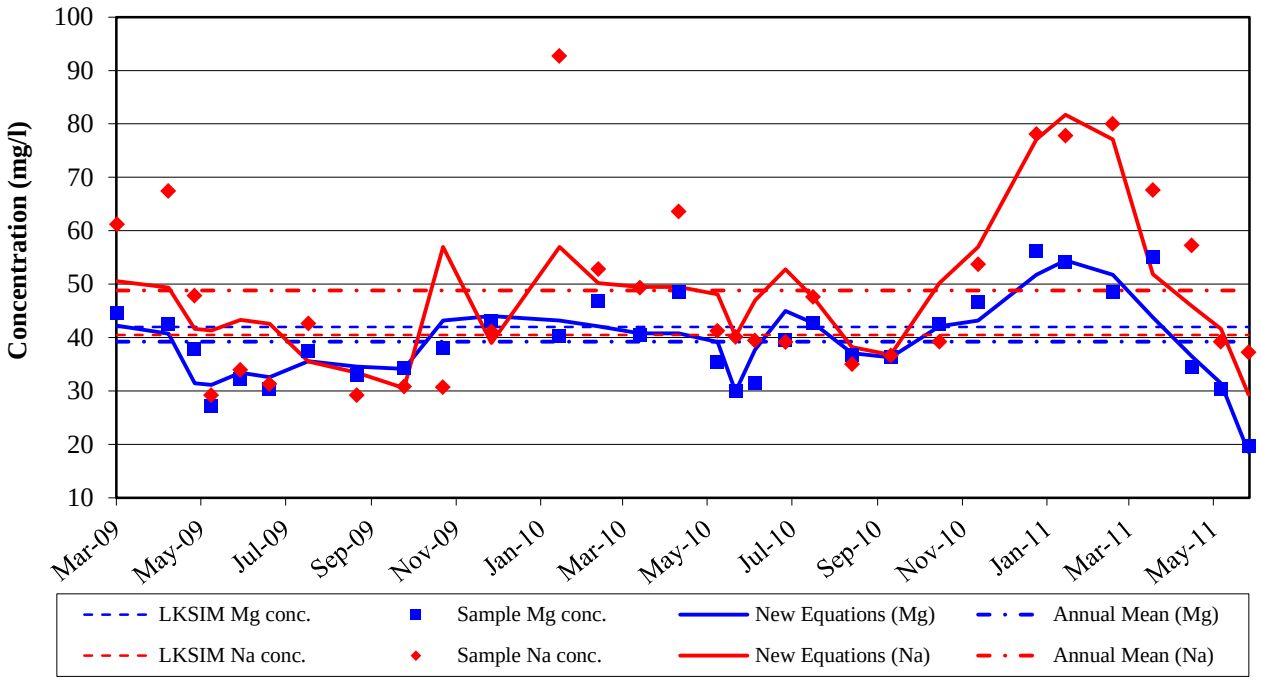

Figure 3-30: UT 18 Measured and Predicted Concentrations for Mg and Na

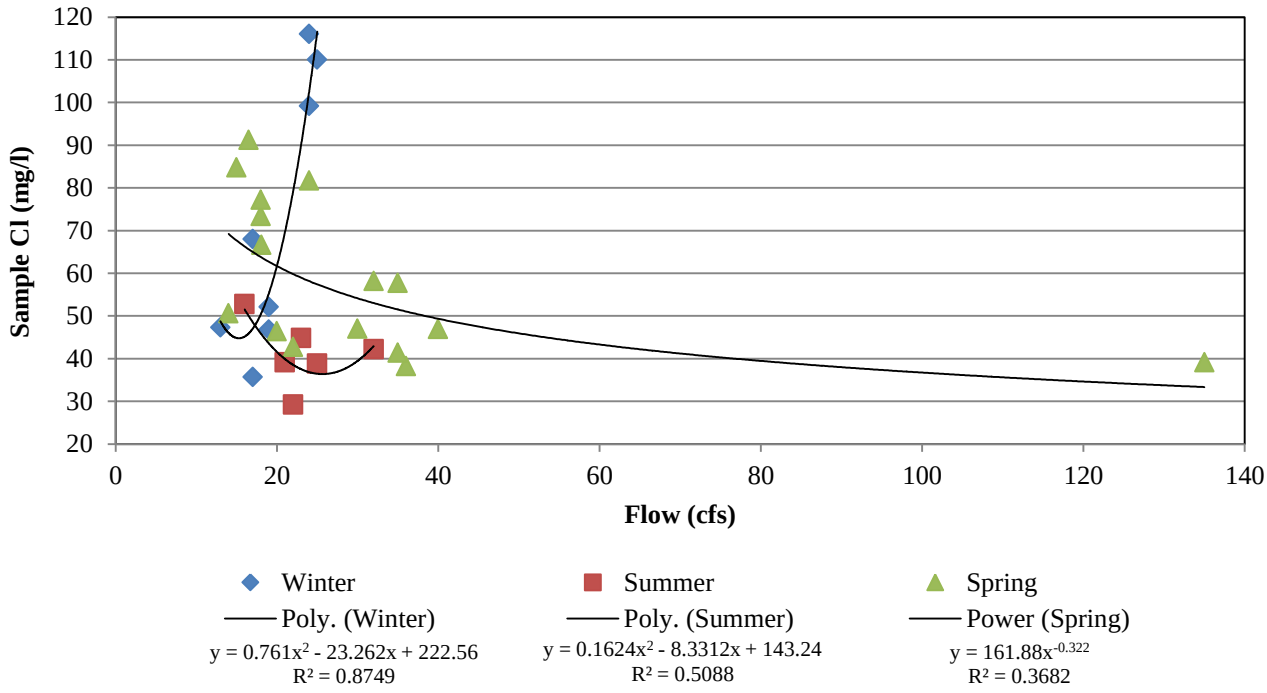

Figure 3-31: UT 18 Trendlines and Equations for Cl

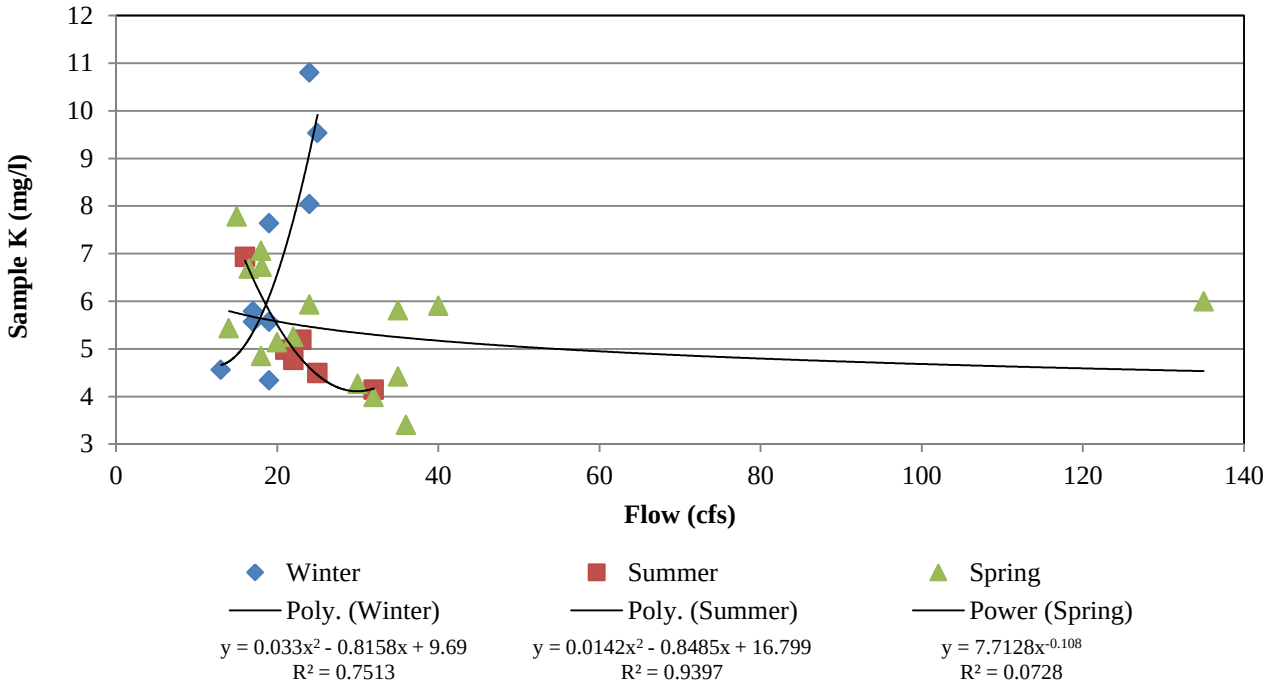

Figure 3-32: UT 18 Trendlines and Equations for K

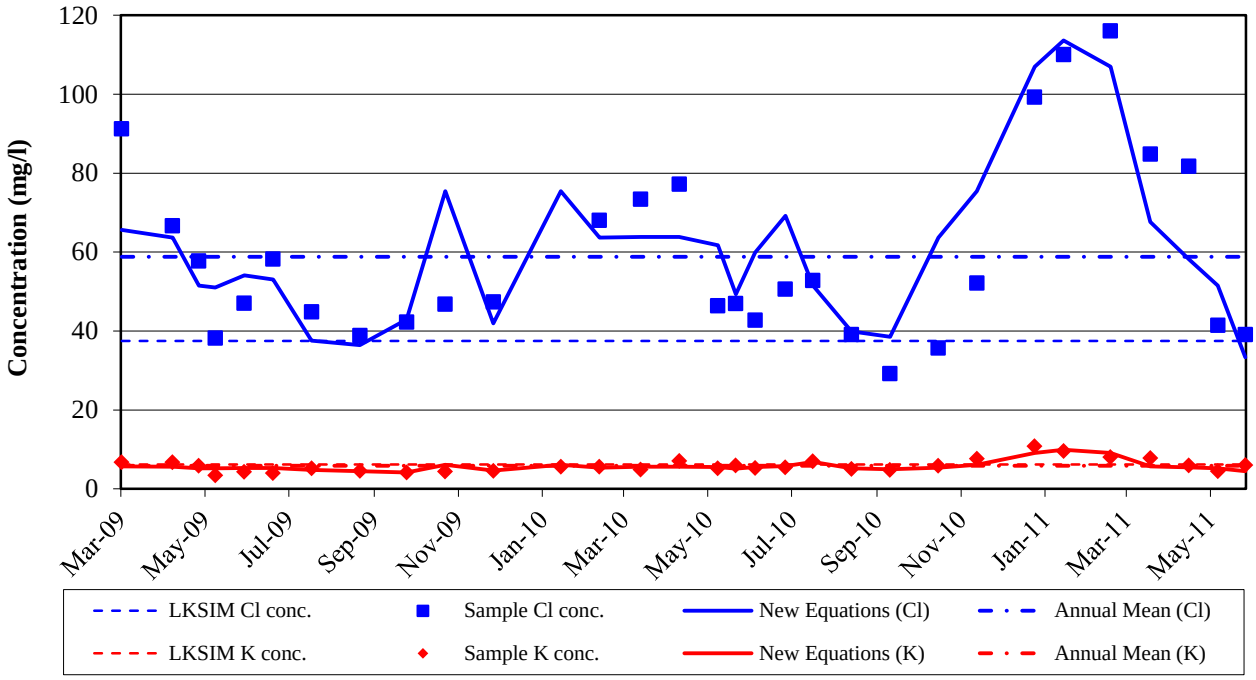

Figure 3-33: UT 18 Measured and Predicted Concentrations for Cl and K

Table 3-4: UT 18 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	788	336	582	669.3	578	535	125	0.68
HCO_3	410	177	315	359.4	299	296	52.6	0.84
SO_4	215	72.6	142	173.1	122	132	40.9	0.62
Ca	115	50.1	89.6	100.9	88.4	83.7	12.8	0.79
Mg	56.2	19.7	39.2	46.2	36.7	36.2	8.40	0.79
Na	92.7	29.2	48.8	60.7	37.0	46.5	17.1	0.55
Cl	148	29.2	58.8	71.9	41.2	58.9	23.0	0.65
K	10.8	3.40	5.84	6.87	5.08	5.54	1.65	0.63

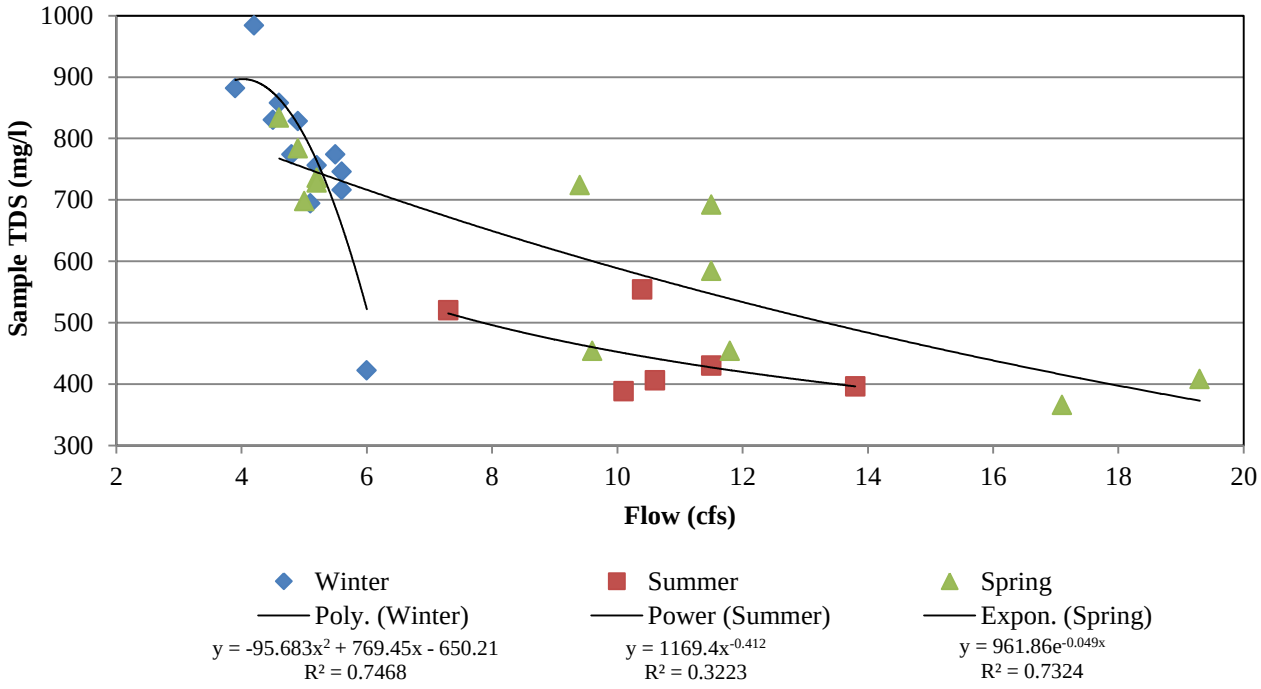

Figure 3-34: UT 20 Trendlines and Equations for TDS

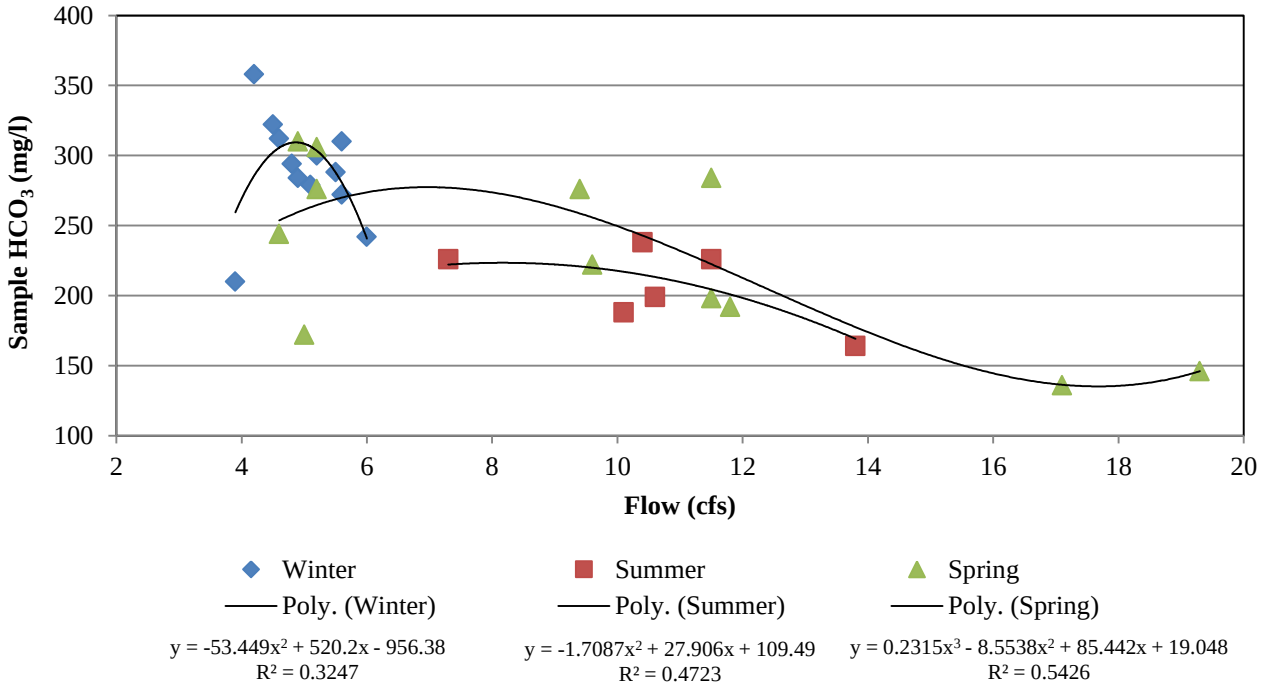

Figure 3-35: UT 20 Trendlines and Equations for HCO_3

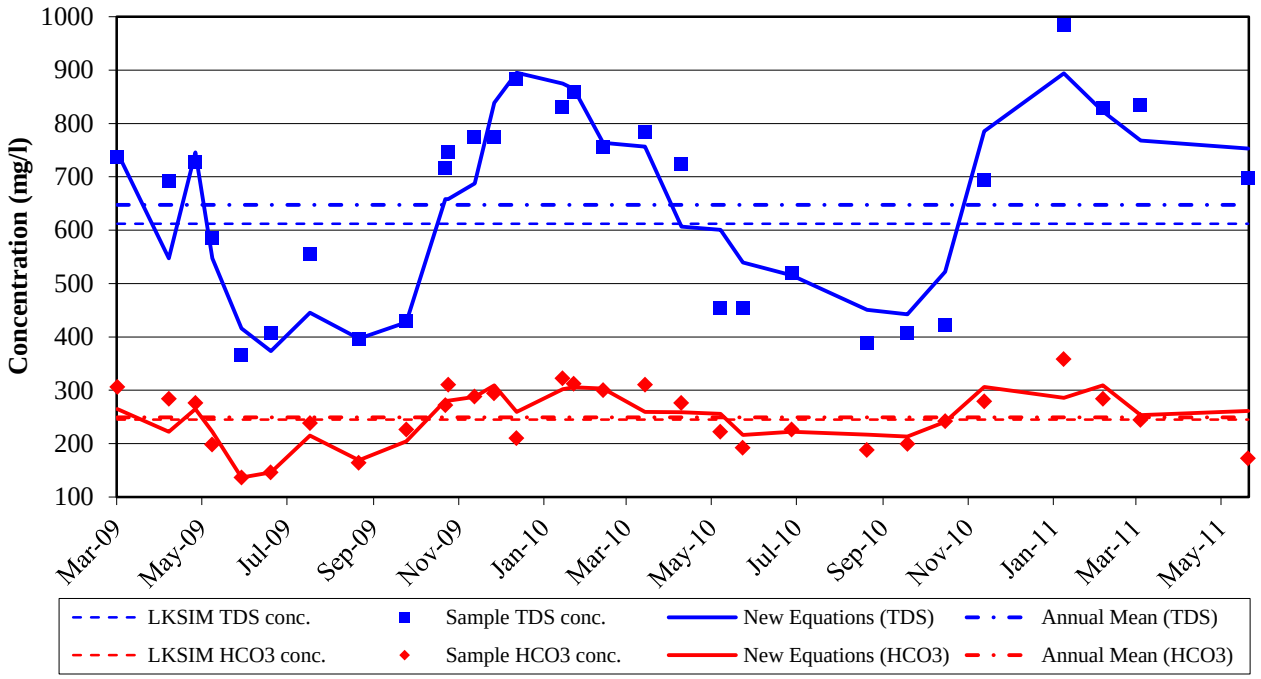

Figure 3-36: UT 20 Measured and Predicted Concentrations for TDS and HCO_3

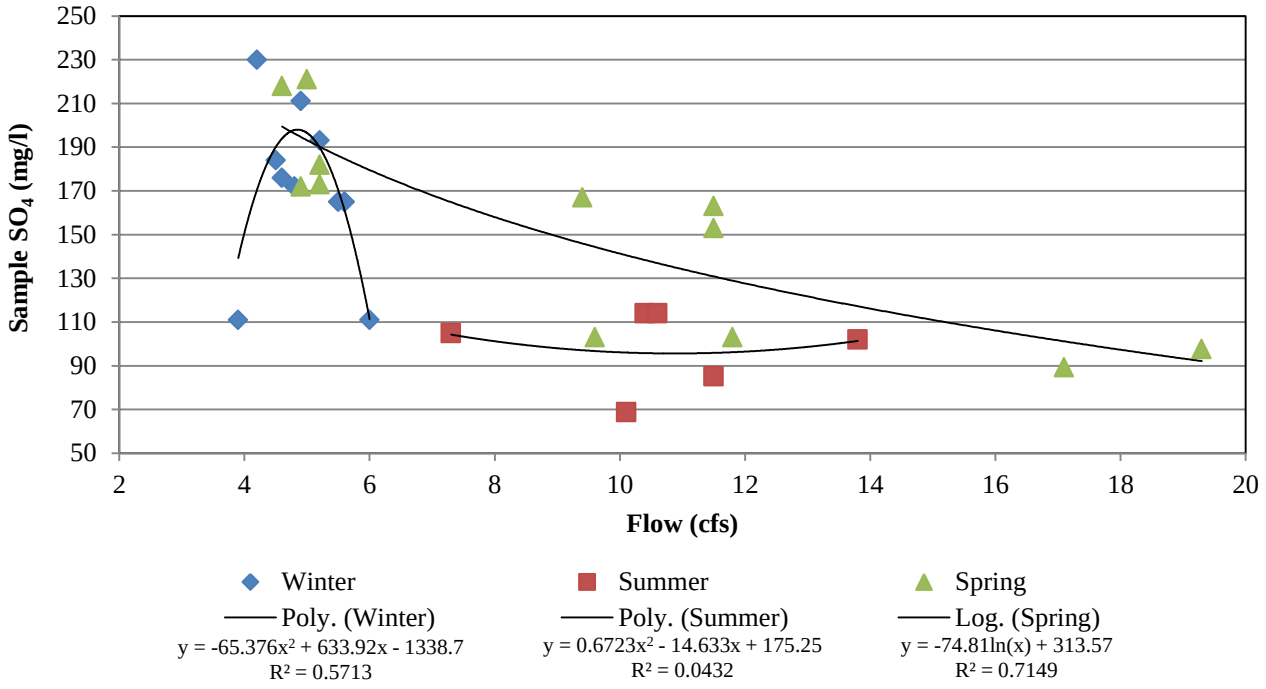

Figure 3-37: UT 20 Trendlines and Equations for SO_4

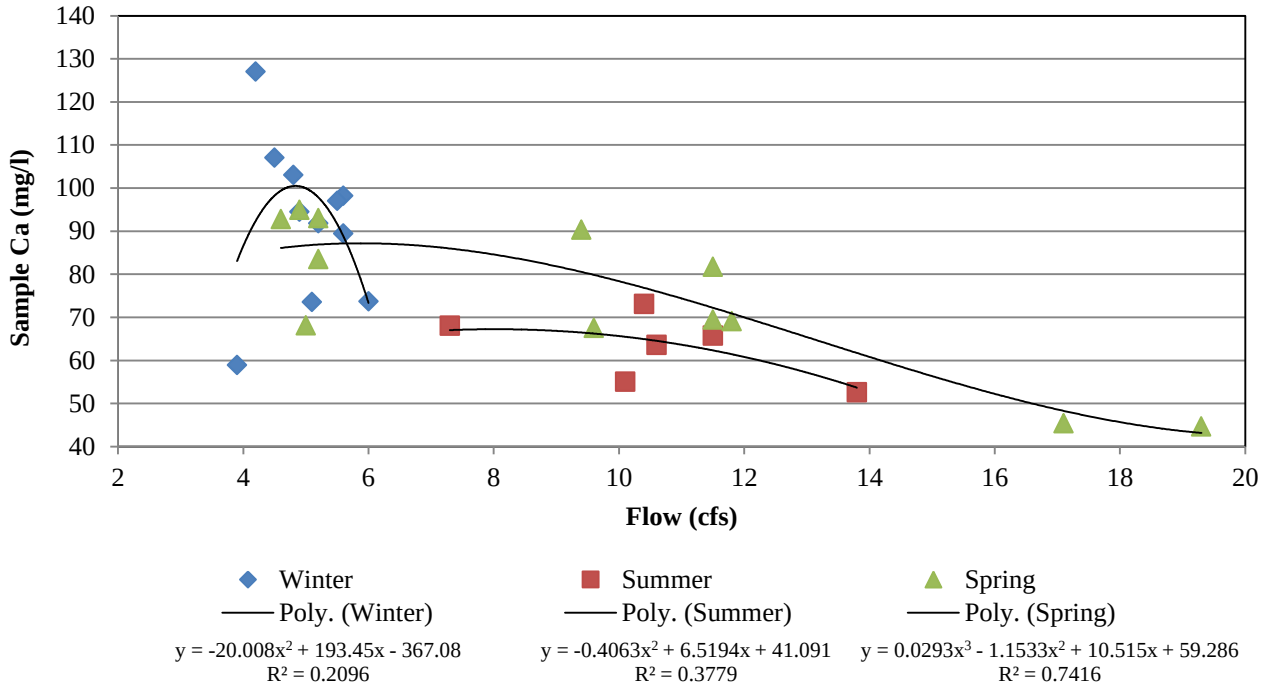

Figure 3-38: UT 20 Trendlines and Equations for Ca

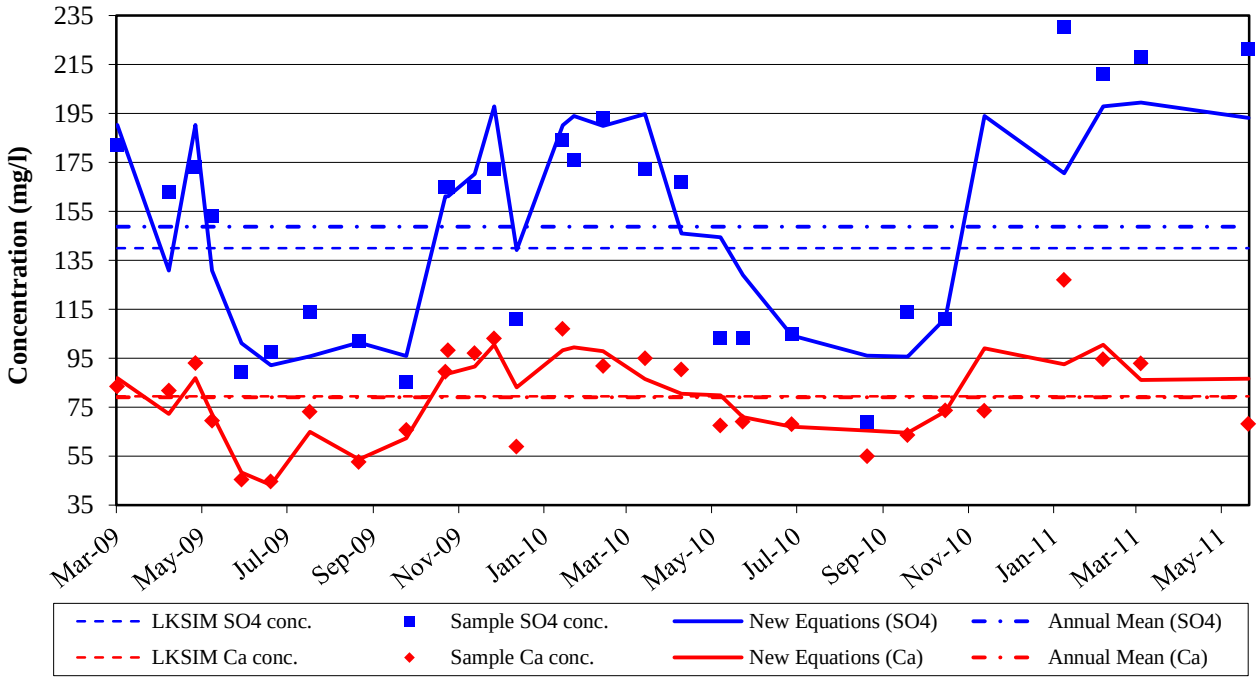

Figure 3-39: UT 20 Measured and Predicted Concentrations for SO_4 and Ca

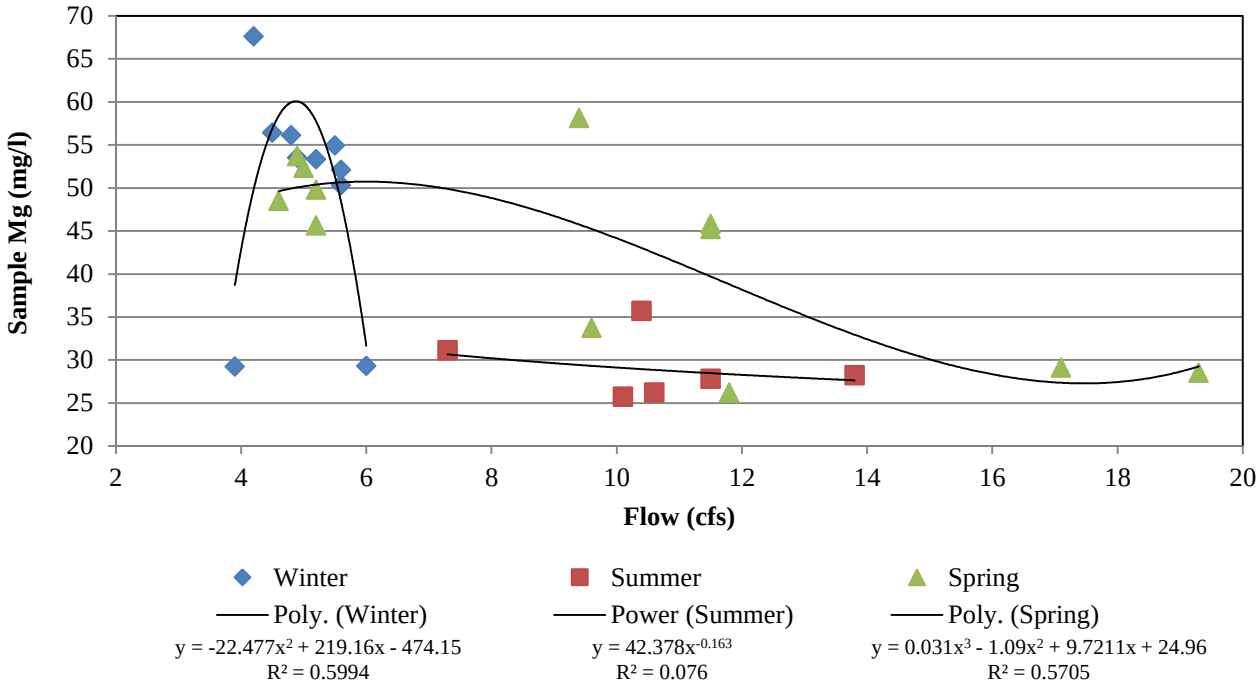

Figure 3-40: UT 20 Trendlines and Equations for Mg

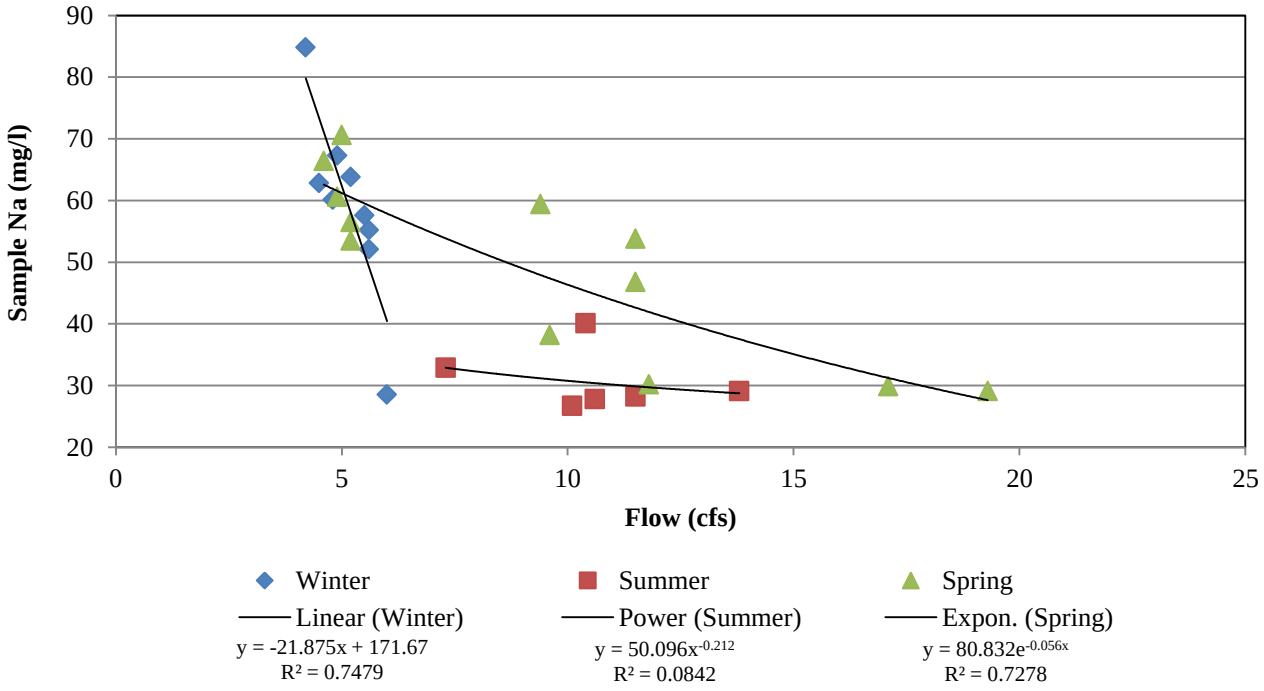

Figure 3-41: UT 20 Trendlines and Equations for Na

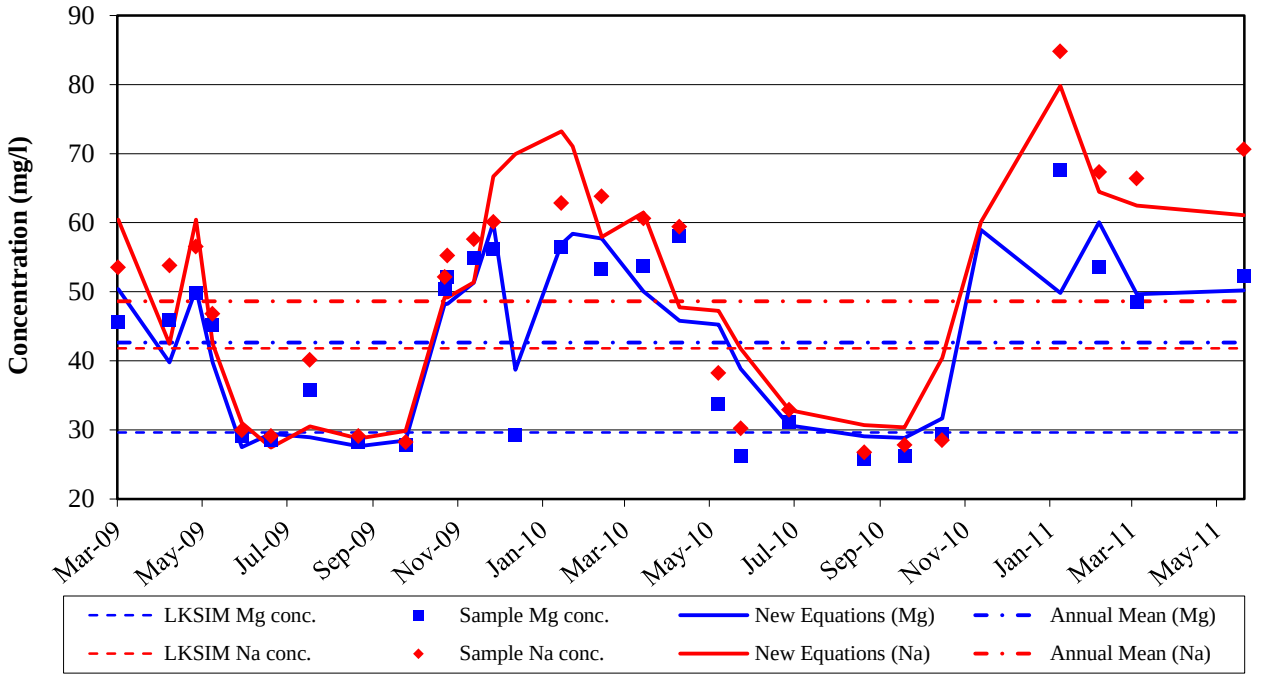

Figure 3-42: UT 20 Measured and Predicted Concentrations for Mg and Na

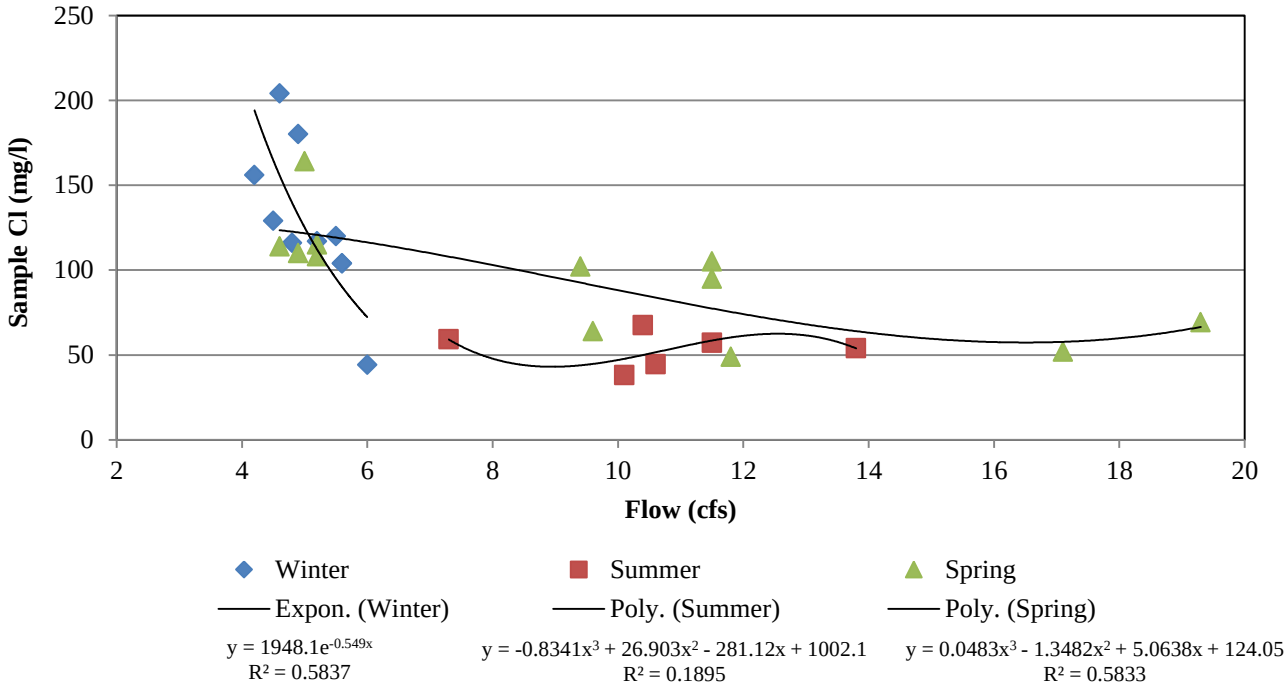

Figure 3-43: UT 20 Trendlines and Equations for Cl

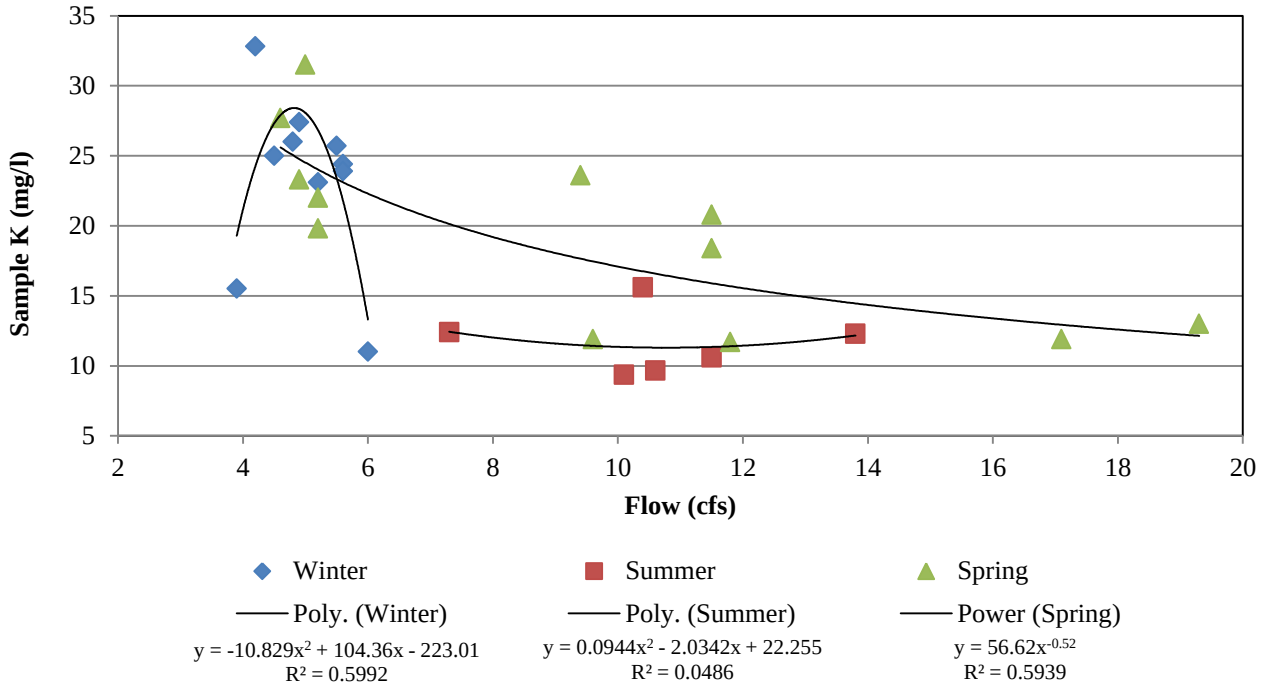

Figure 3-44: UT 20 Trendlines and Equations for K

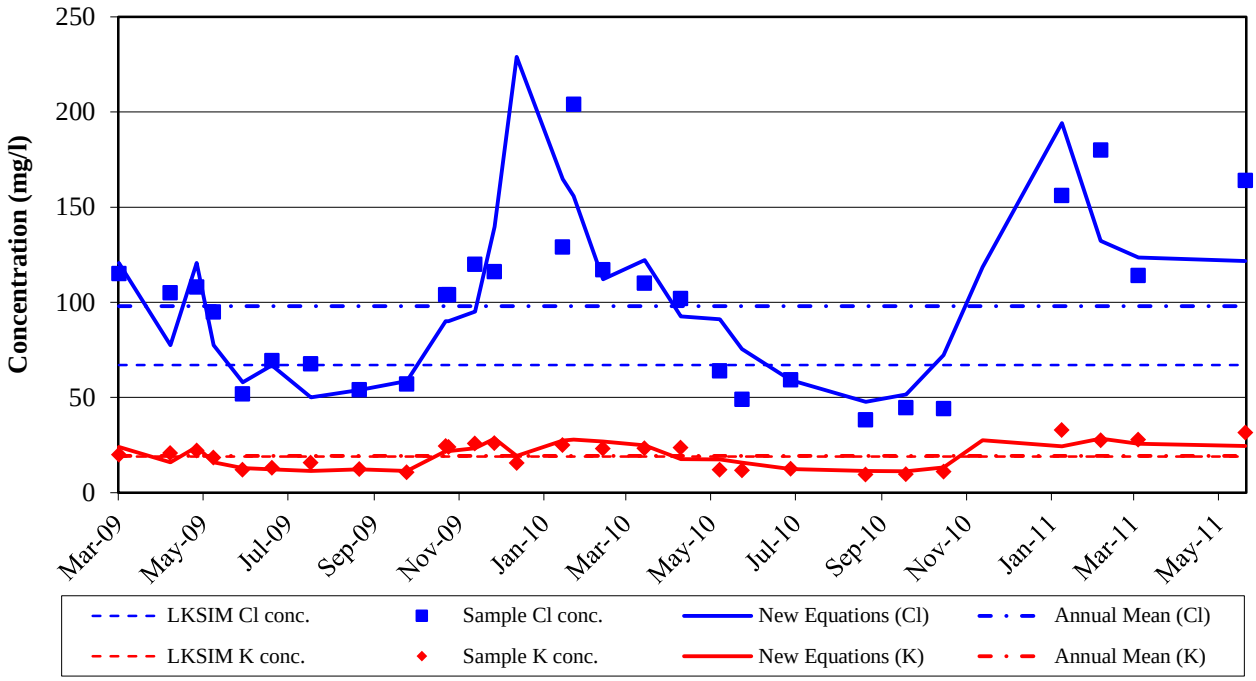

Figure 3-45: UT 20 Measured and Predicted Concentrations for Cl and K

Table 3-5: UT 20 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	984	366	647	772	449	622	180	0.85
HCO_3	358	136	249	289	207	230	57.4	0.67
SO_4	230	68.8	149	171	98.2	153	45.8	0.77
Ca	127	44.6	79.0	92.2	63.0	75.0	19.6	0.65
Mg	67.6	25.7	42.6	50.3	29.1	43.0	12.7	0.74
Na	84.8	26.7	48.6	58.6	30.8	49.6	25.0	0.83
Cl	204	38.2	97.9	127	53.5	95.6	43.3	0.71
K	32.8	9.37	19.3	23.5	11.7	19.6	7.10	0.74

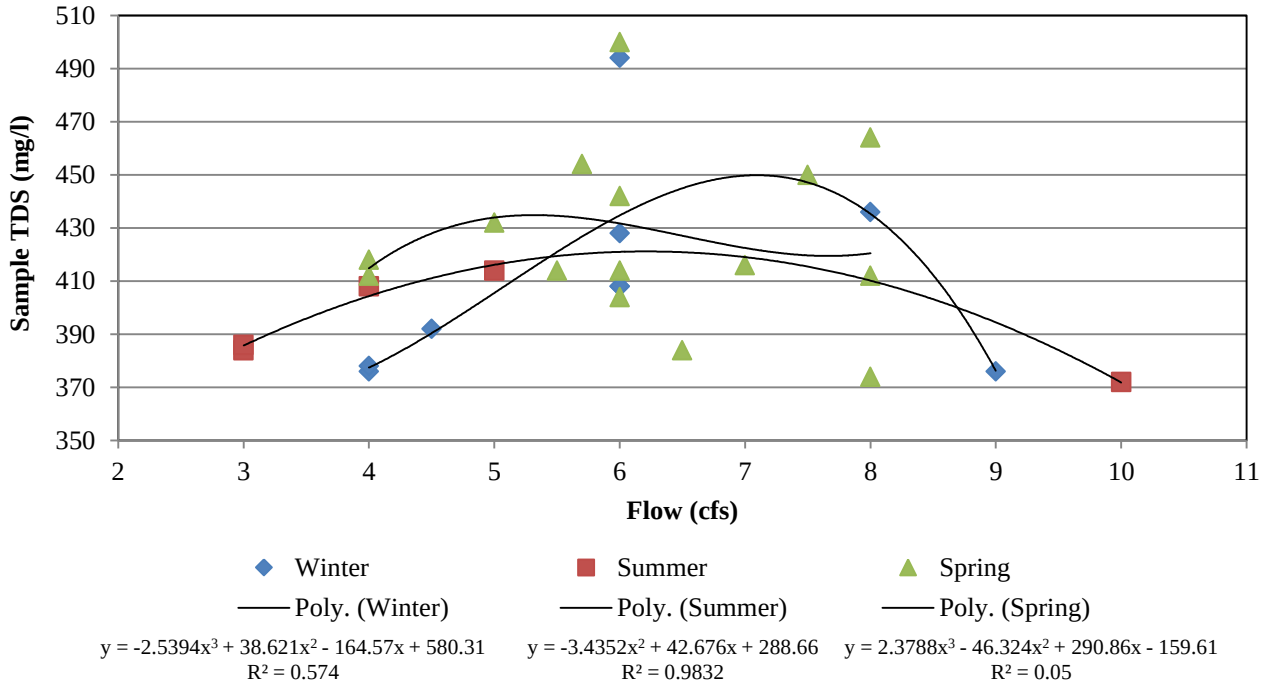

Figure 3-46: UT 27 Trendlines and Equations for TDS

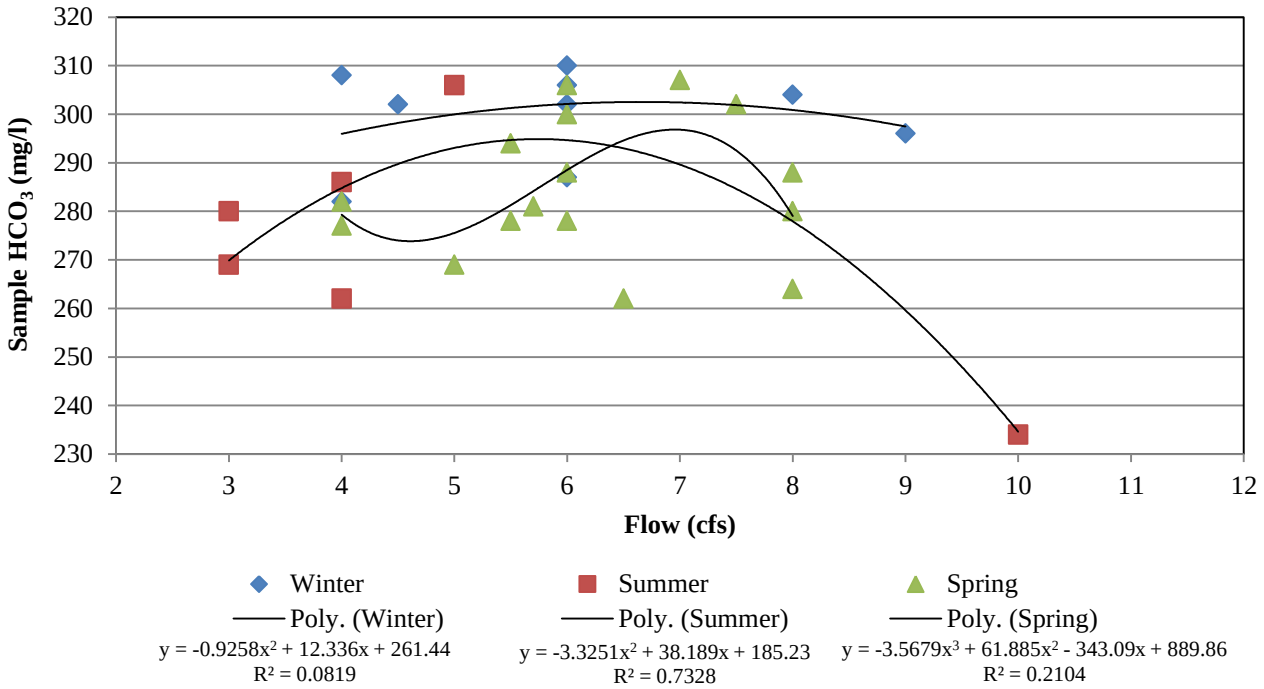

Figure 3-47: UT 27 Trendlines and Equations for HCO_3

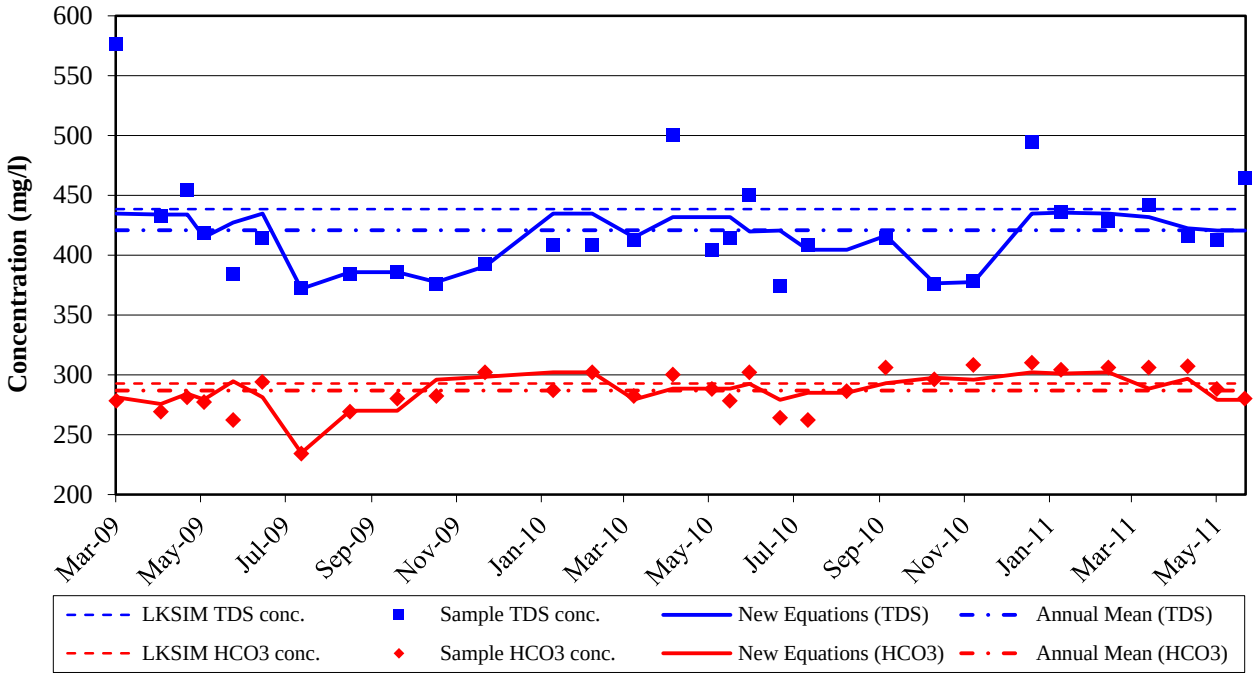

Figure 3-48: UT 27 Measured and Predicted Concentrations for TDS and HCO_3

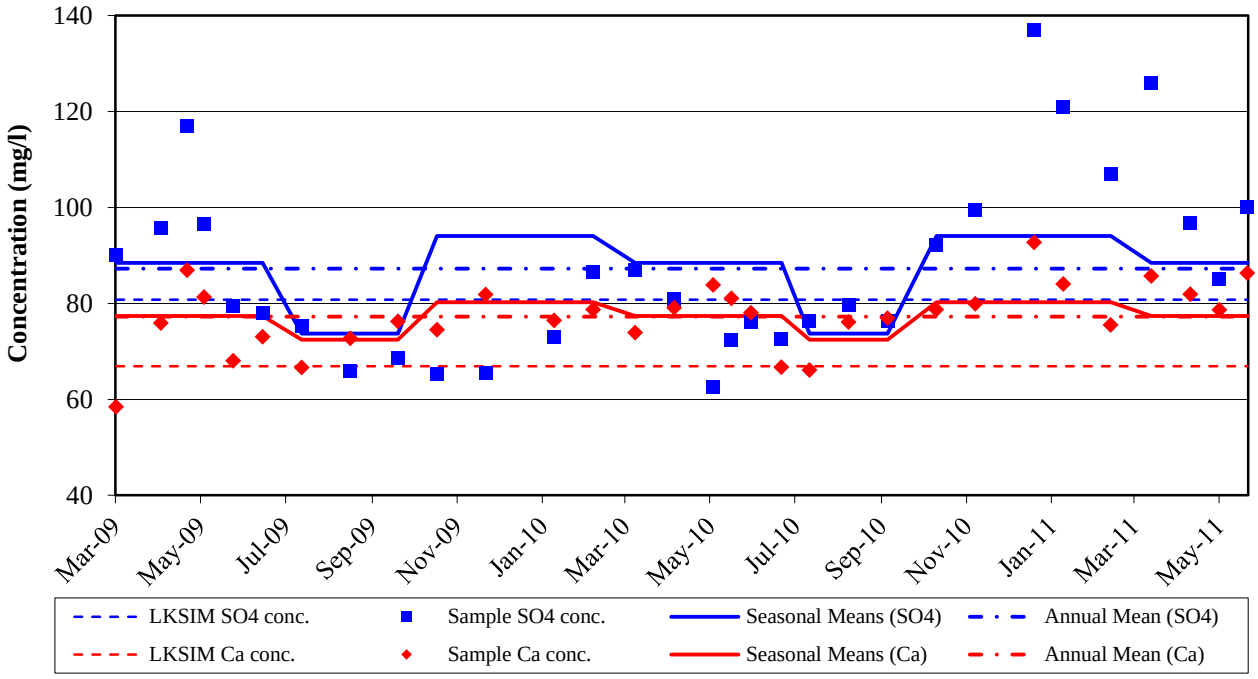

Figure 3-49: UT 27 Measured and Predicted Concentrations for SO_4 and Ca

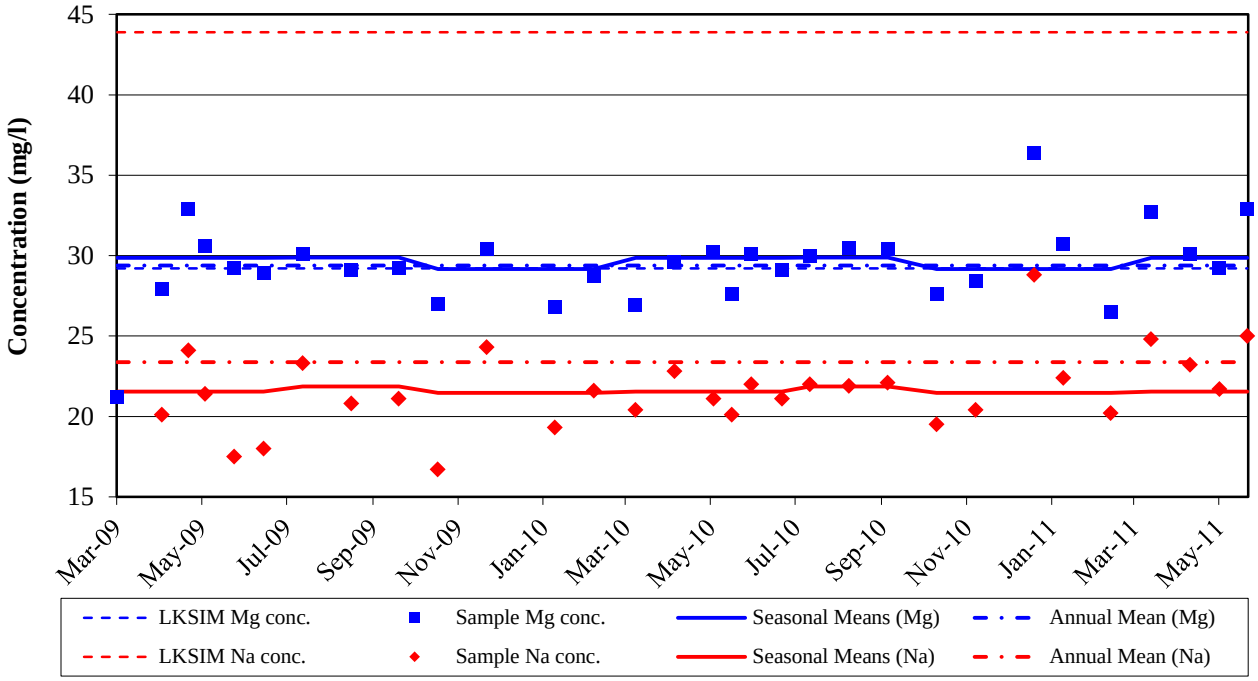

Figure 3-50: UT 27 Measured and Predicted Concentrations for Mg and Na

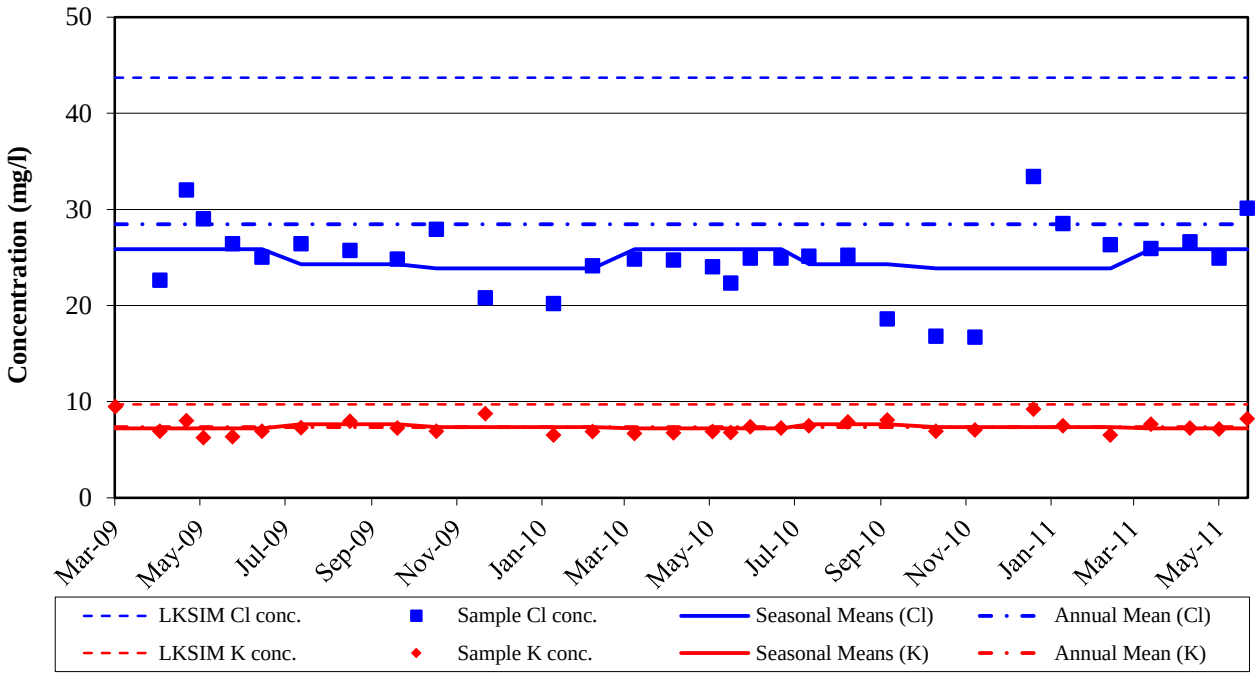

Figure 3-51: UT 27 Measured and Predicted Concentrations for Cl and K

Table 3-6: UT 27 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	500	372	421	411	393	426	44.2	0.41
HCO_3	310	234	287	300	273	285	17.7	0.59
SO_4	137	62.6	87.2	94.1	73.7	88.5	18.9	-
Ca	92.7	58.4	77.3	80.2	72.4	77.4	7.12	-
Mg	36.4	21.2	29.4	29.2	29.9	29.9	2.57	-
Na	28.8	16.7	23.4	21.5	21.9	21.6	10.2	-
Cl	33.4	16.7	28.5	23.9	24.3	25.9	19.9	-
K	9.48	6.22	7.34	7.35	7.65	7.23	0.788	-

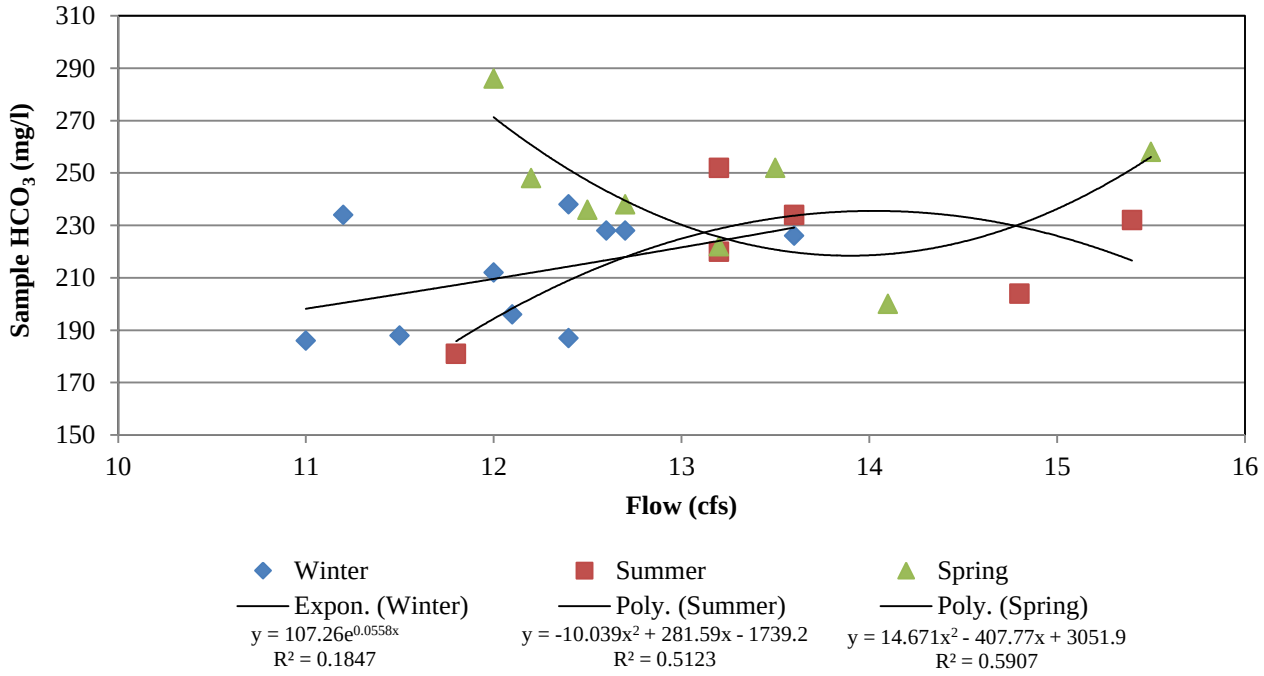

Figure 3-52: UT 27A Trendlines and Equations for HCO_3

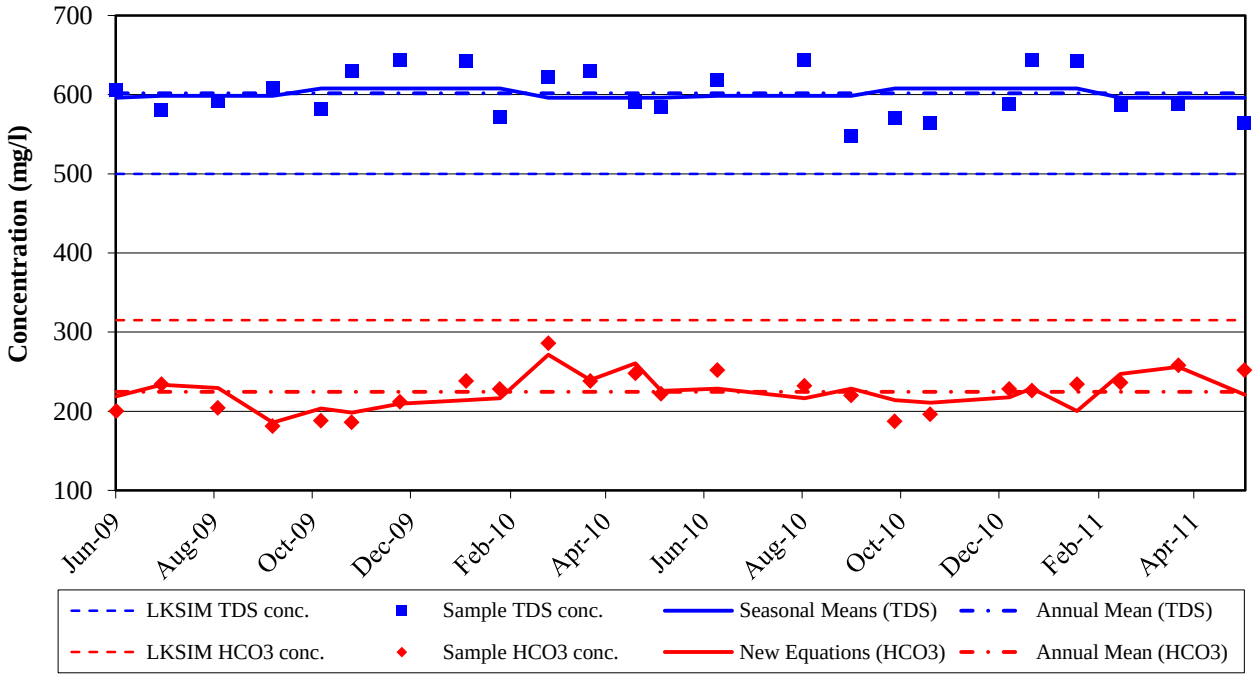

Figure 3-53: UT 27A Measured and Predicted Concentrations for TDS and HCO_3

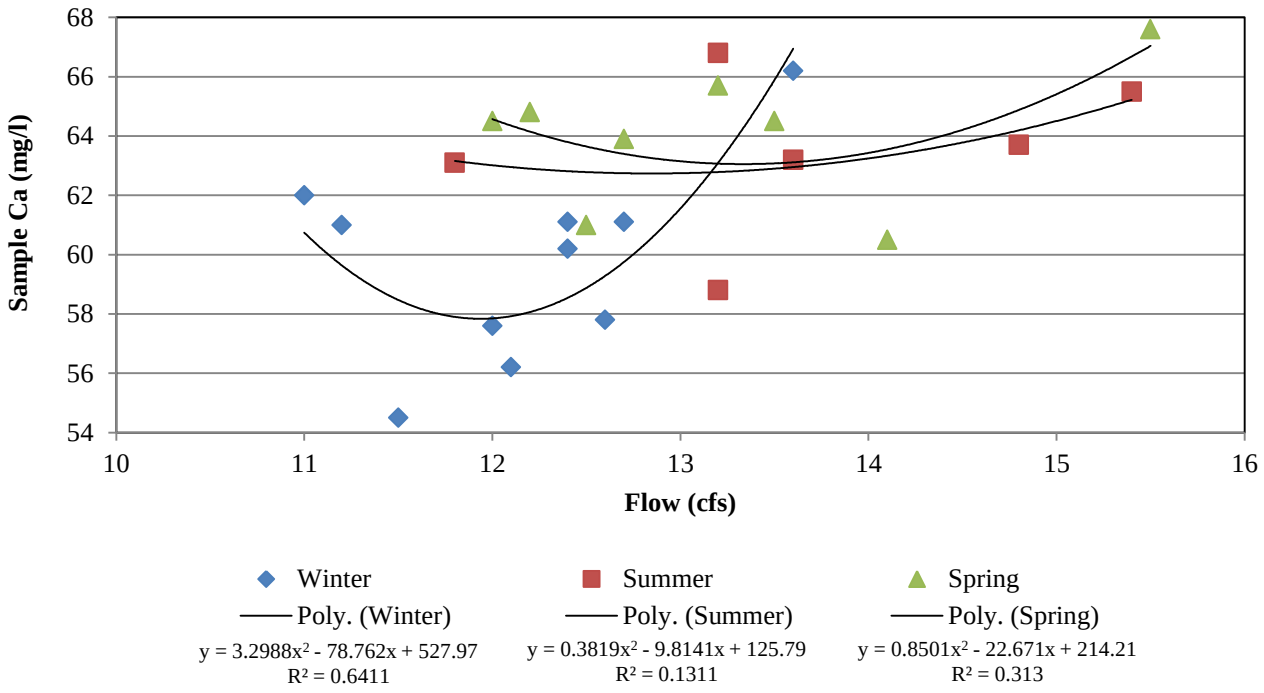

Figure 3-54: UT 27A Trendlines and Equations for Ca

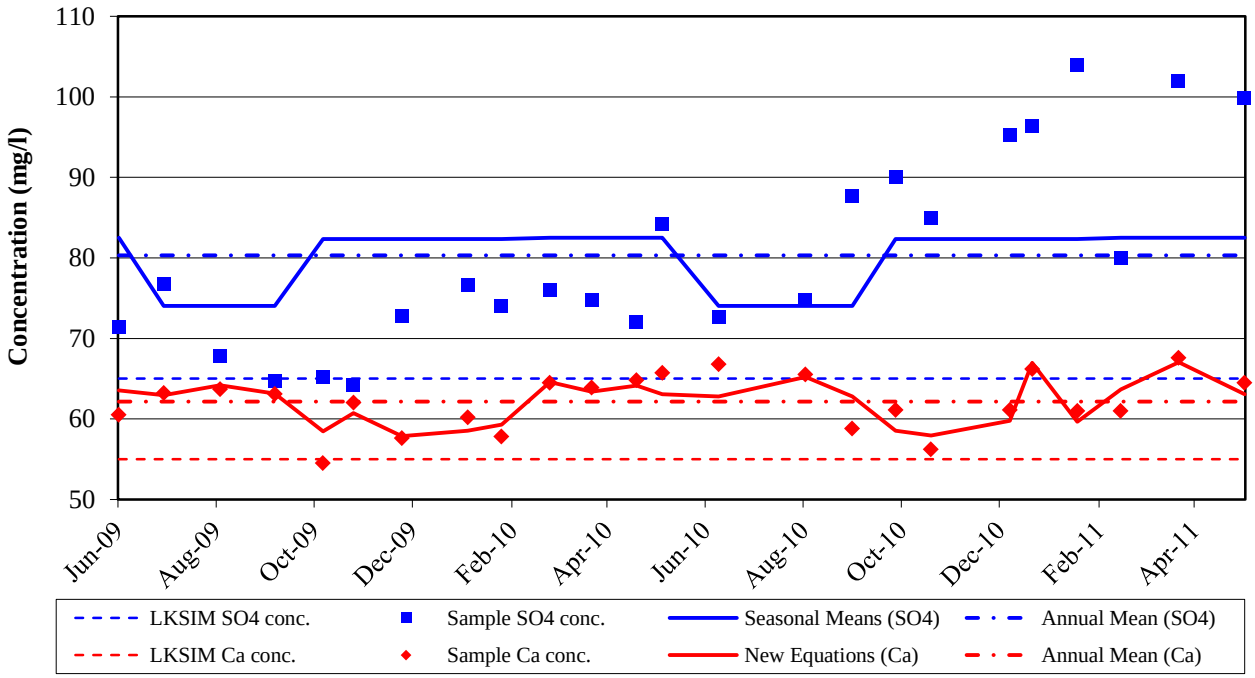

Figure 3-55: UT 27A Measured and Predicted Concentrations for SO_4 and Ca

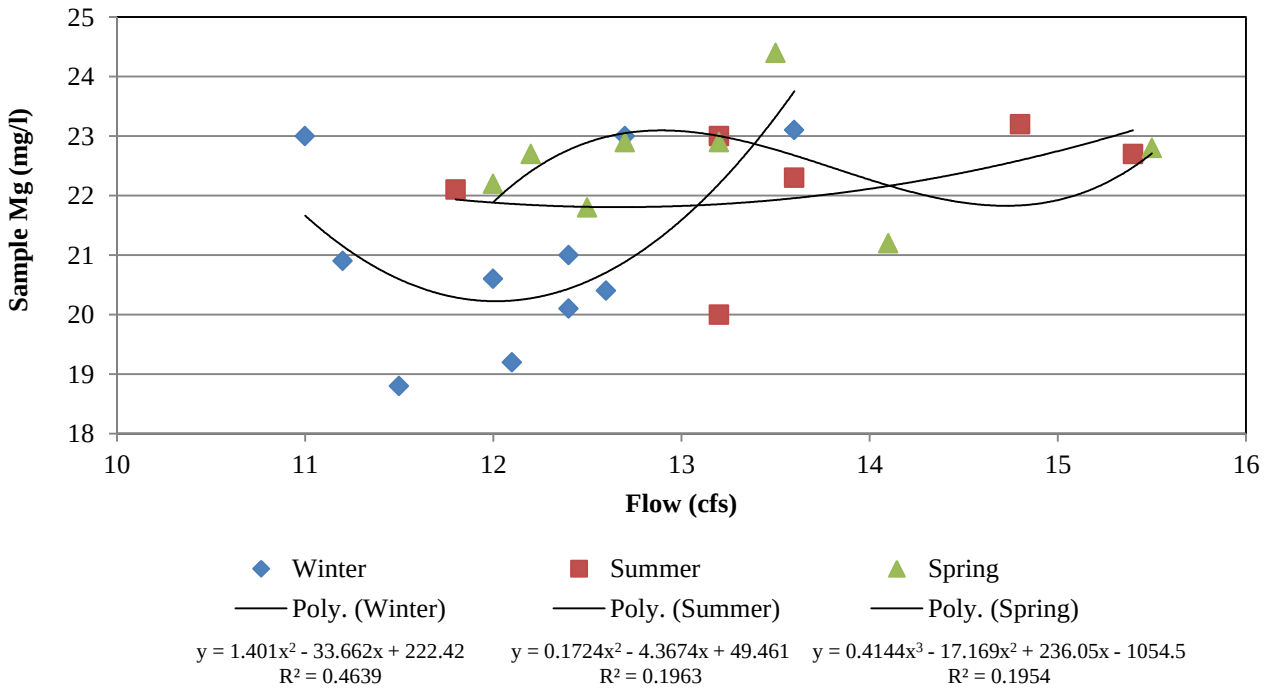

Figure 3-56: UT 27A Trendlines and Equations for Mg

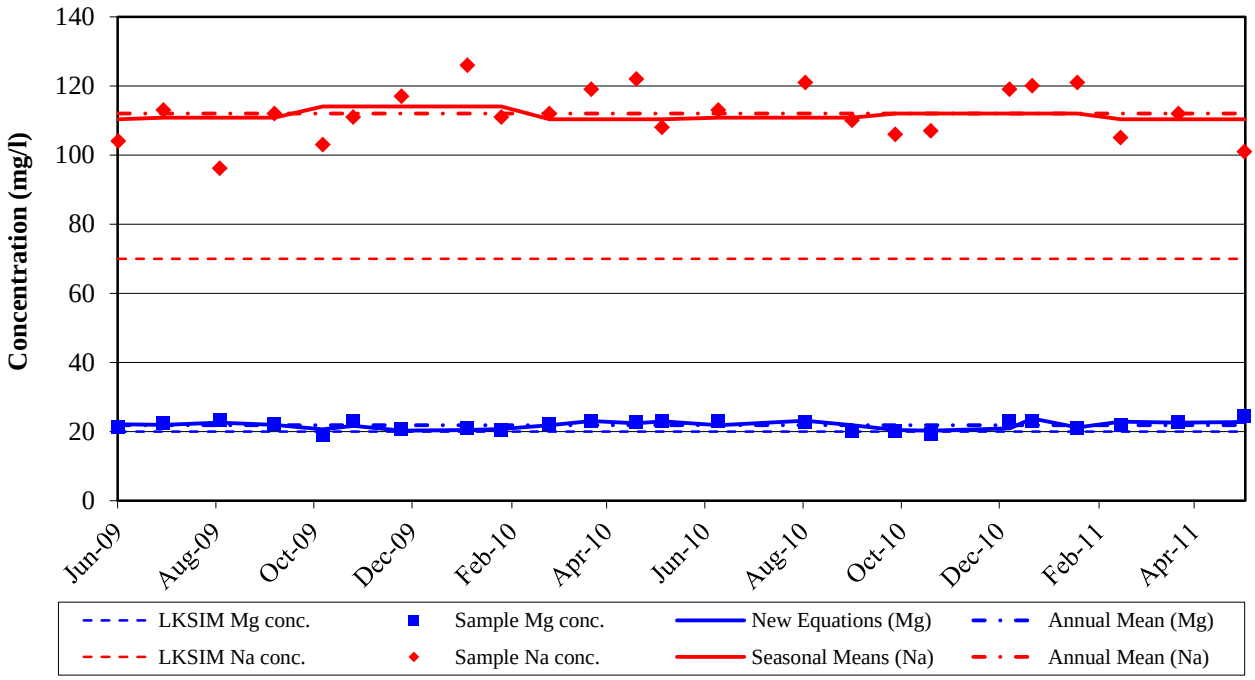

Figure 3-57: UT 27A Measured and Predicted Concentrations for Mg and Na

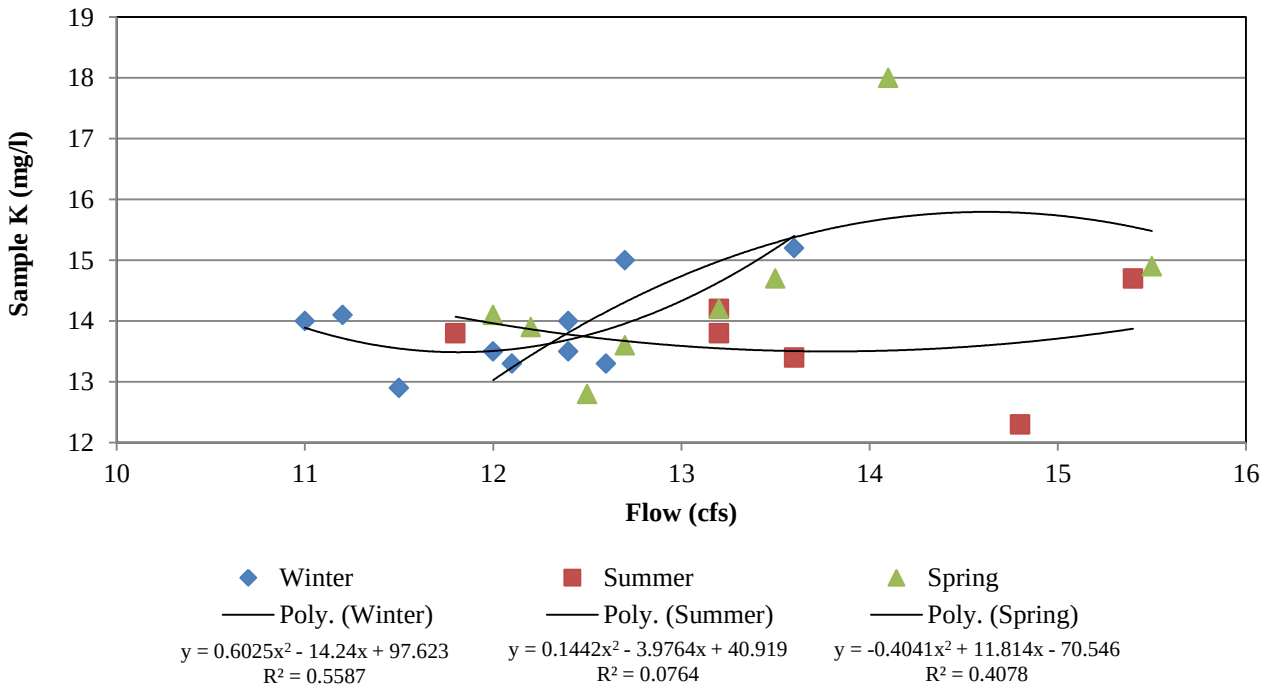

Figure 3-58: UT 27A Trendlines and Equations for K

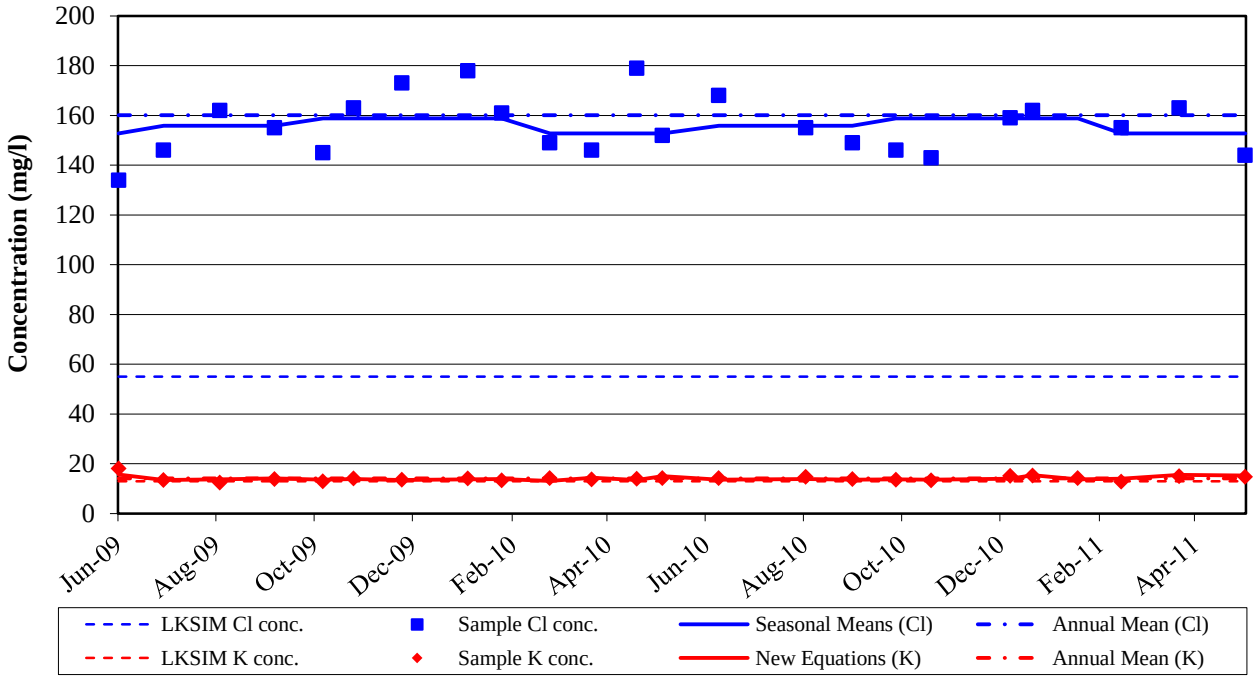

Figure 3-59: UT 27A Measured and Predicted Concentrations for Cl and K

Table 3-7: UT 27A Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	644	548	602	608	598	596	29.9	-
HCO_3	286	181	224	212	221	243	26.3	0.58
SO_4	104	64.2	80.3	82.3	74.1	82.5	12.1	-
Ca	255	54.5	62.1	59.8	63.5	64.1	3.45	0.65
Mg	24.4	18.8	21.8	21.0	22.2	22.6	1.43	0.53
Na	126	96.1	112	114	111	110	7.51	-
Cl	255	134	160	159	156	153	23.2	-
K	18.0	12.3	14.1	13.9	13.7	14.5	1.10	0.46

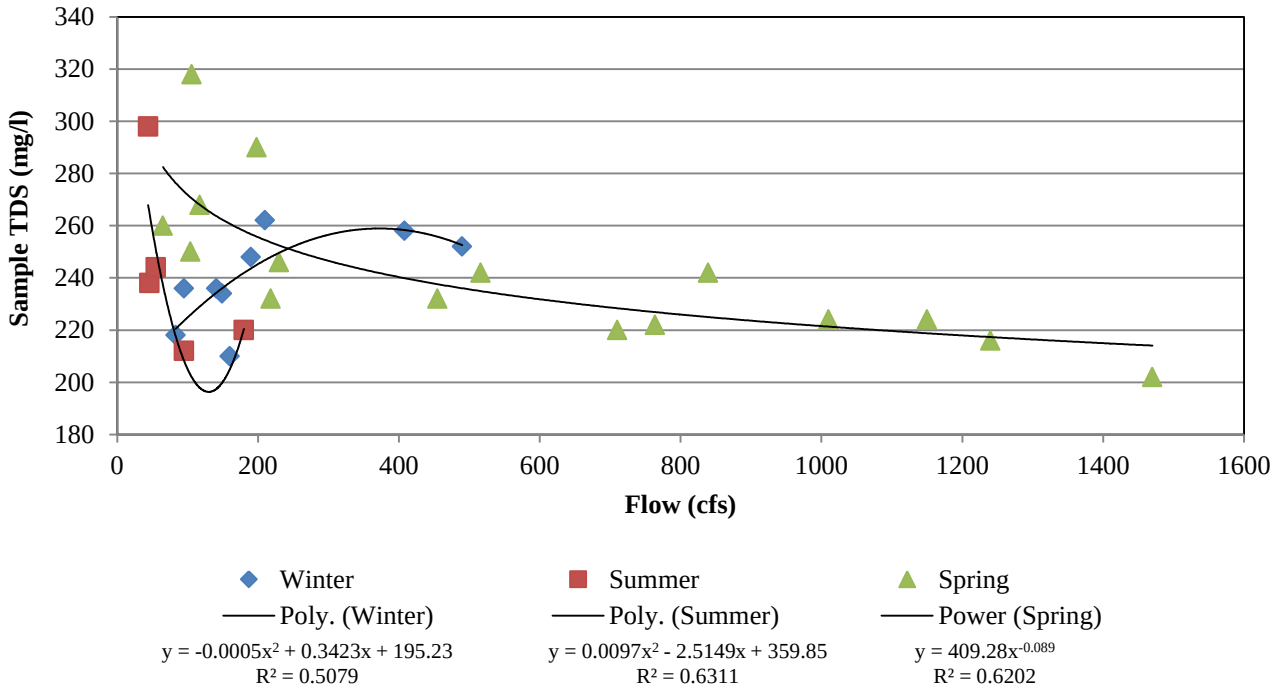

Figure 3-60: UT 29 Trendlines and Equations for TDS

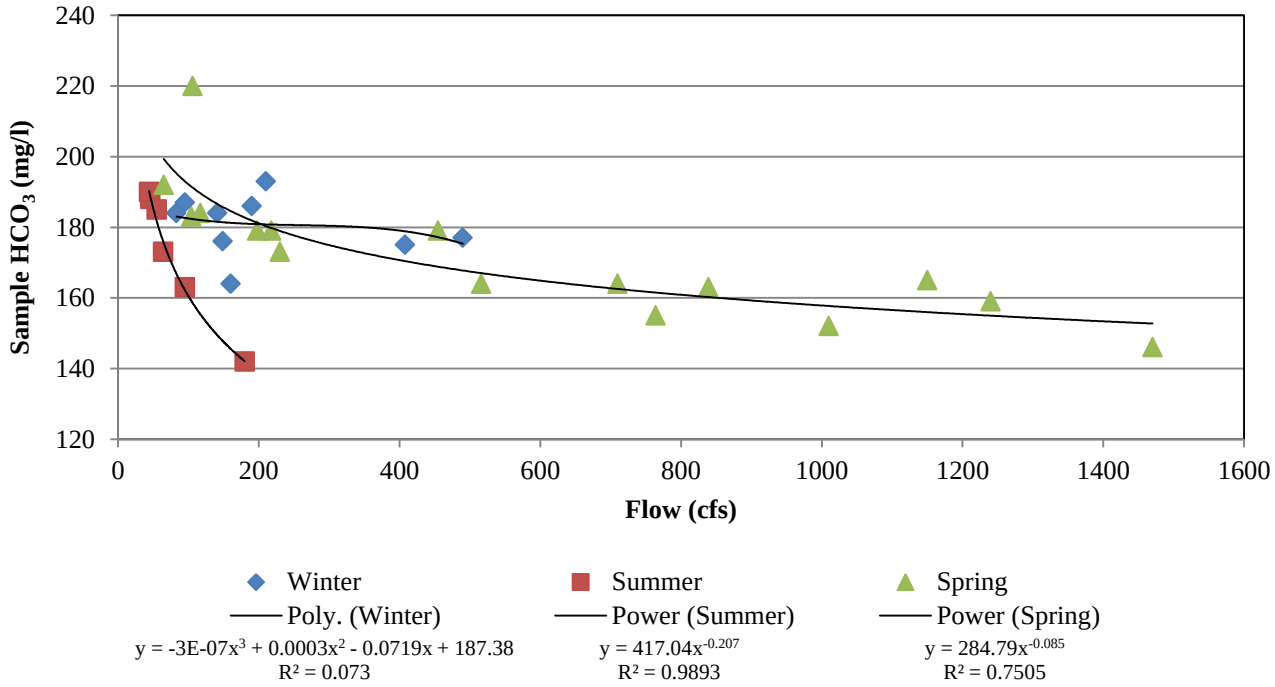

Figure 3-61: UT 29 Trendlines and Equations for HCO_3

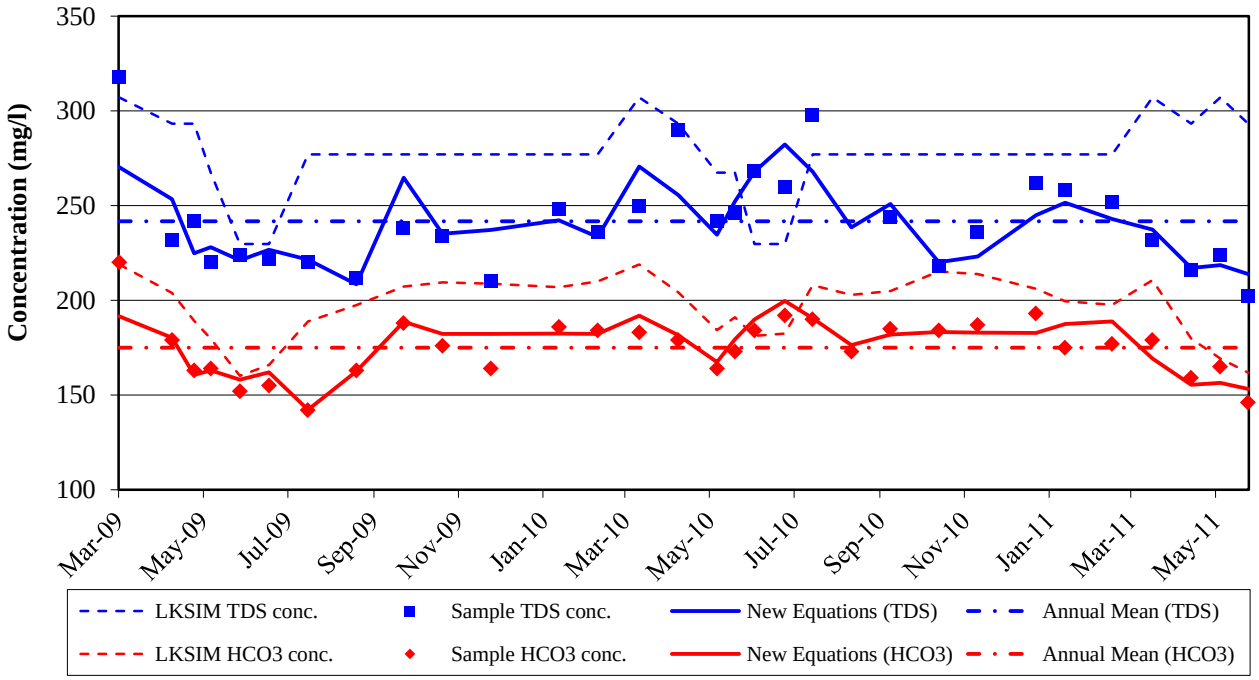

Figure 3-62: UT 29 Measured and Predicted Concentrations for TDS and HCO_3

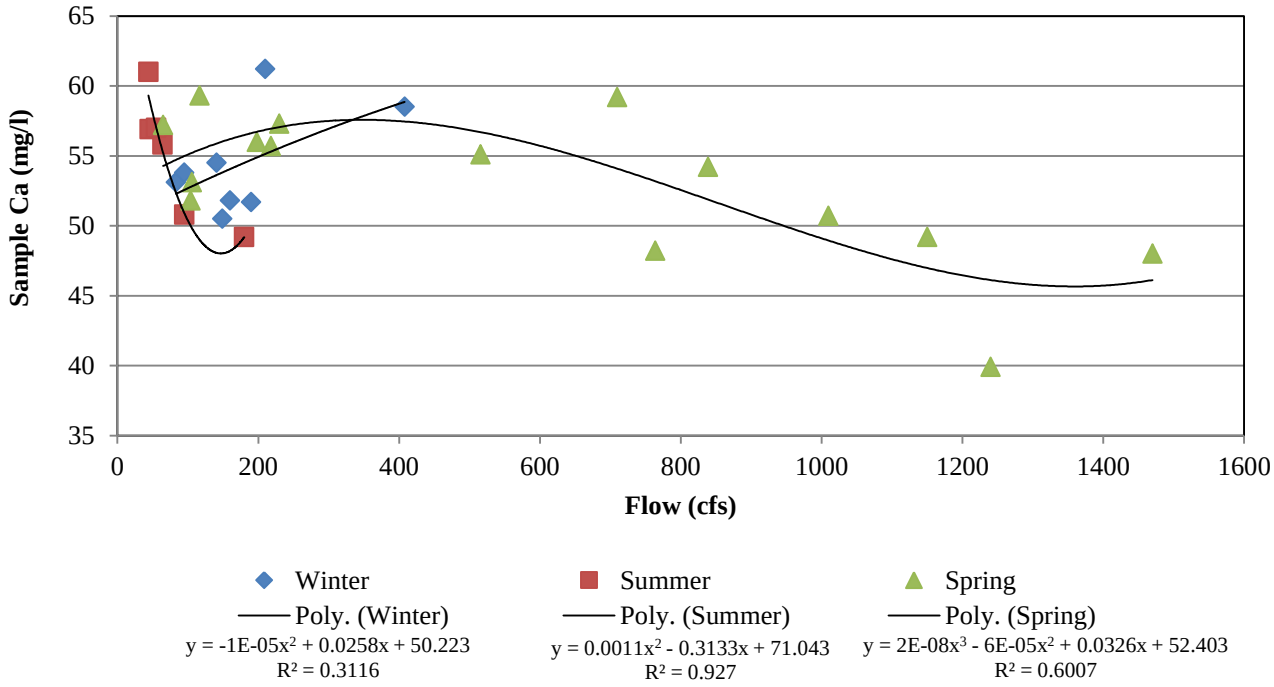

Figure 3-63: UT 29 Trendlines and Equations for Ca

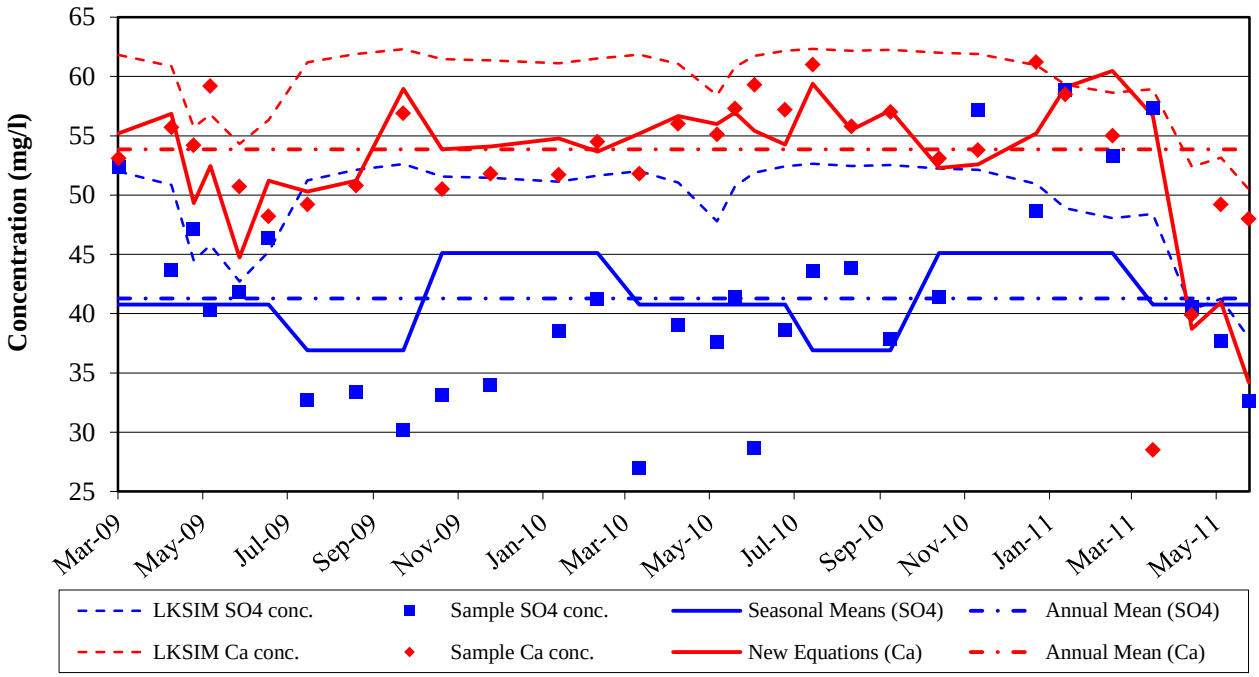

Figure 3-64: UT 29 Measured and Predicted Concentrations for SO_4 and Ca

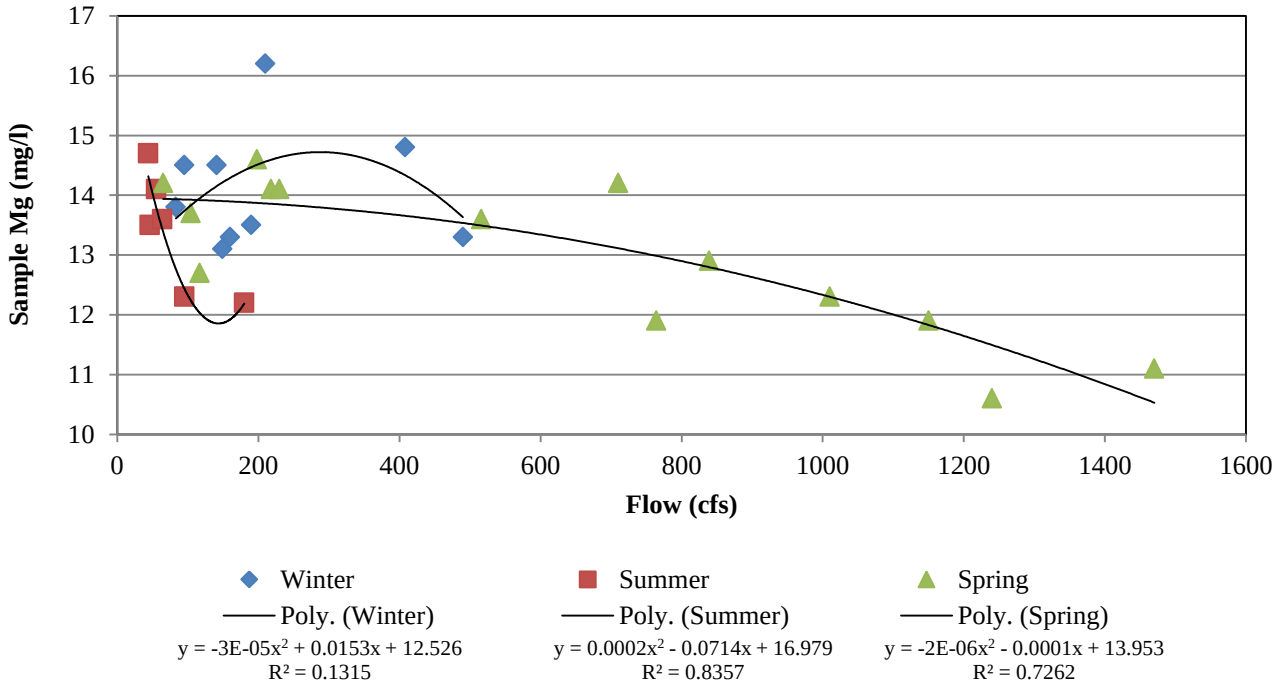

Figure 3-65: UT 29 Trendlines and Equations for Mg

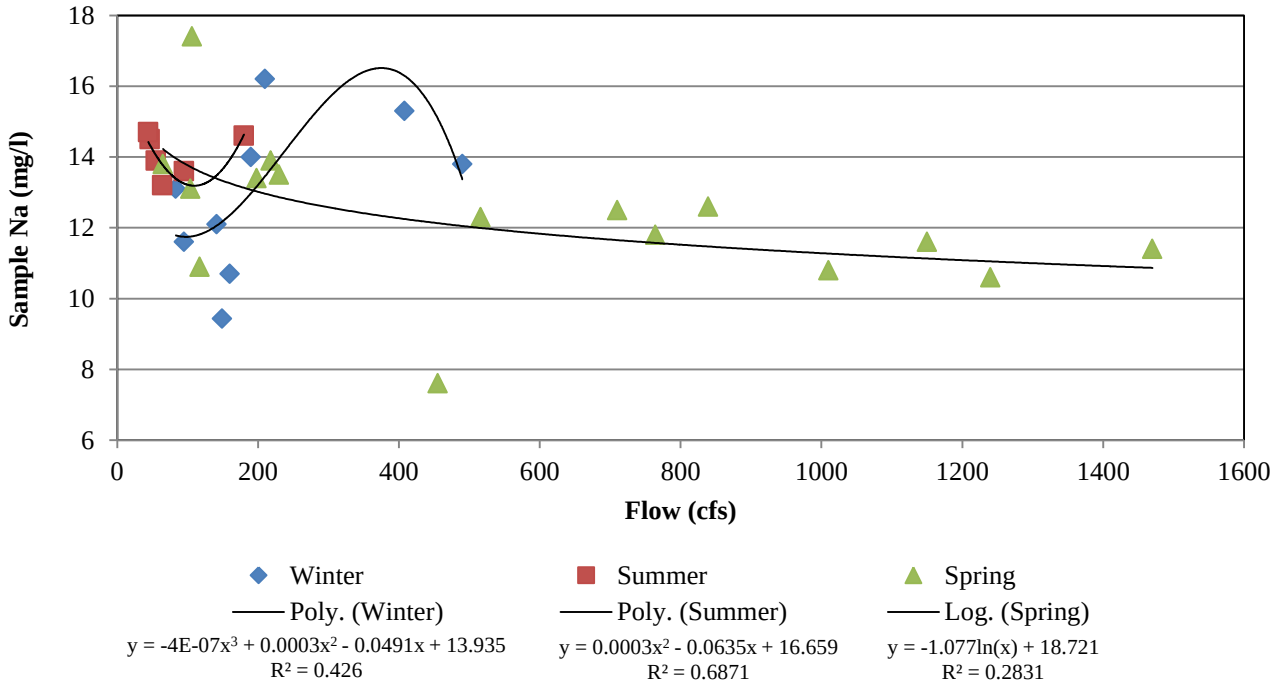

Figure 3-66: UT 29 Trendlines and Equations for Na

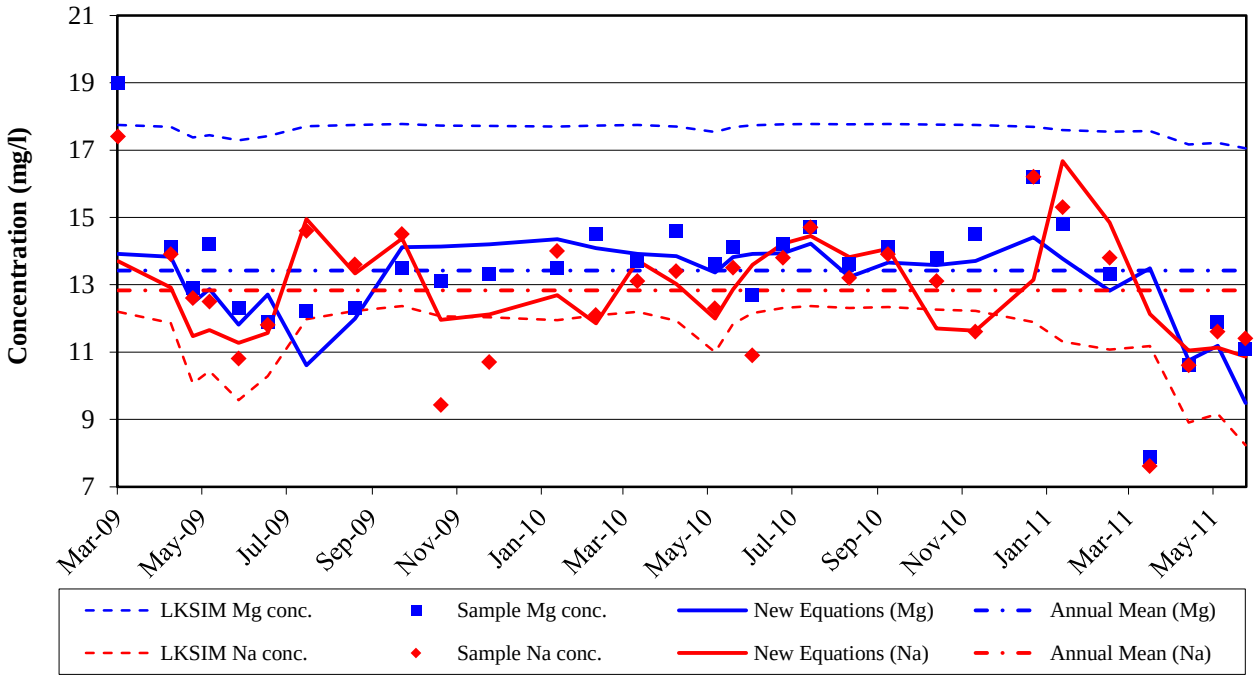

Figure 3-67: UT 29 Measured and Predicted Concentrations for Mg and Na

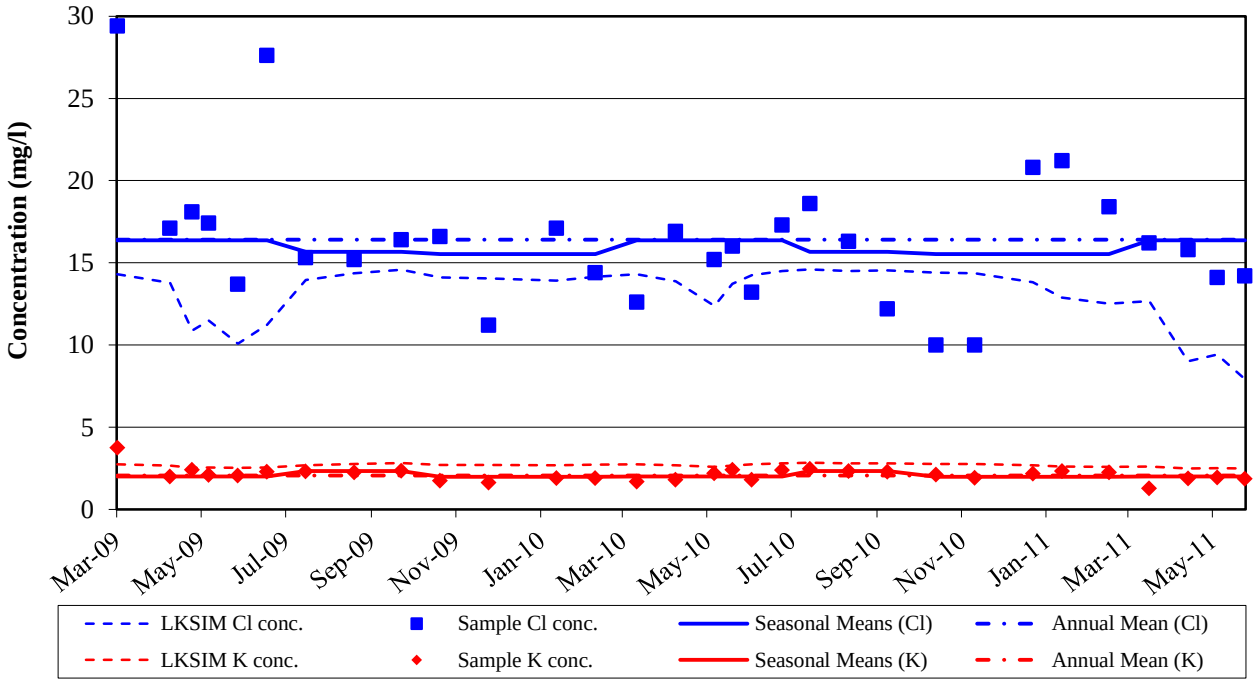

Figure 3-68: UT 29 Measured and Predicted Concentrations for Cl and K

Table 3-8: UT 29 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	318	202	242	239	242	243	26.4	0.58
HCO_3	219	160	175	181	174	172	15.9	0.72
SO_4	58.8	27.0	41.3	45.1	36.9	40.8	8.35	-
Ca	61.2	39.9	53.9	54.5	55.1	53.0	4.52	0.54
Mg	16.2	10.6	13.4	14.1	13.4	13.0	1.21	0.64
Na	17.4	7.61	12.8	12.9	14.1	12.3	1.99	0.40
Cl	29.4	10.0	16.4	15.5	15.7	16.4	4.20	-
K	2.47	1.27	2.07	1.99	2.33	2.00	0.287	-

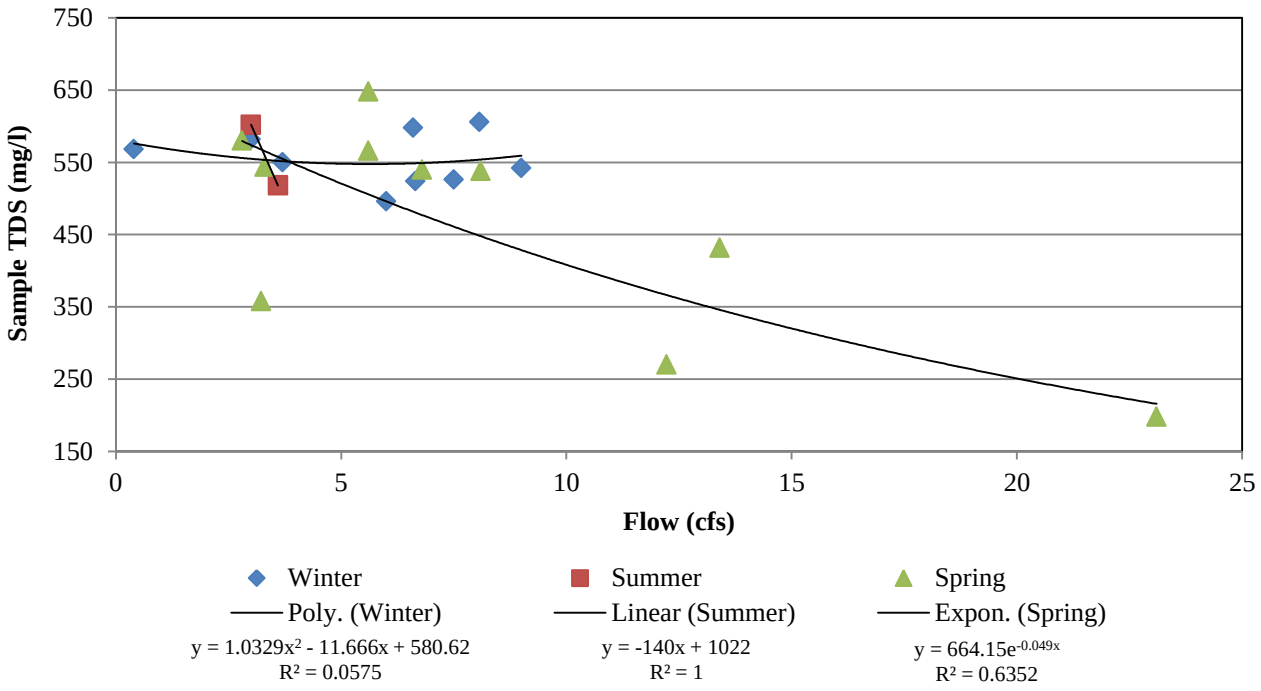

Figure 3-69: UT 38B* Trendlines and Equations for TDS

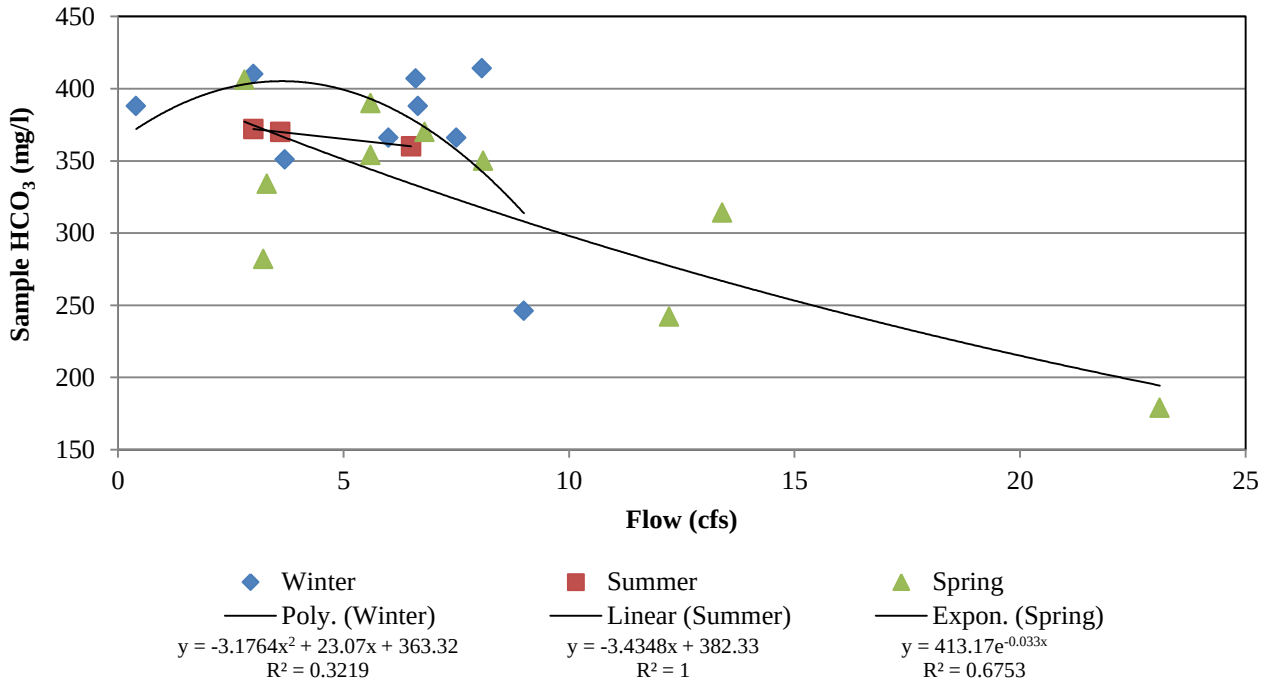

Figure 3-70: UT 38B* Trendlines and Equations for HCO_3

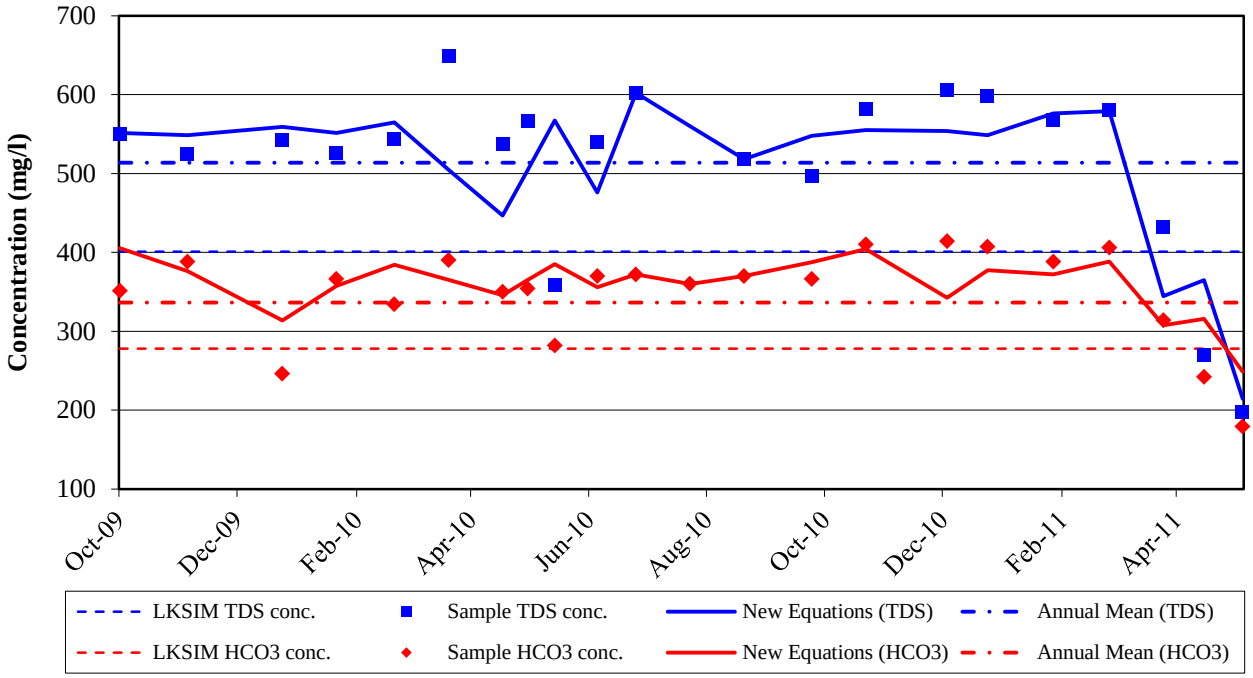

Figure 3-71: UT 38B* Measured and Predicted Concentrations for TDS and HCO_3

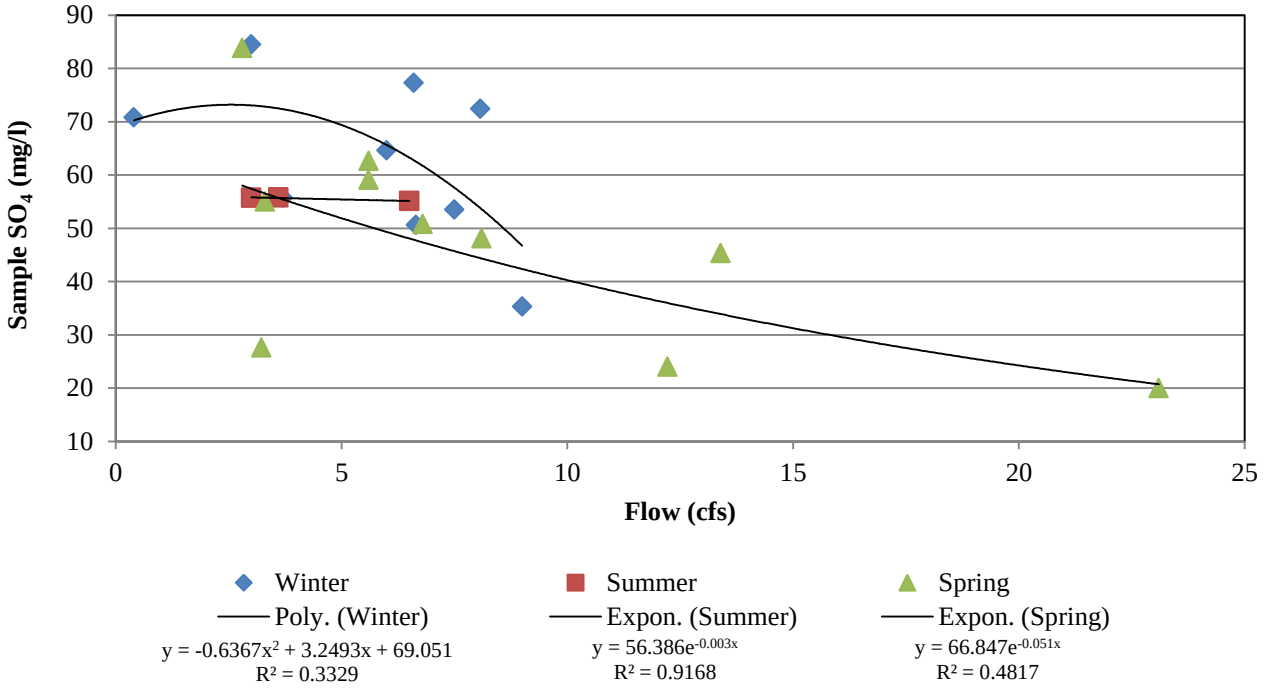

Figure 3-72: UT 38B* Trendlines and Equations for SO_4

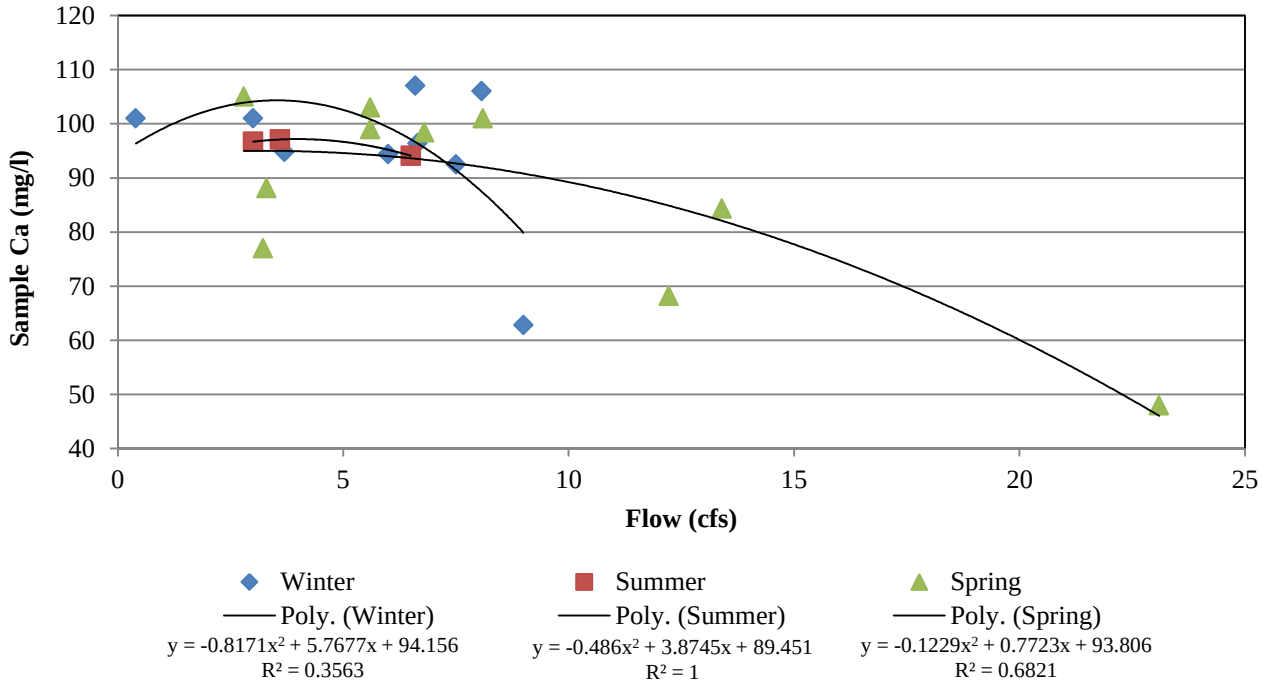

Figure 3-73: UT 38B* Trendlines and Equations for Ca

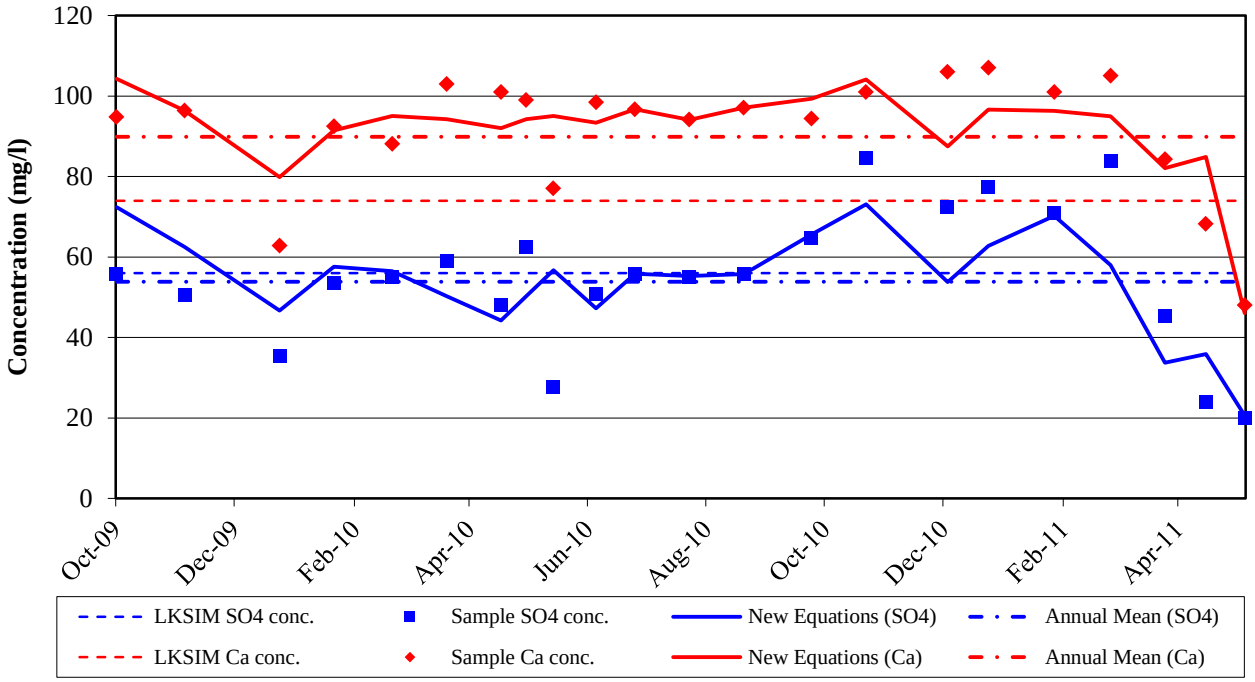

Figure 3-74: UT 38B* Measured and Predicted Concentrations for SO_4 and Ca

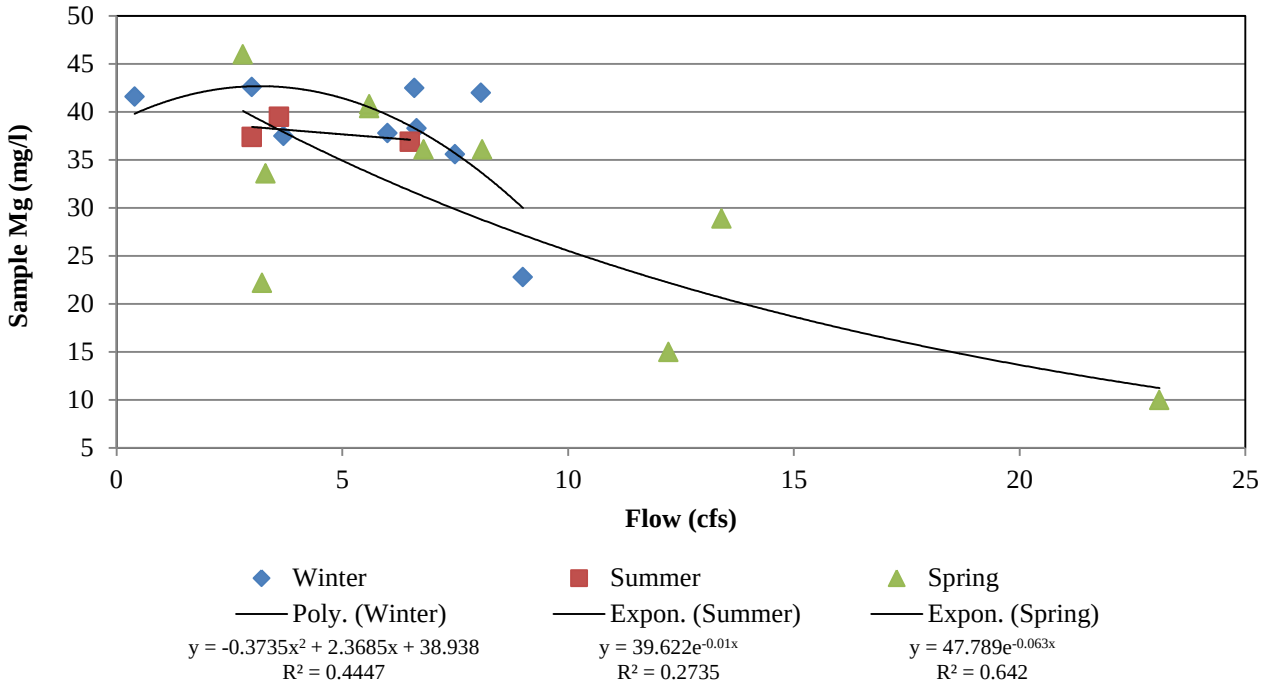

Figure 3-75: UT 38B* Trendlines and Equations for Mg

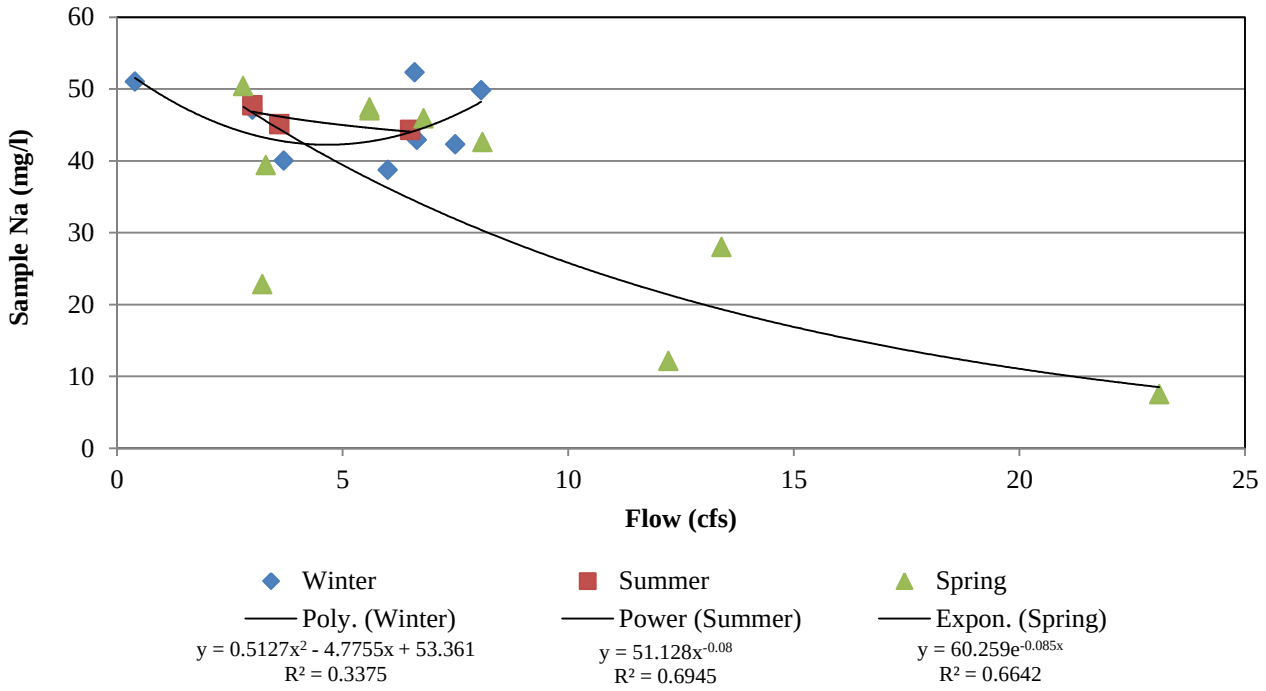

Figure 3-76: UT 38B* Trendlines and Equations for Na

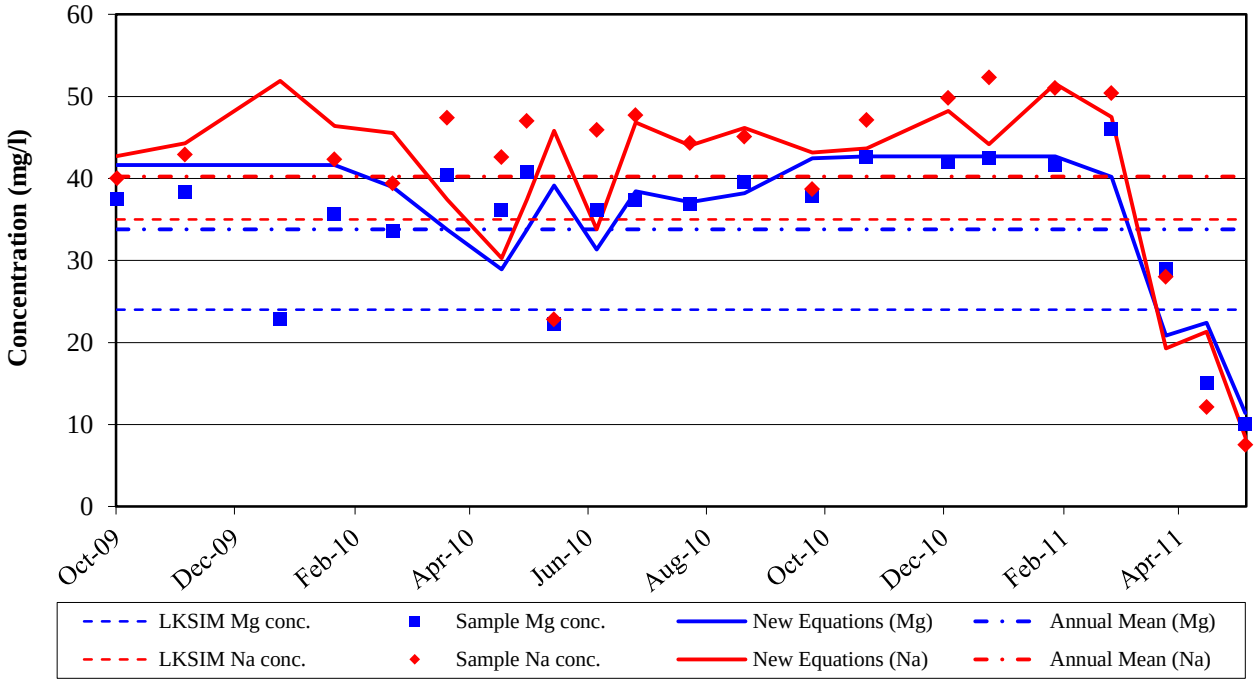

Figure 3-77: UT 38B* Measured and Predicted Concentrations for Mg and Na

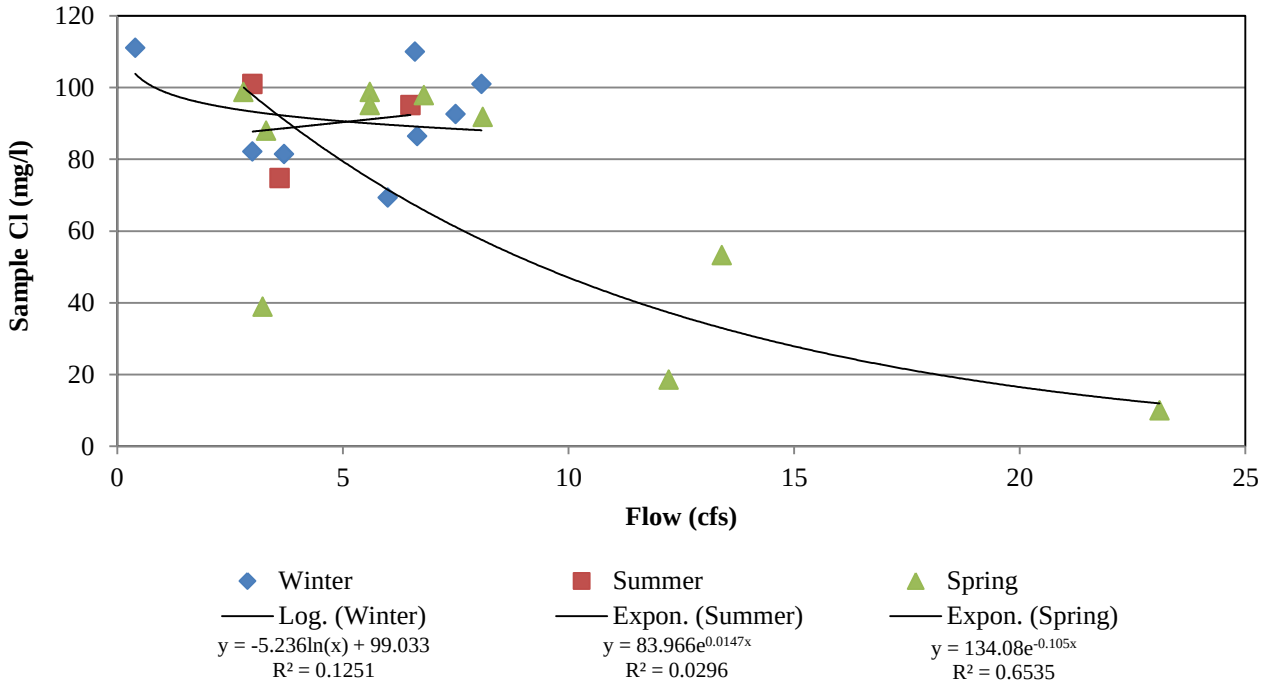

Figure 3-78: UT 38B* Trendlines and Equations for Cl

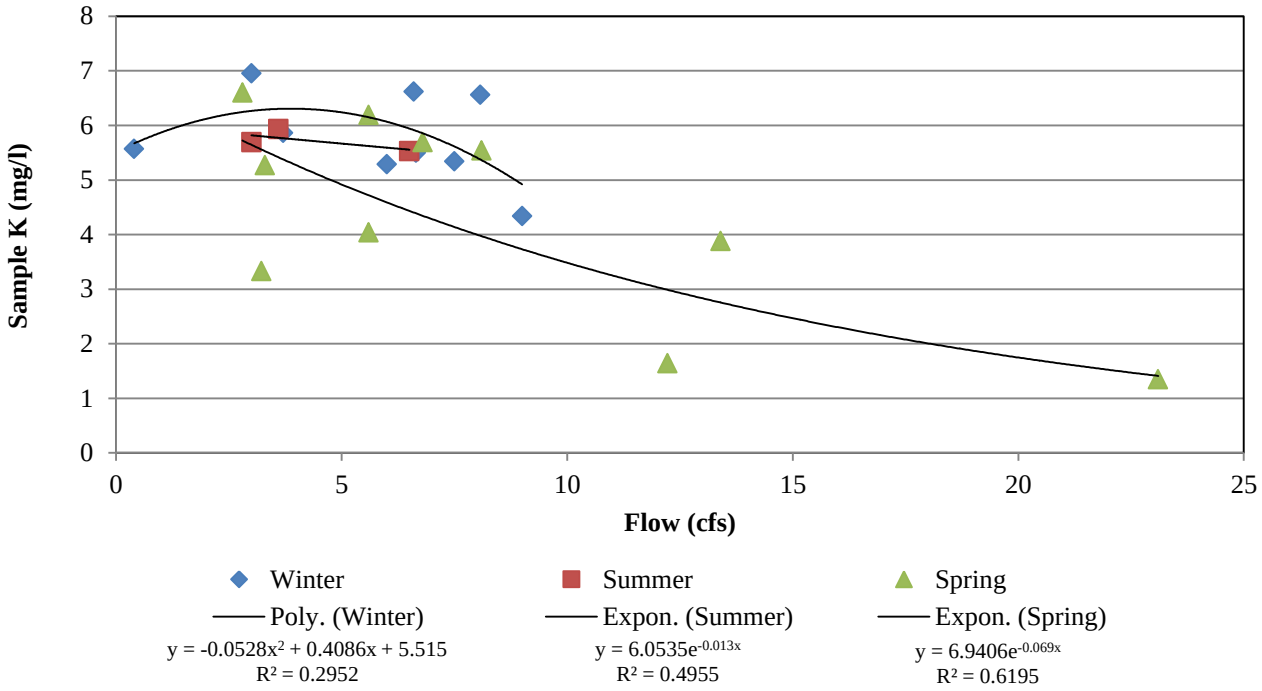

Figure 3-79: UT 38B* Trendlines and Equations for K

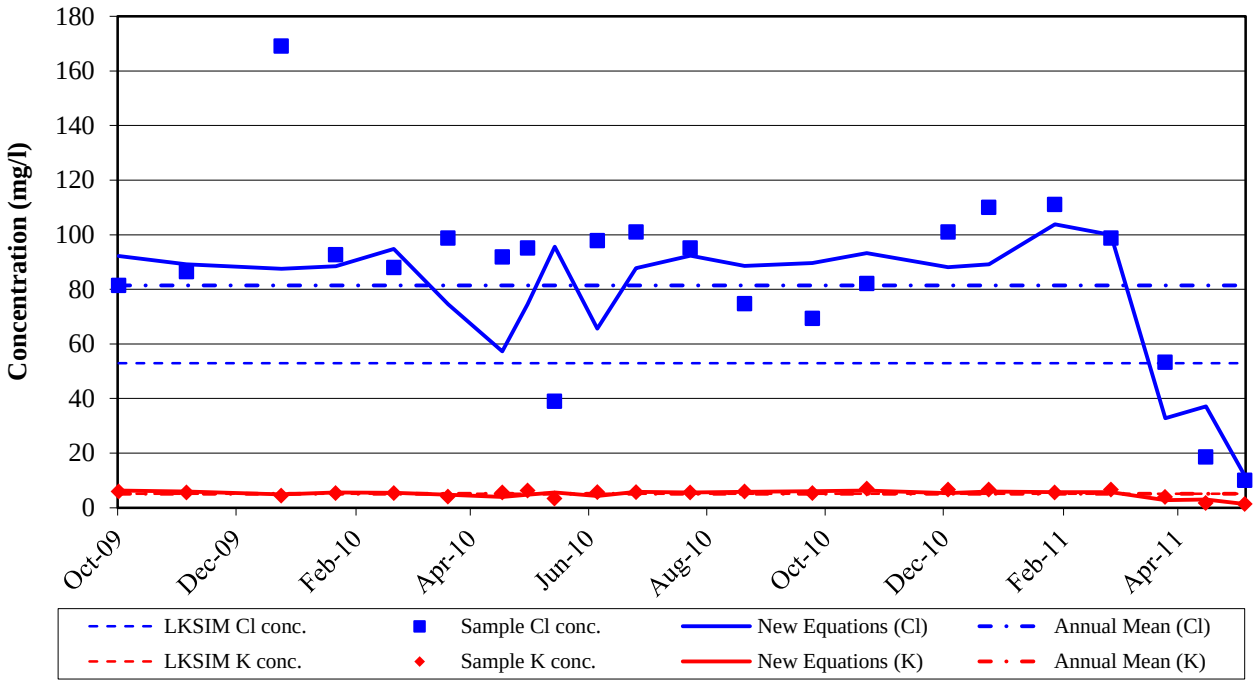

Figure 3-80: UT 38B* Measured and Predicted Concentrations for Cl and K

Table 3-9: UT 38B* Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	648	198	514	555	541	472	105	0.58
HCO_3	414	179	337	371	350	312	62.6	0.56
SO_4	84.5	20.0	53.8	62.7	56.2	47.9	16.1	0.49
Ca	107	48.0	89.9	95.1	94.8	85.2	14.5	0.61
Mg	46	10.0	33.8	37.9	37.2	30.3	9.00	0.48
Na	69.7	7.50	40.2	45.5	44.1	36.1	13.0	0.58
Cl	124	10.0	81.5	91.7	88.7	73.6	27.4	0.47
K	8.86	1.18	5.12	5.78	5.54	4.60	1.61	0.59

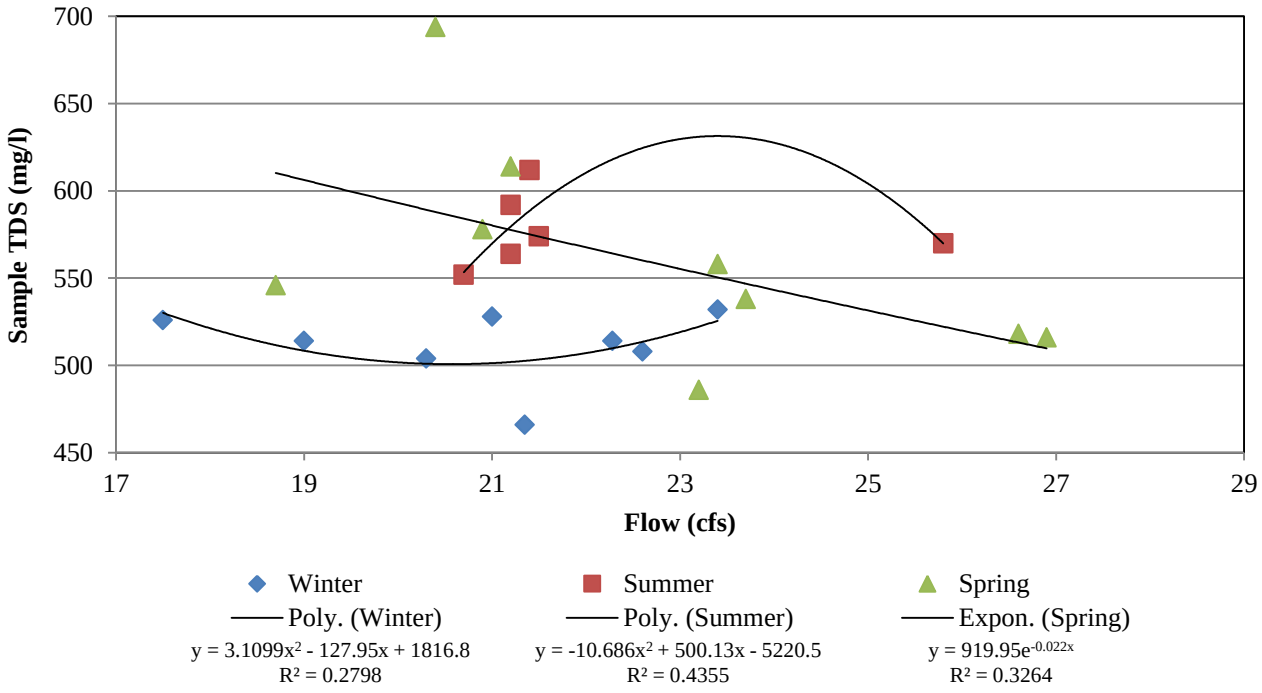

Figure 3-81: UT 38A Trendlines and Equations for TDS

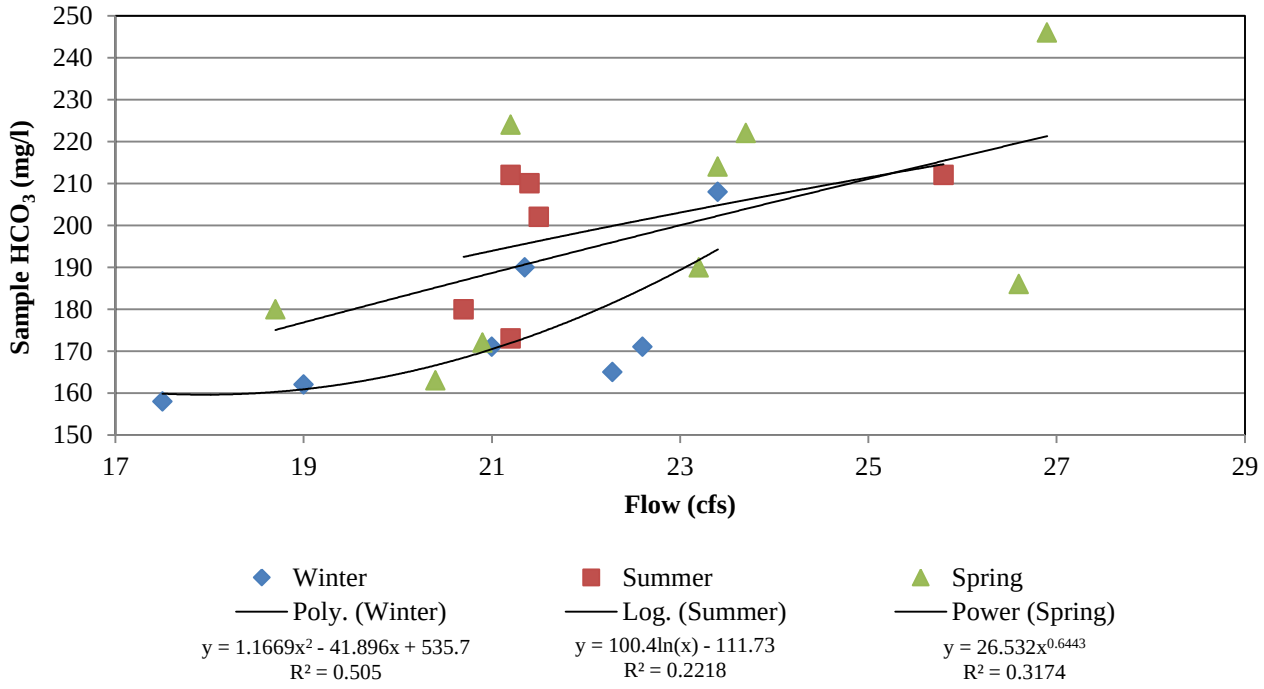

Figure 3-82: UT 38A Trendlines and Equations for HCO_3

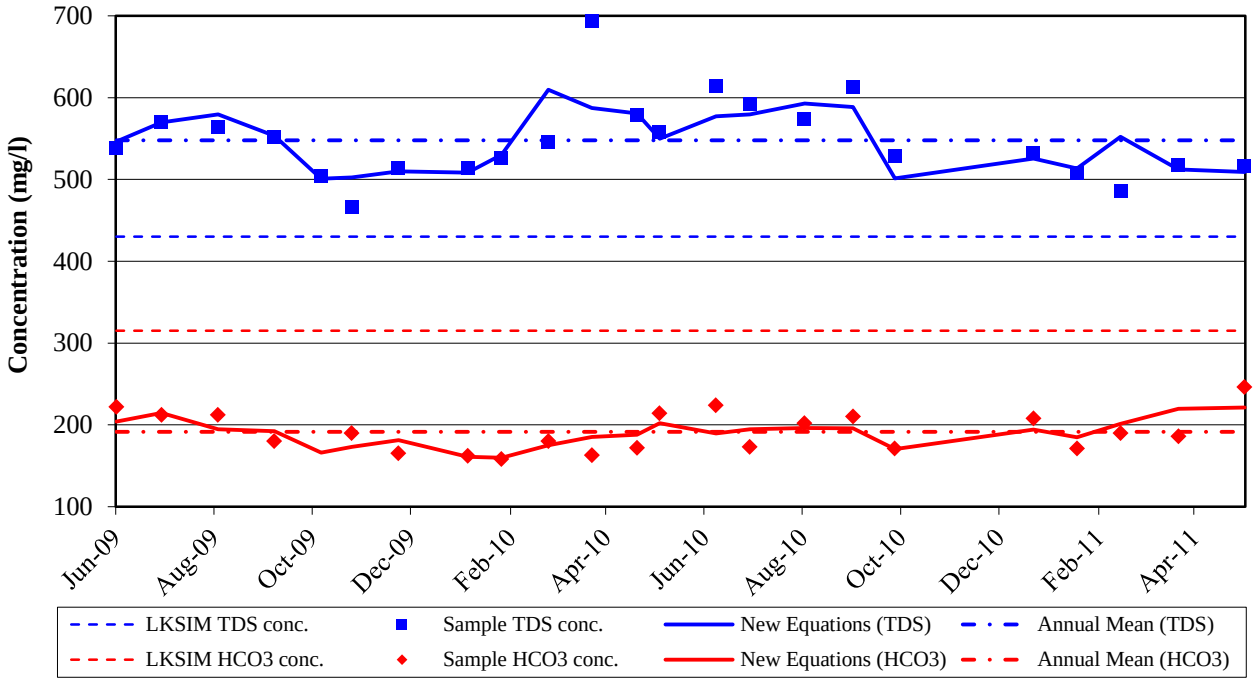

Figure 3-83: UT 38A Measured and Predicted Concentrations for TDS and HCO_3

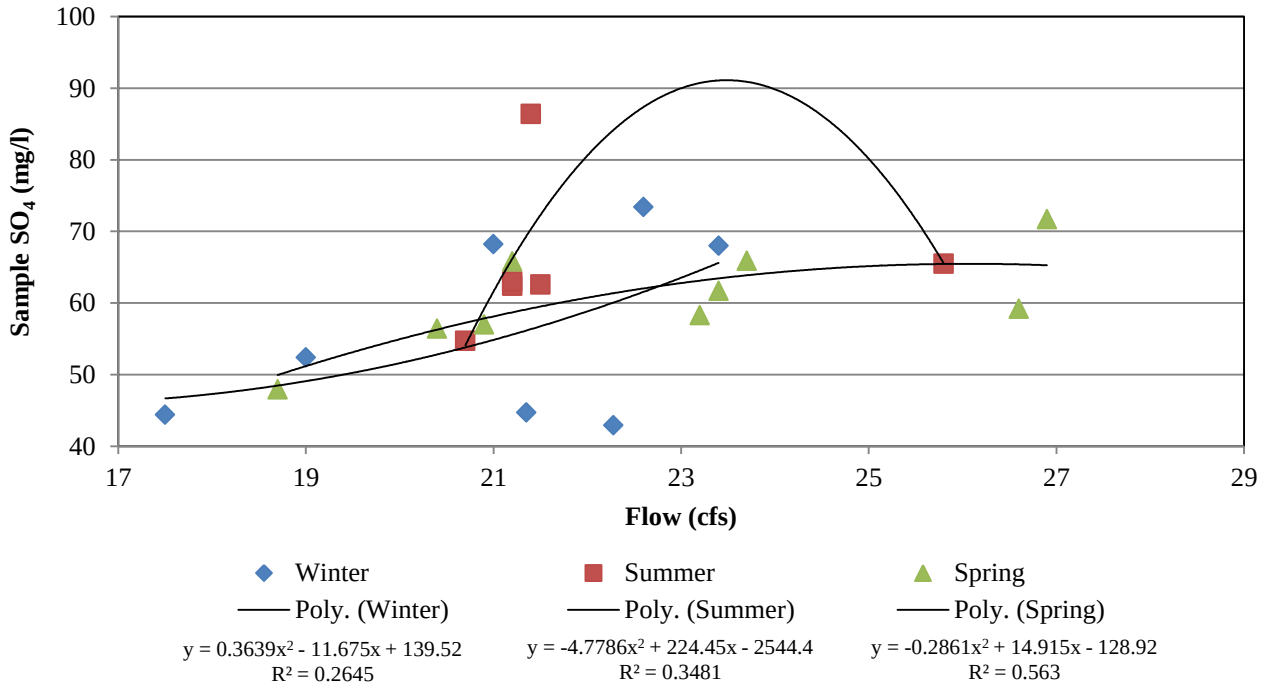

Figure 3-84: UT 38A Trendlines and Equations for SO_4

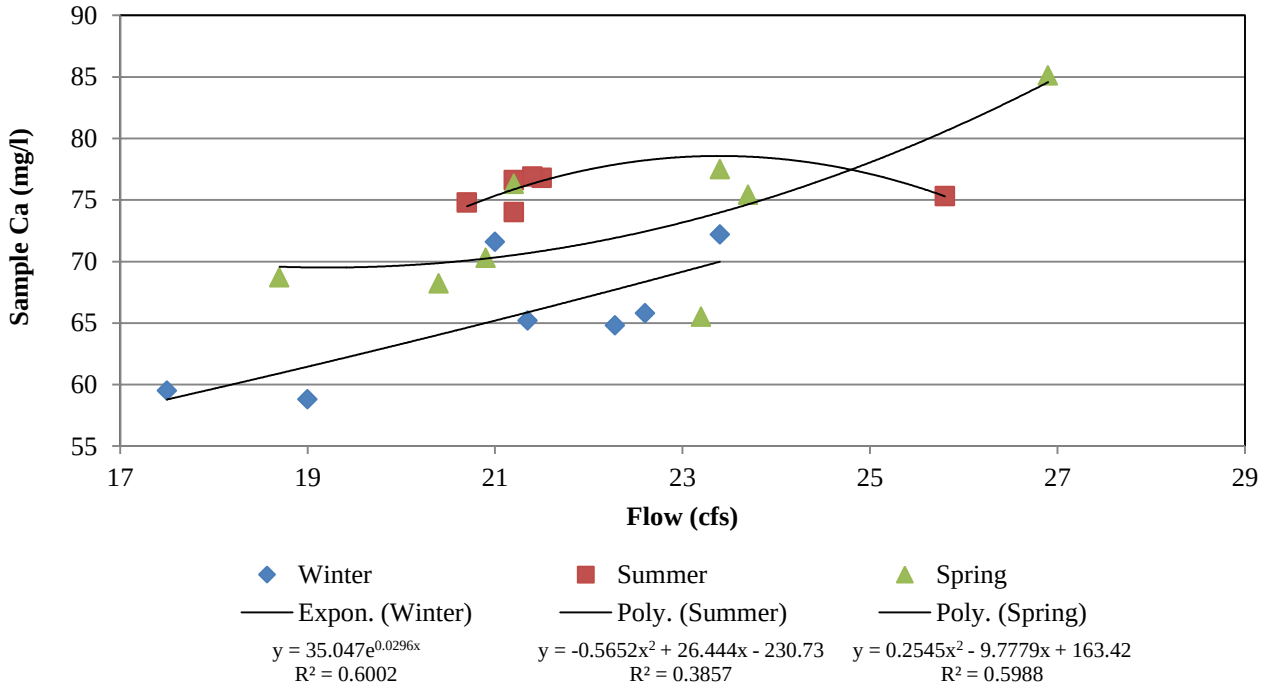

Figure 3-85: UT 38A Trendlines and Equations for Ca

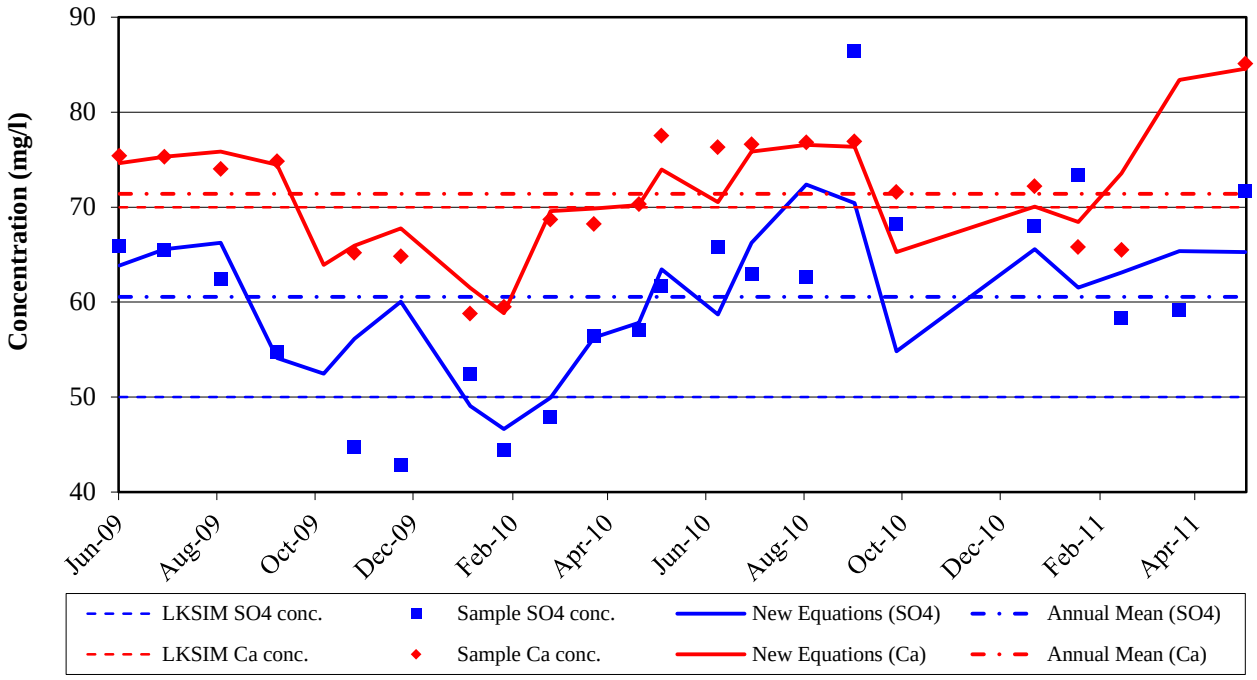

Figure 3-86: UT 38A Measured and Predicted Concentrations for SO_4 and Ca

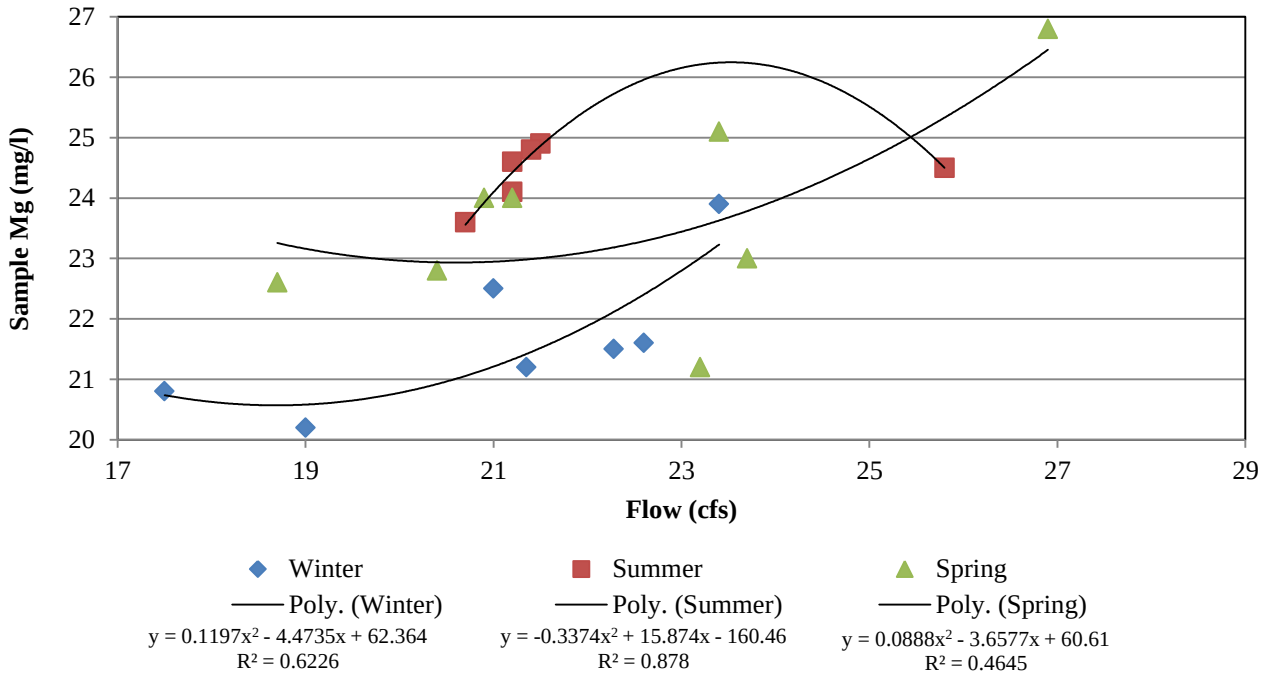

Figure 3-87: UT 38A Trendlines and Equations for Mg

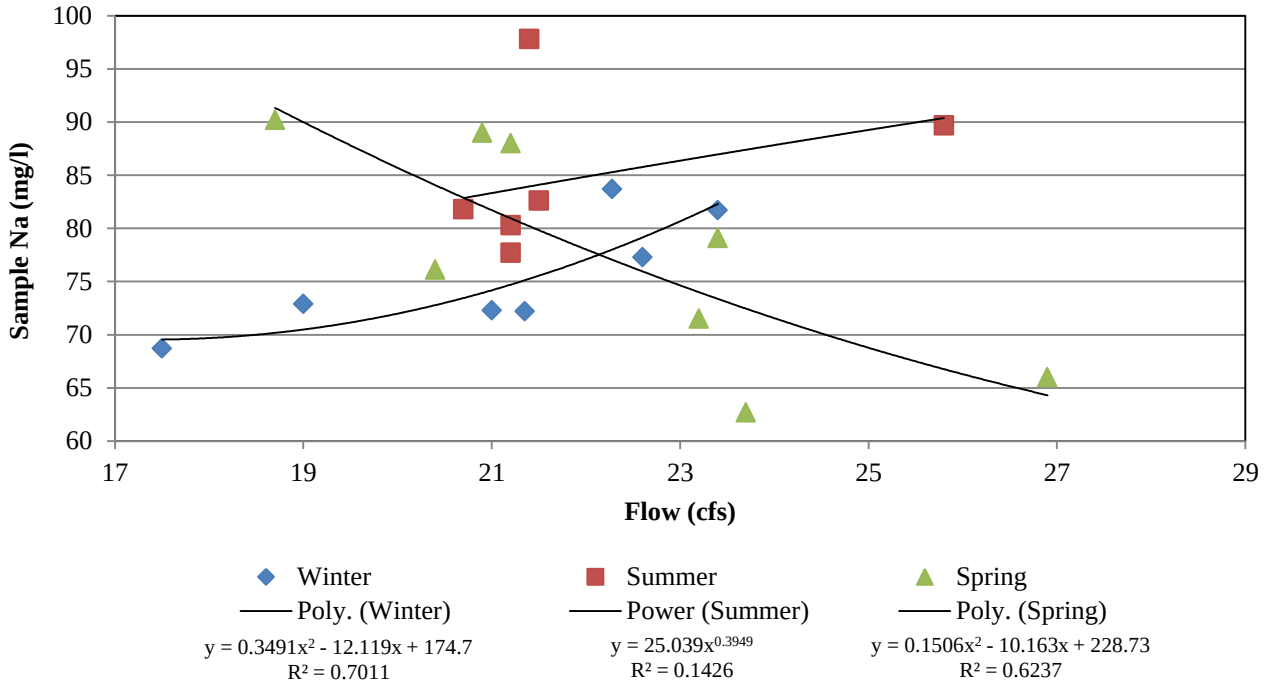

Figure 3-88: UT 38A Trendlines and Equations for Na

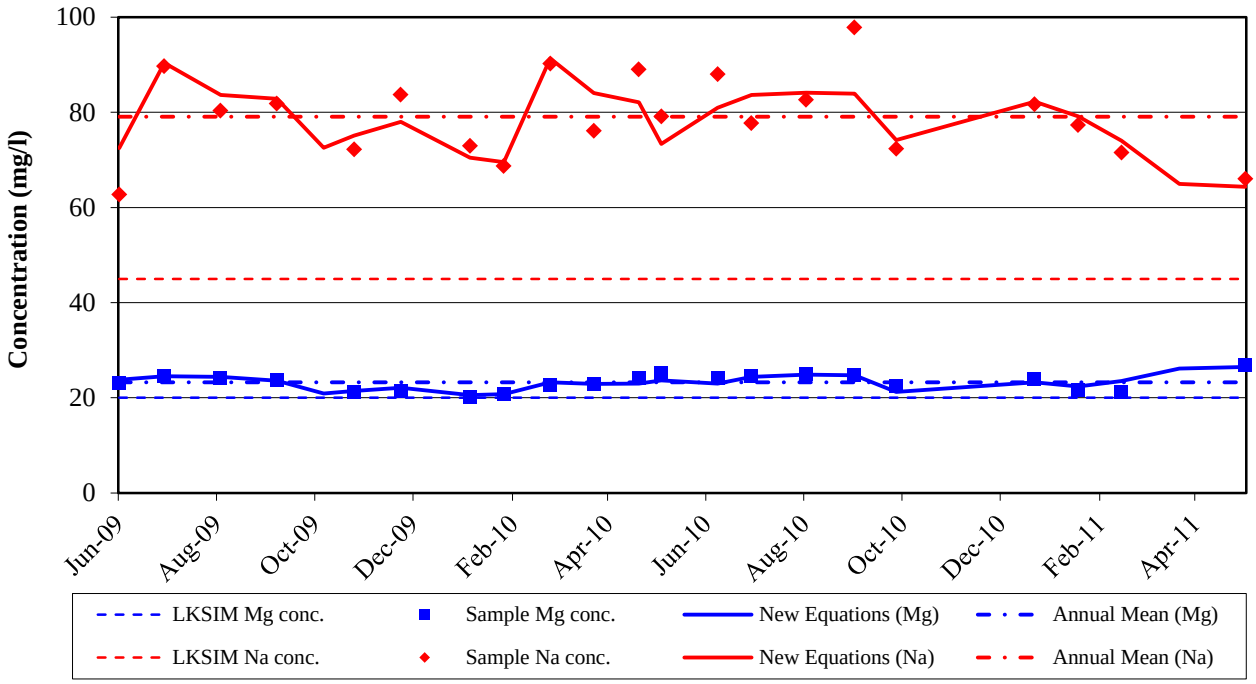

Figure 3-89: UT 38A Measured and Predicted Values for Mg and Na

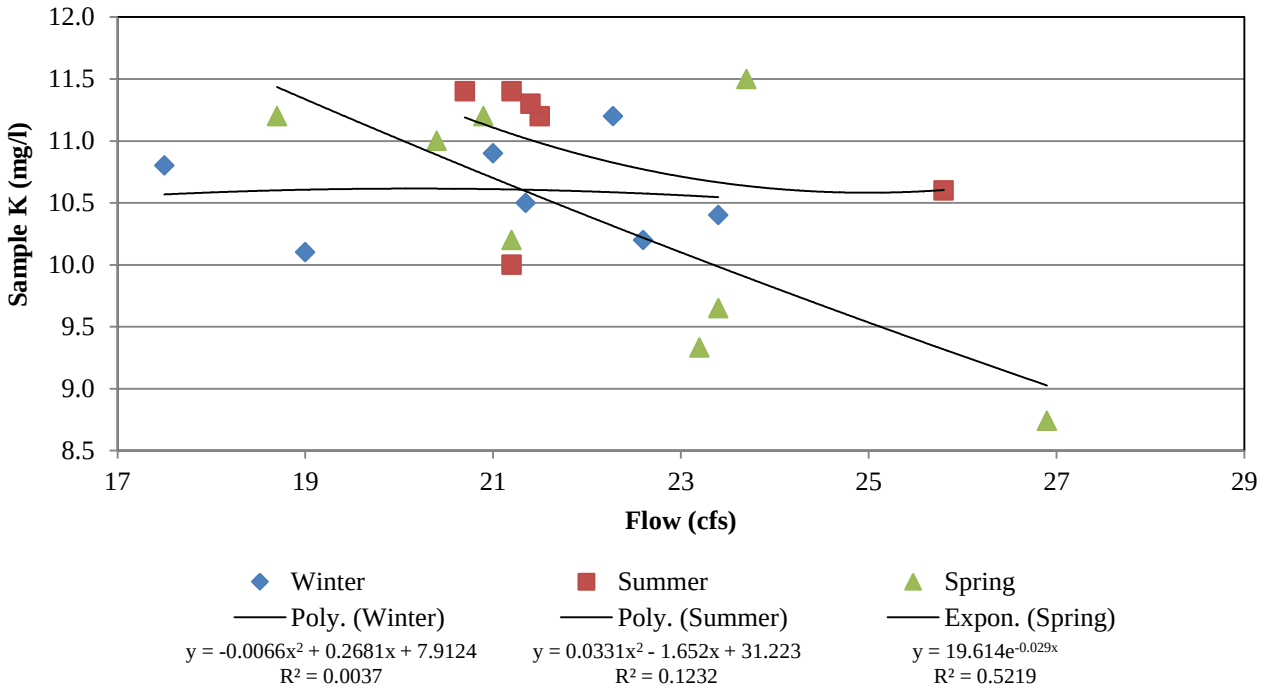

Figure 3-90: UT 38A Trendlines and Equations for K

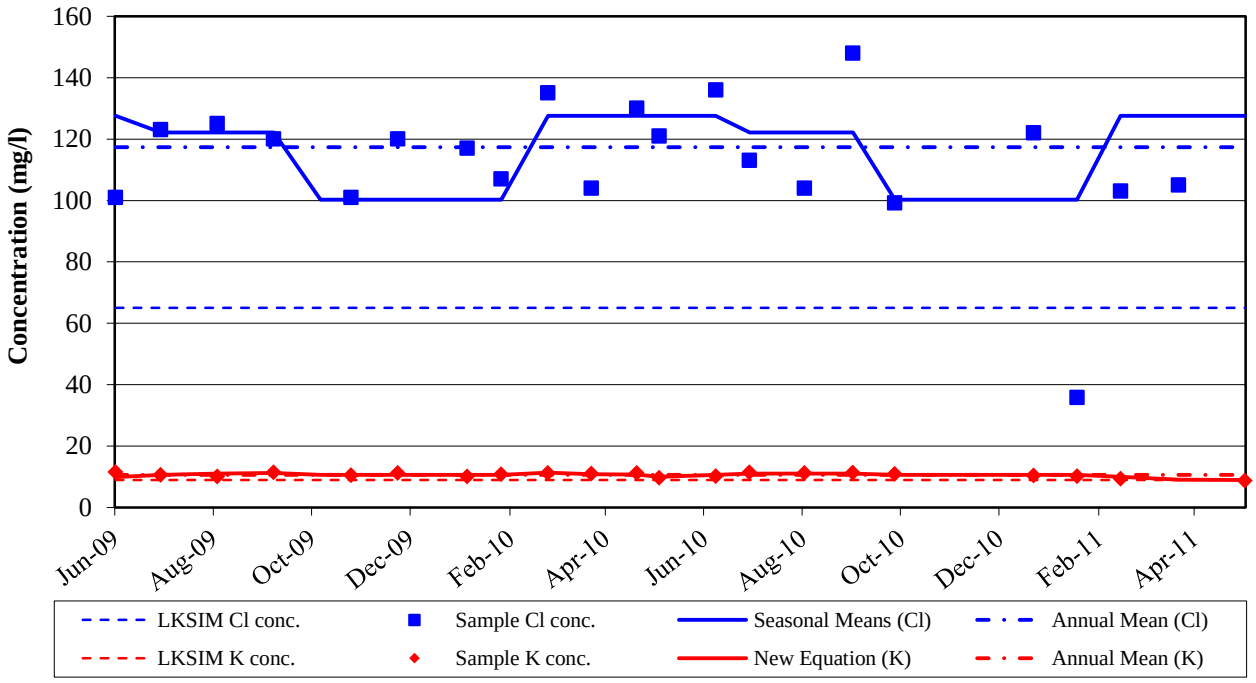

Figure 3-91: UT 38A Measured and Predicted Concentrations for Cl and K

Table 3-10: UT 38A Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	694	466	548	512	577	561	49.4	0.54
HCO_3	246	158	191	175	198	200	24.3	0.49
SO_4	86.4	42.9	60.6	56.3	65.8	60.4	10.4	0.43
Ca	85.1	58.8	71.4	65.4	75.7	73.4	6.53	0.78
Mg	26.8	20.2	23.2	21.7	24.4	23.7	1.70	0.75
Na	97.8	62.7	79.1	75.5	85.0	77.8	8.84	0.62
Cl	213	35.8	117	100	122	128	30.4	-
K	11.5	8.74	10.6	10.4	11.0	10.4	0.750	0.46

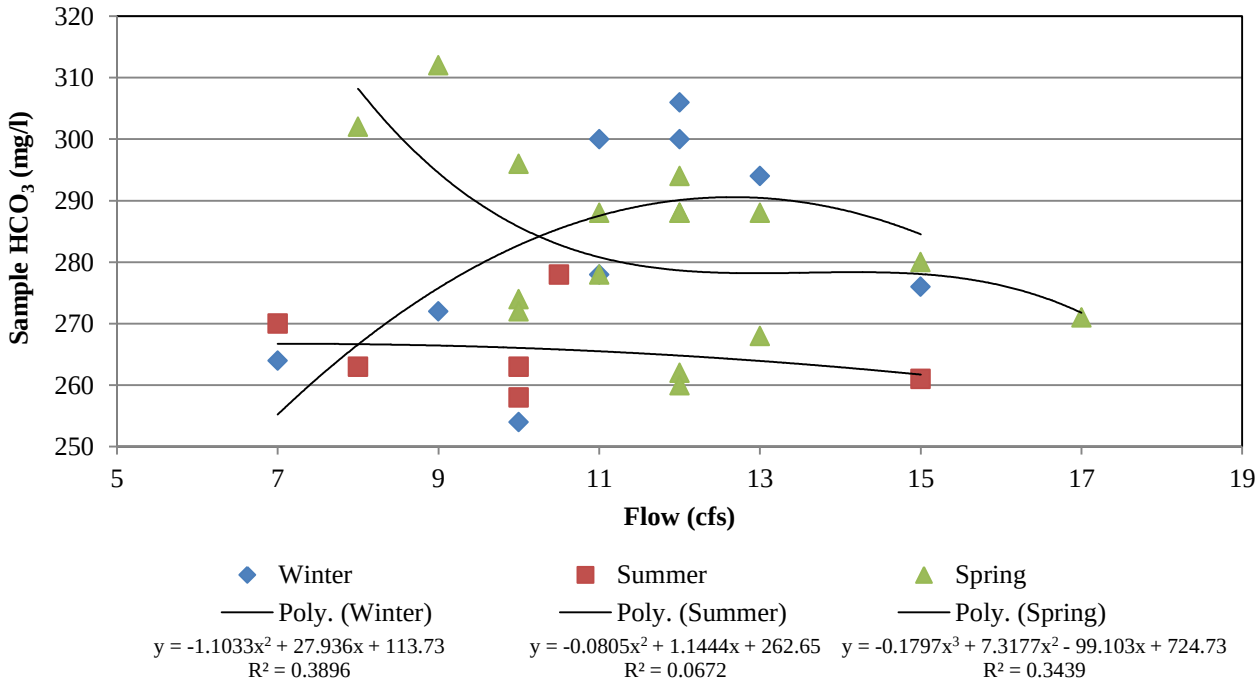

Figure 3-92: UT 42 Trendlines and Equations for HCO_3

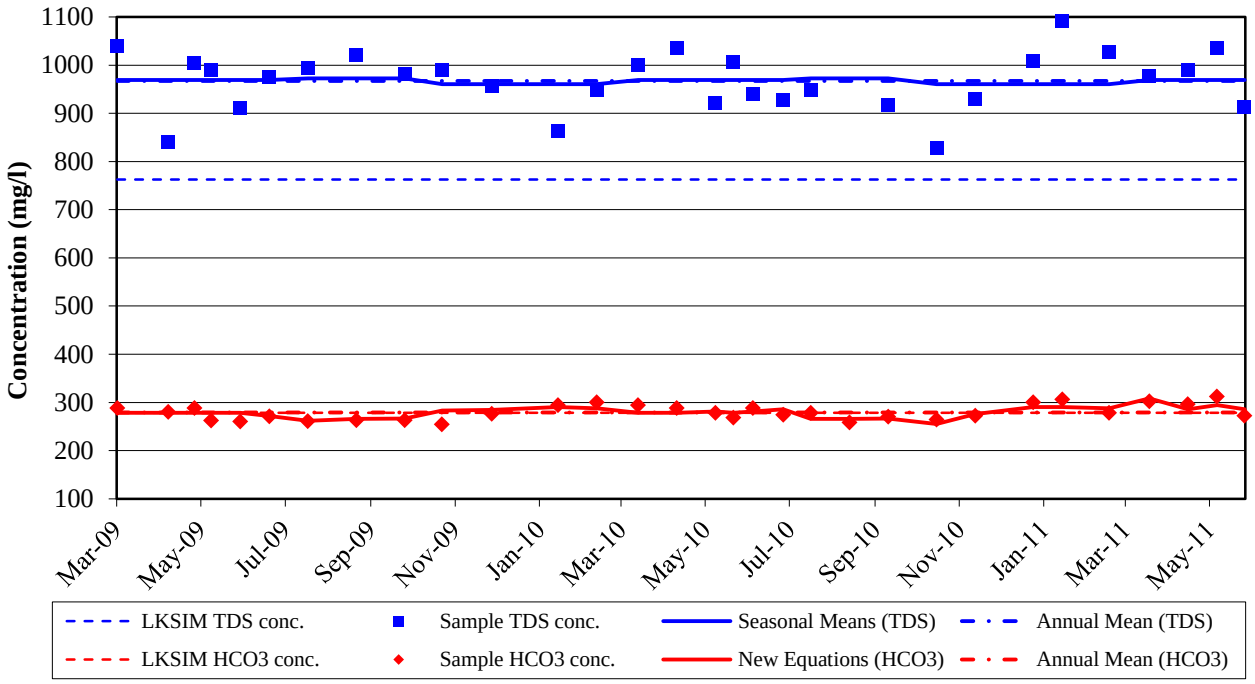

Figure 3-93: UT 42 Measured and Predicted Concentrations for TDS and HCO_3

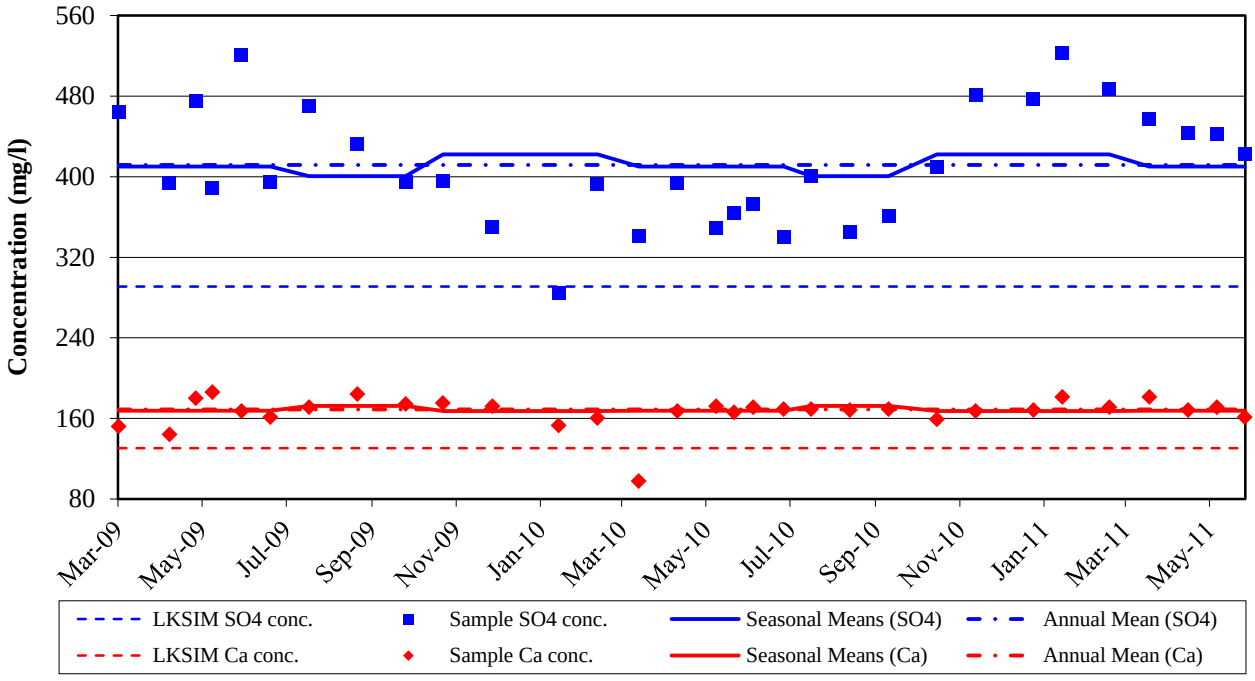

Figure 3-94: UT 42 Measured and Predicted Concentrations for SO_4 and Ca

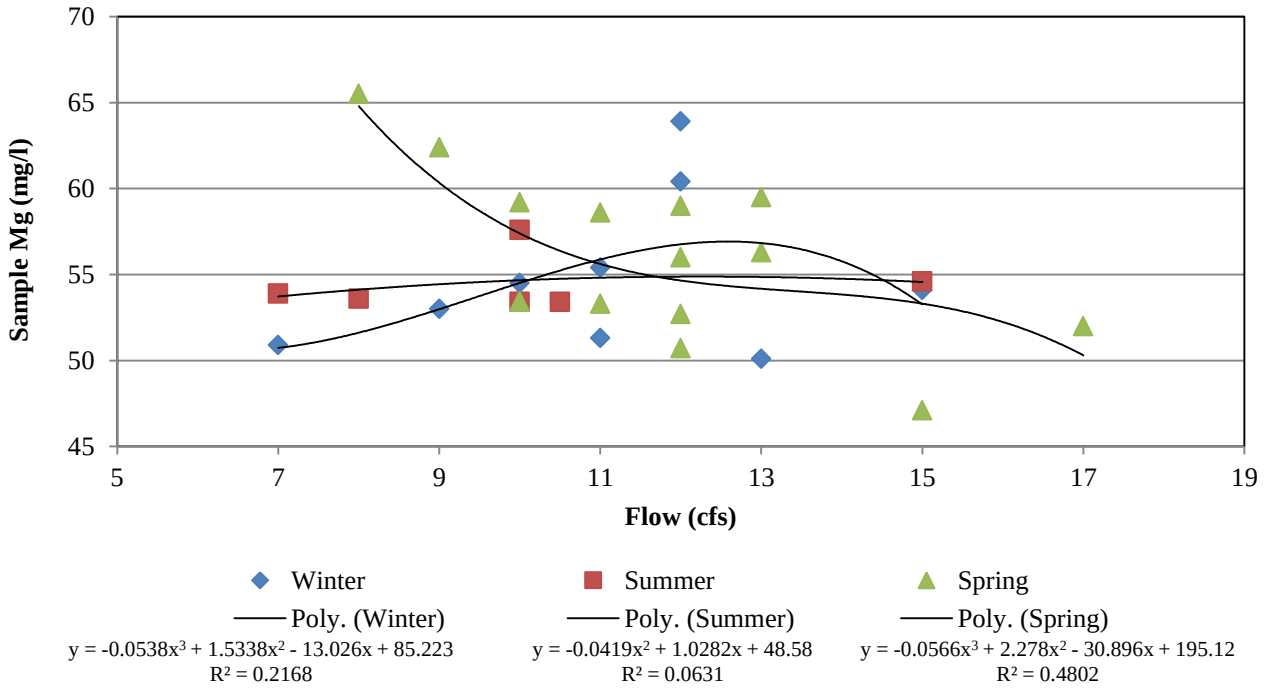

Figure 3-95: UT 42 Trendlines and Equations for Mg

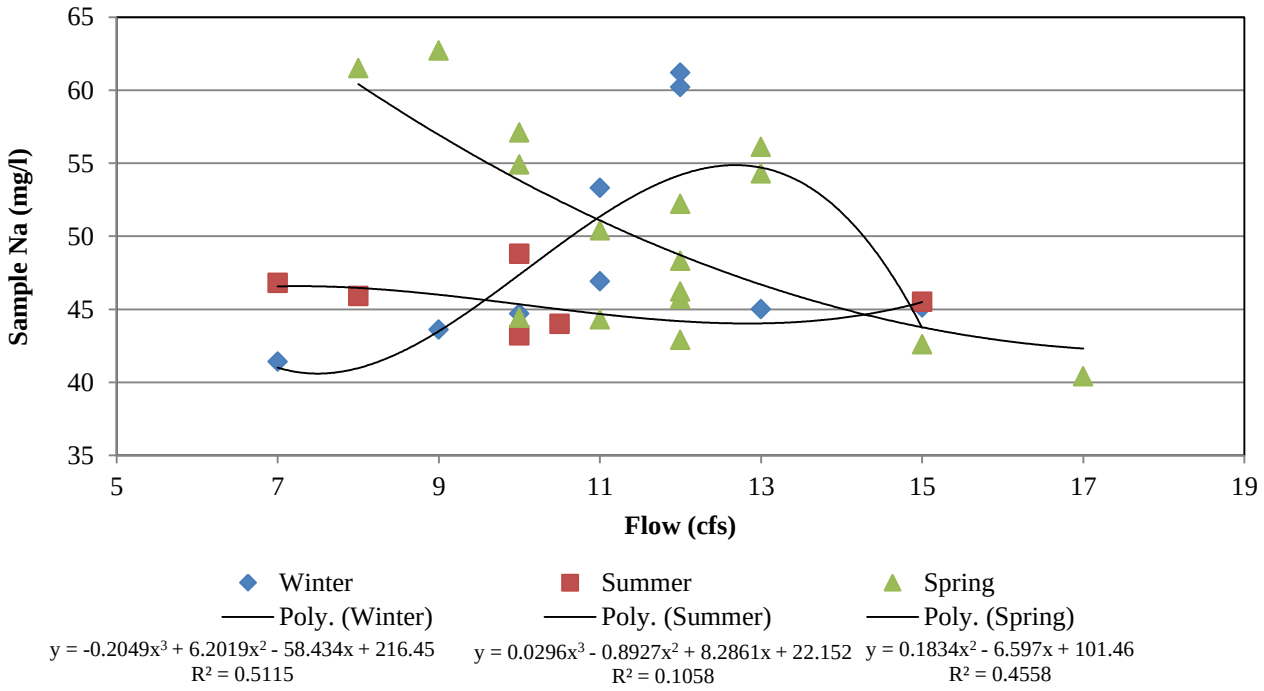

Figure 3-96: UT 42 Trendlines and Equations for Na

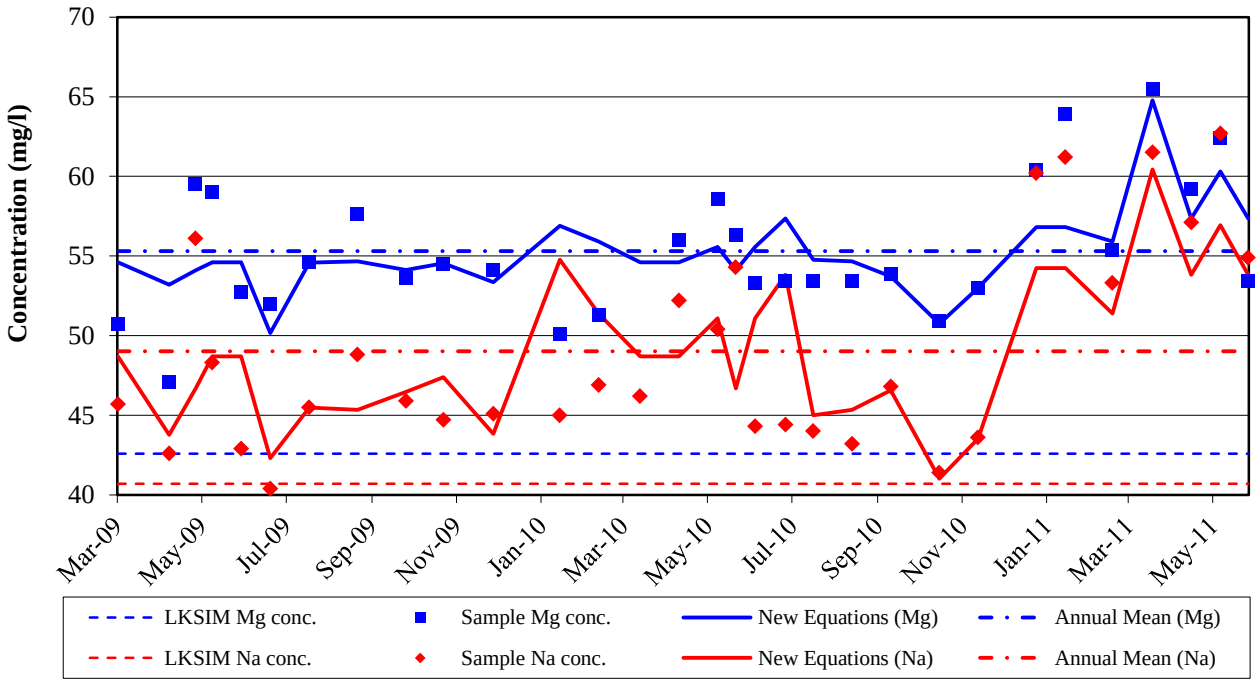

Figure 3-97: UT 42 Measured and Predicted Concentrations for Mg and Na

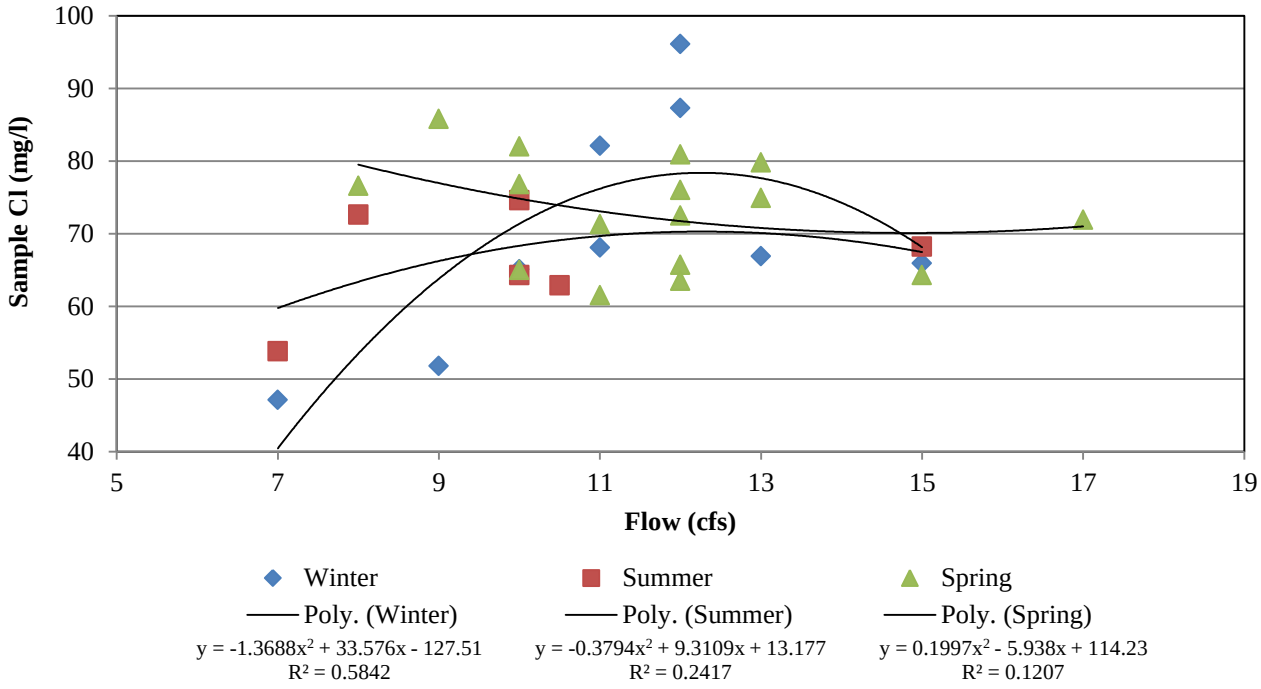

Figure 3-98: UT 42 Trendlines and Equations for Cl

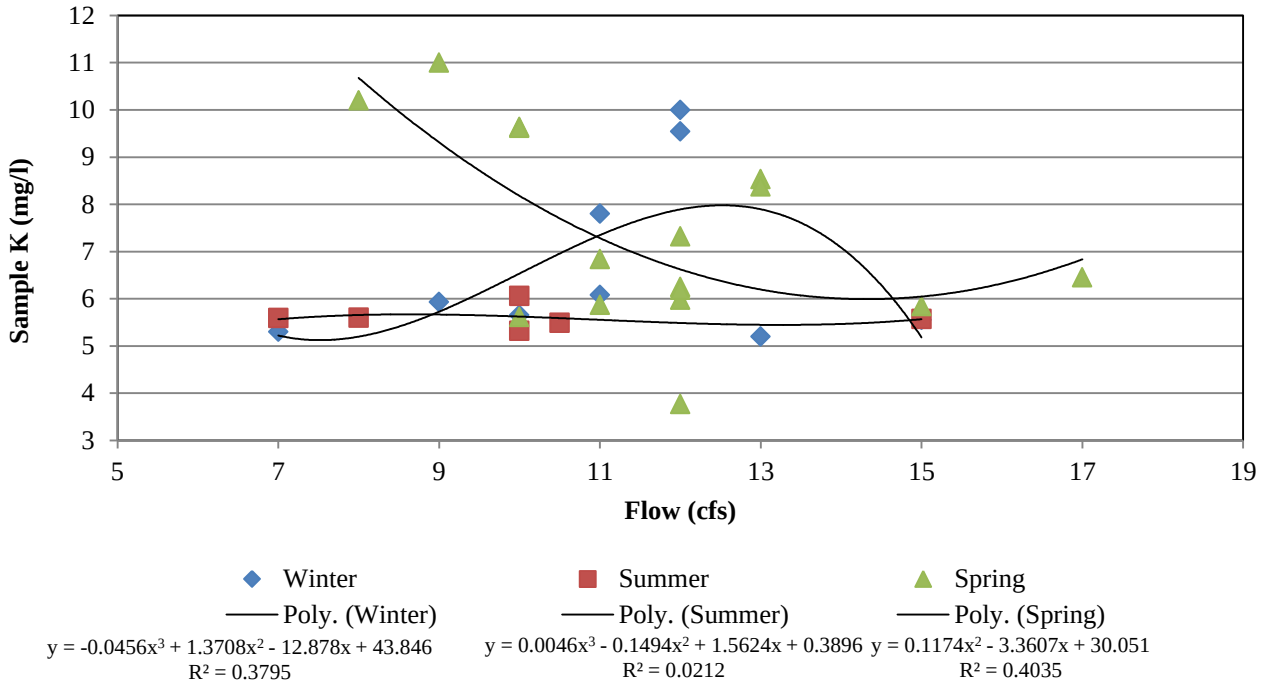

Figure 3-99: UT 42 Trendlines and Equations for K

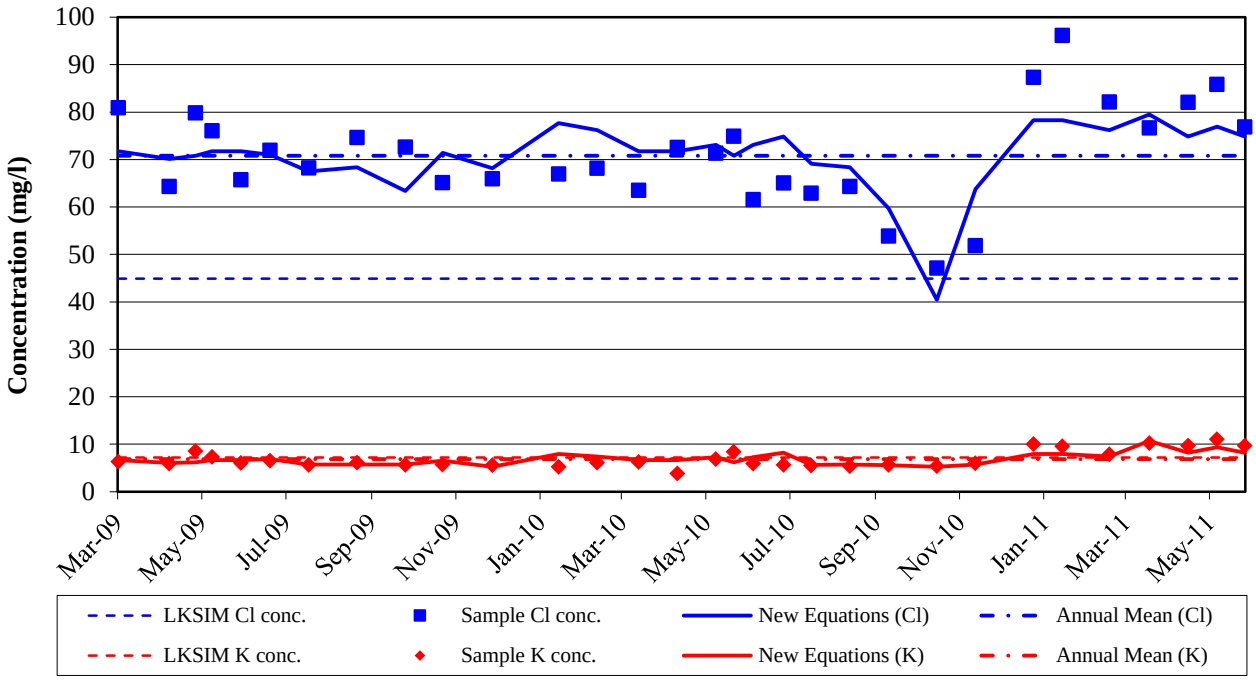

Figure 3-100: UT 42 Measured and Predicted Values for Cl and K

Table 3-11: UT 42 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	1092	828	967	960	972	969	60.6	-
HCO_3	312	254	279	283	266	283	15.8	0.47
SO_4	523	284	412	422	401	410	58.1	-
Ca	186	144	169	167	173	168	9.31	-
Mg	65.5	47.1	55.3	54.8	54.4	55.9	4.23	0.40
Na	62.7	40.4	49.0	49.0	45.7	50.3	6.50	0.51
Cl	96.1	47.1	70.8	70.0	66.1	73.0	10.6	0.47
K	11.0	3.77	6.84	6.78	5.61	7.34	6.84	0.47

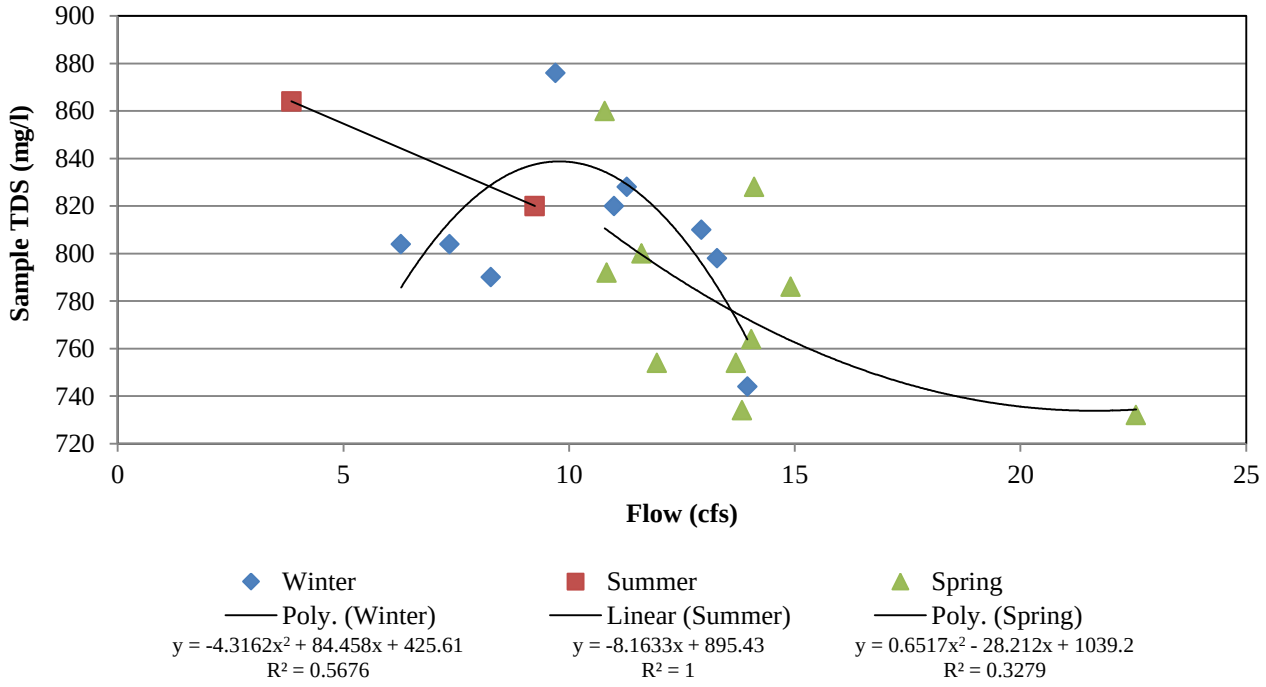

Figure 3-101: UT 43* Trendlines and Equations for TDS

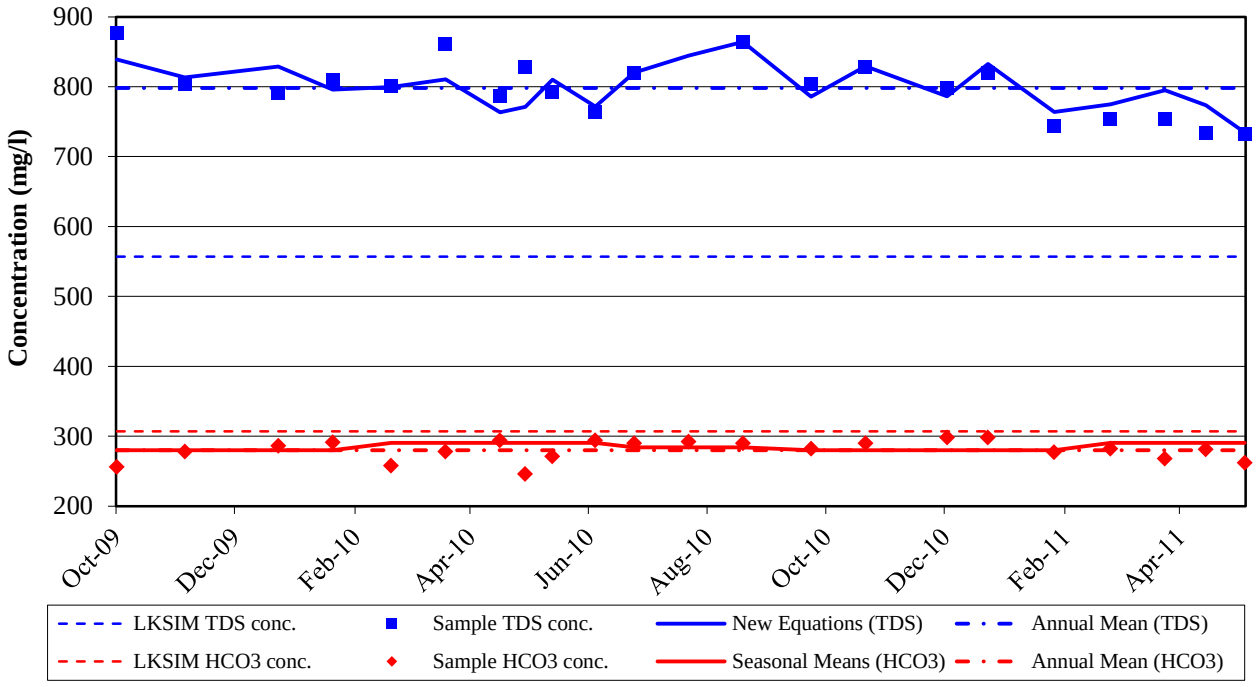

Figure 3-102: UT 43* Measured and Predicted Concentrations for TDS and HCO_3

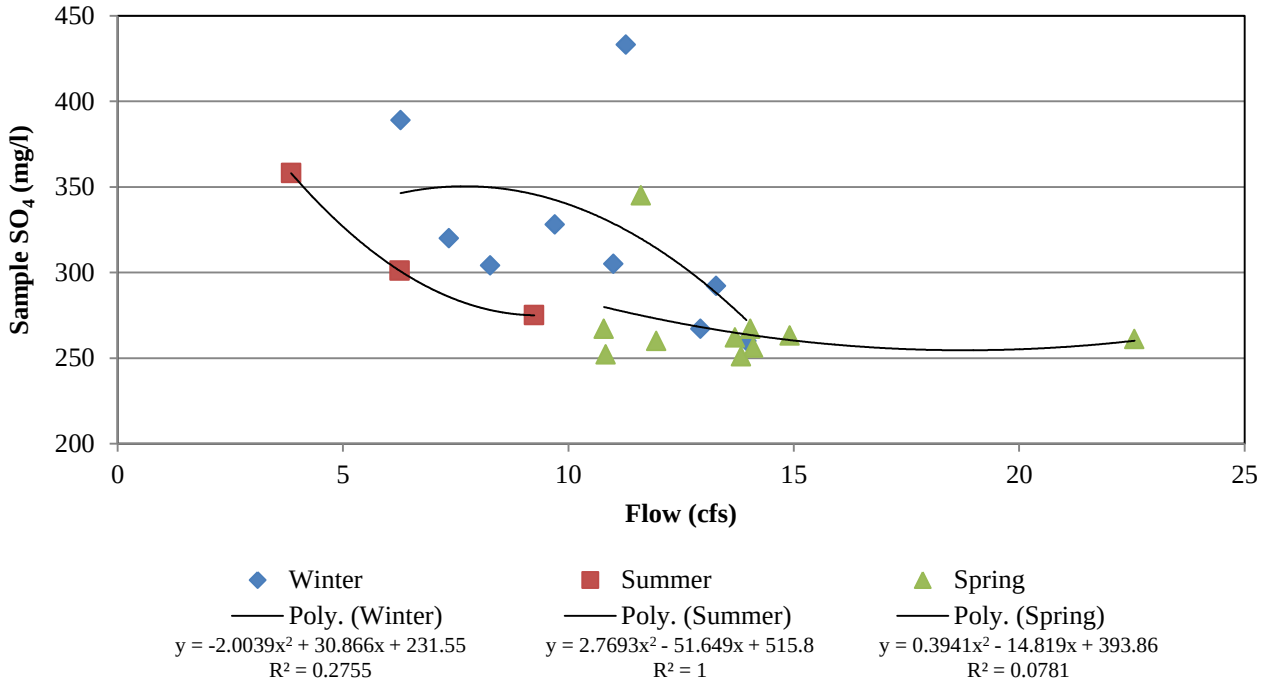

Figure 3-103: UT 43* Trendlines and Equations for SO_4

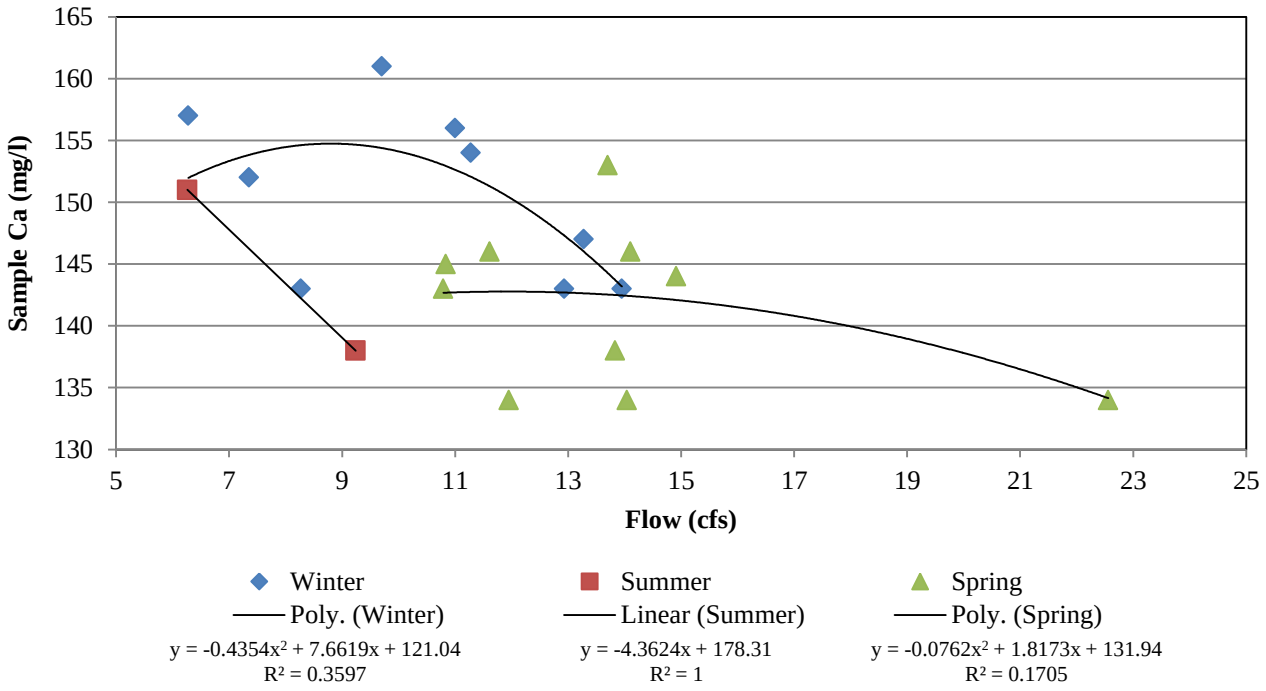

Figure 3-104: UT 43* Trendlines and Equations for Ca

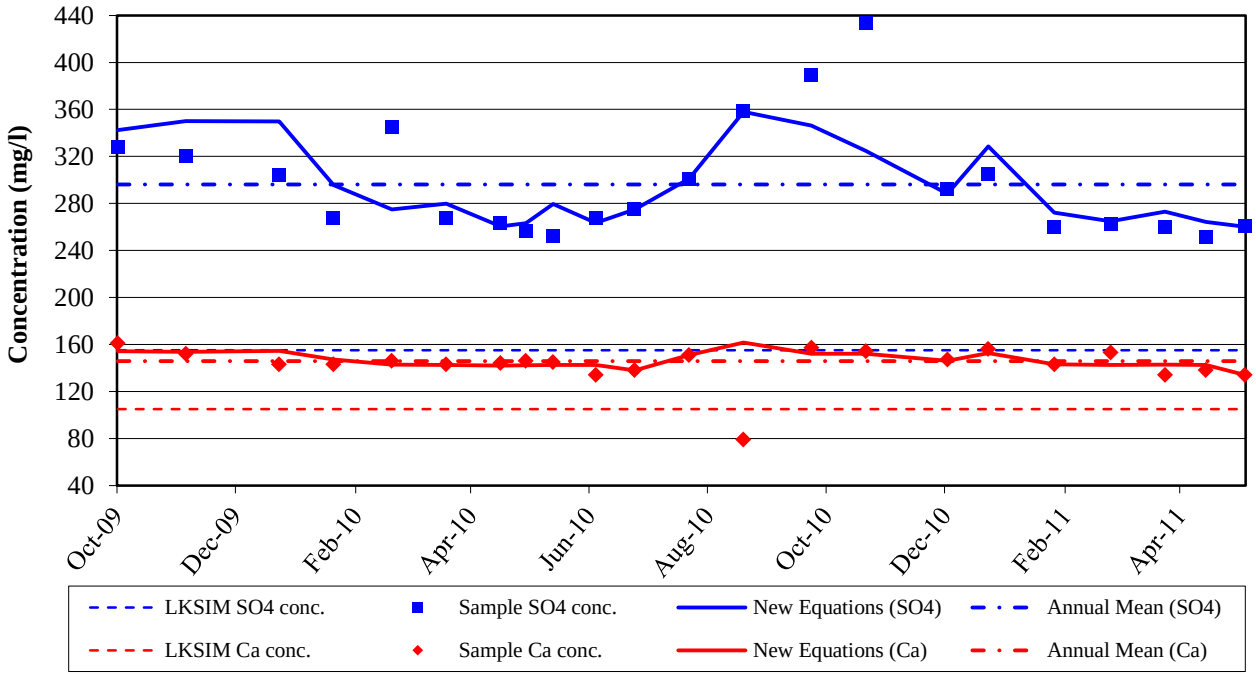

Figure 3-105: UT 43* Measured and Predicted Concentrations for SO_4 and Ca

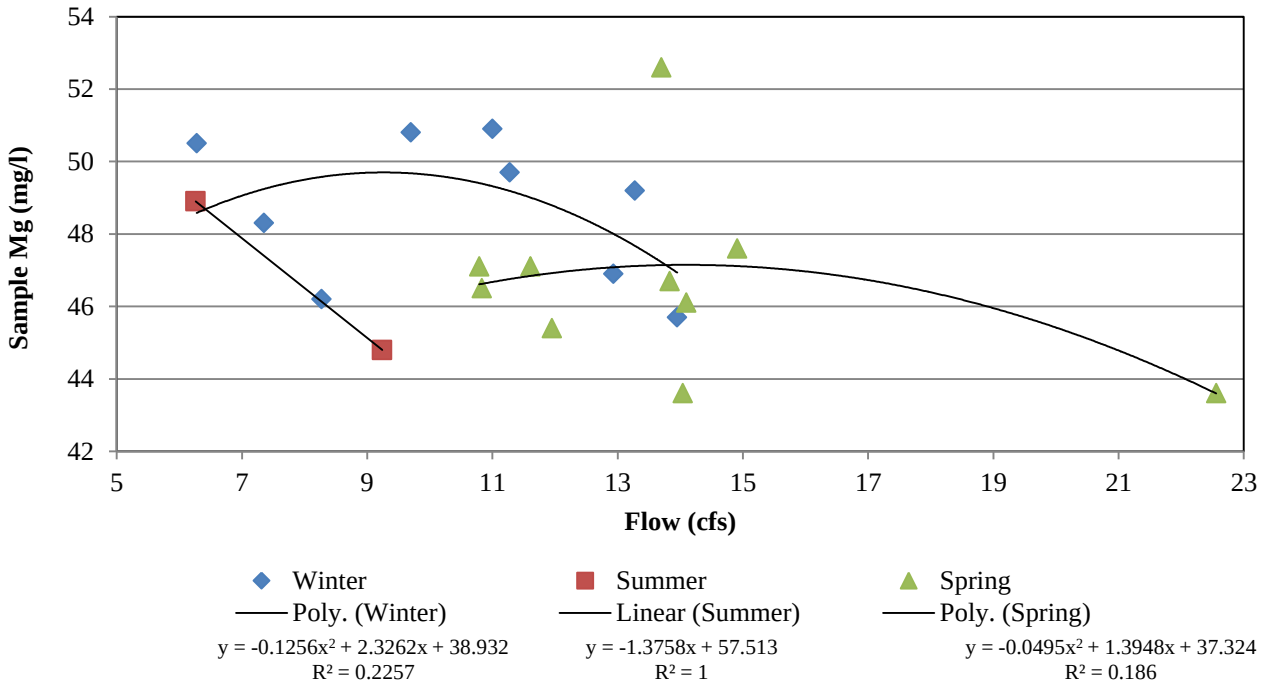

Figure 3-106: UT 43* Trendlines and Equations for Mg

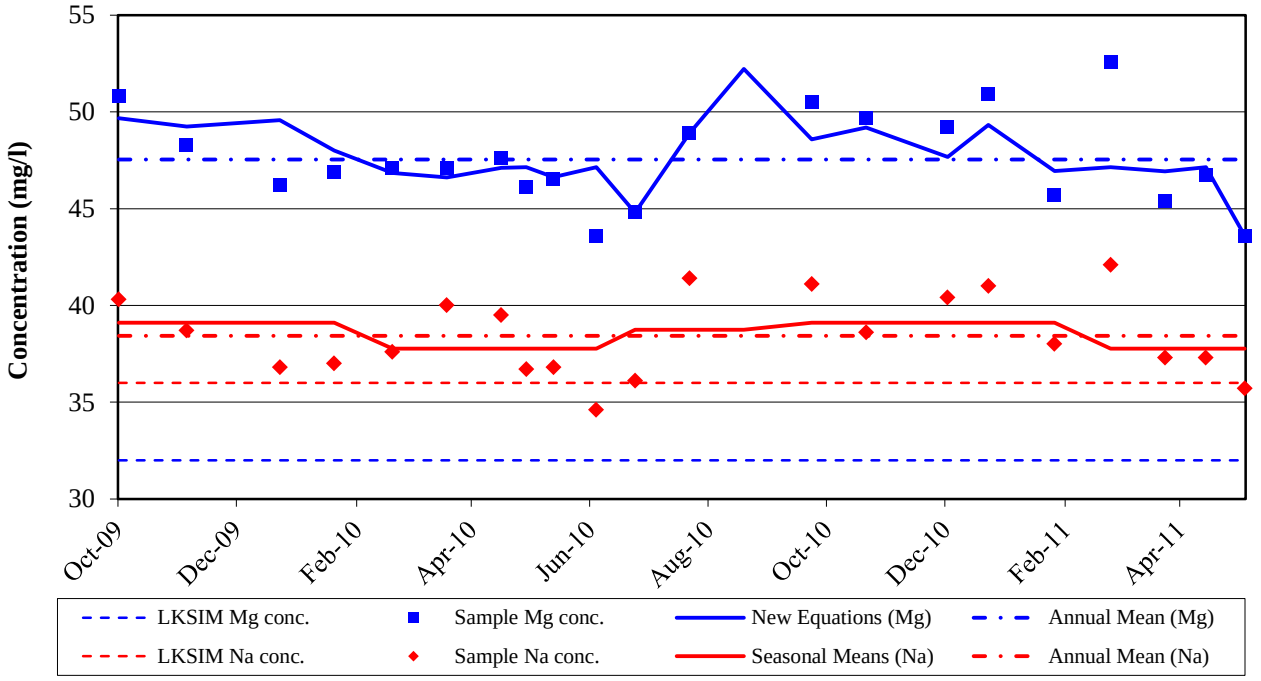

Figure 3-107: UT 43* Measured and Predicted Concentrations for Mg and Na

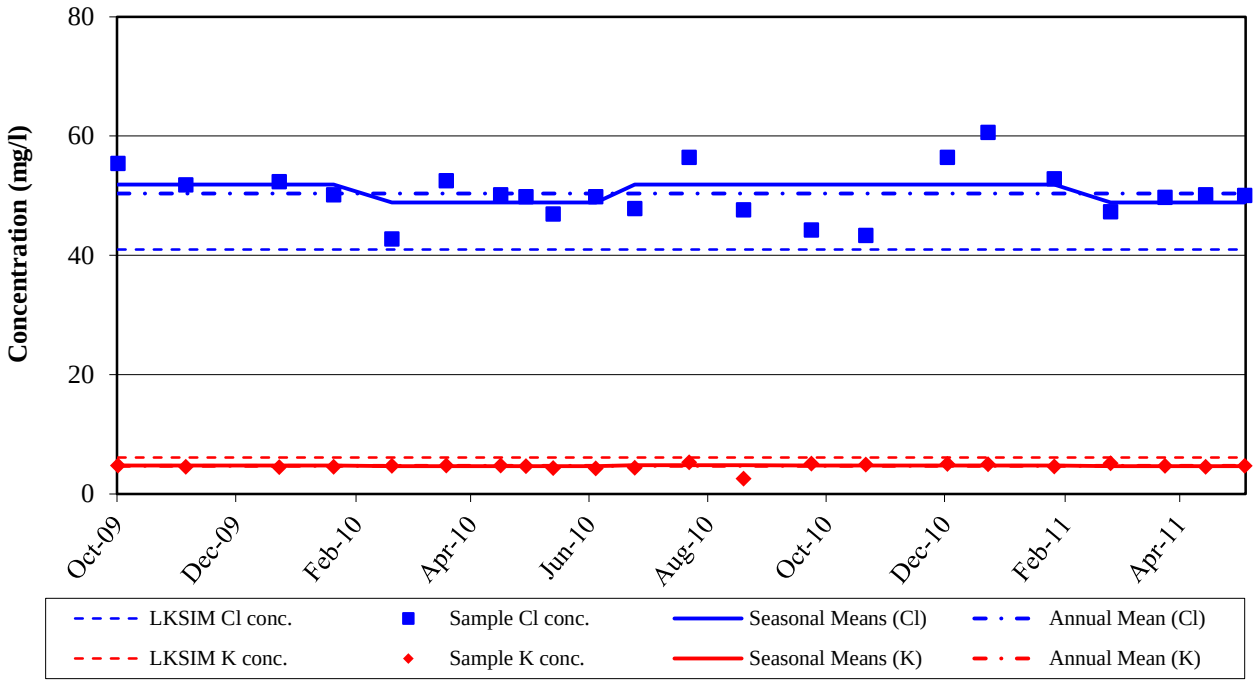

Figure 3-108: UT 43* Measured and Predicted Values for Cl and K

Table 3-12: UT 43* Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	876	732	798	808	842	780	41.2	0.57
HCO_3	298	246	280	284	291	273	14.5	-
SO_4	433	251	296	322	311	268	48.8	0.51
Ca	161	134	146	151	145	142	7.81	0.55
Mg	52.6	43.6	47.5	48.7	46.9	46.6	2.44	0.40
Na	42.1	34.6	38.4	39.1	38.8	37.8	2.10	-
Cl	60.6	42.7	50.3	51.9	51.9	48.9	4.38	-
K	5.30	4.26	4.71	4.76	4.84	4.65	0.272	-

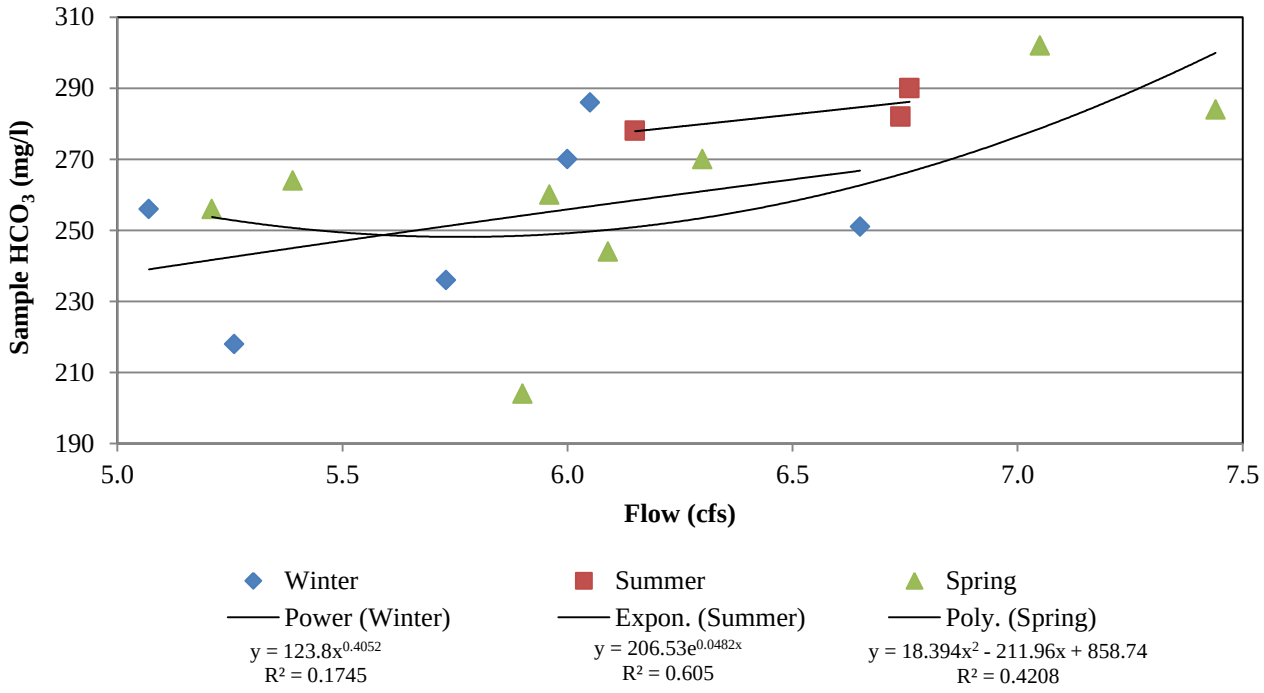

Figure 3-109: UT 43A Trendlines and Equations for HCO_3

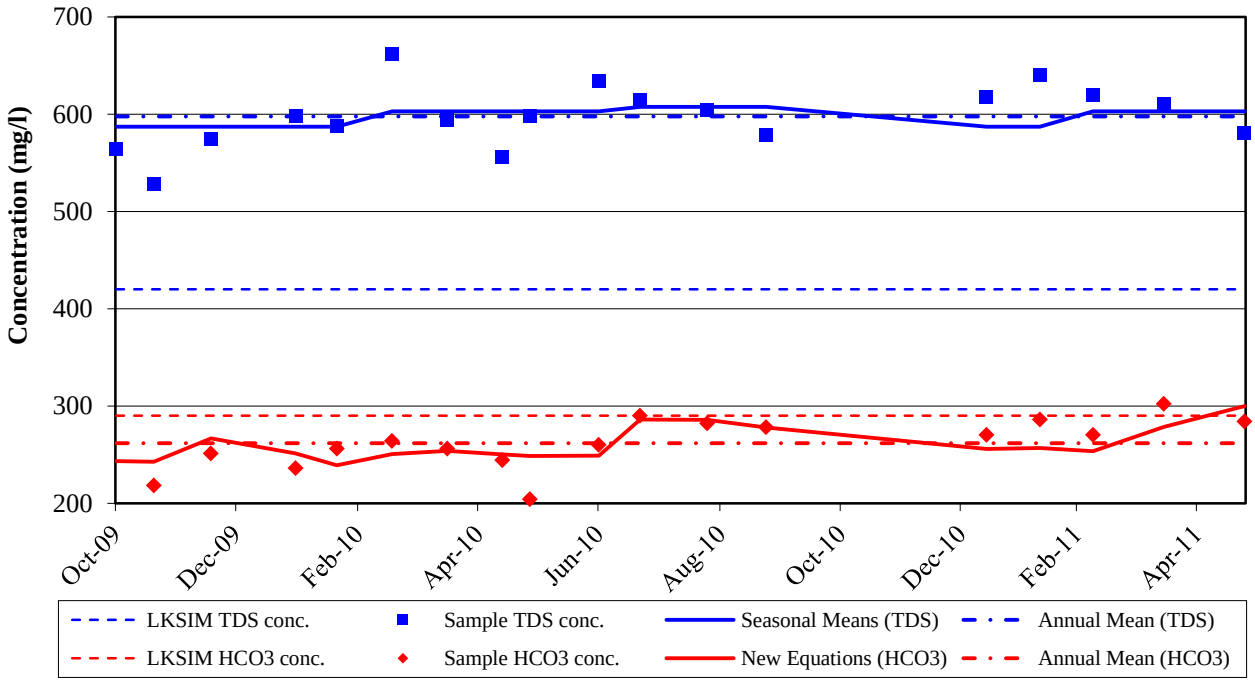

Figure 3-110: UT 43A Measured and Predicted Concentrations for TDS and HCO_3

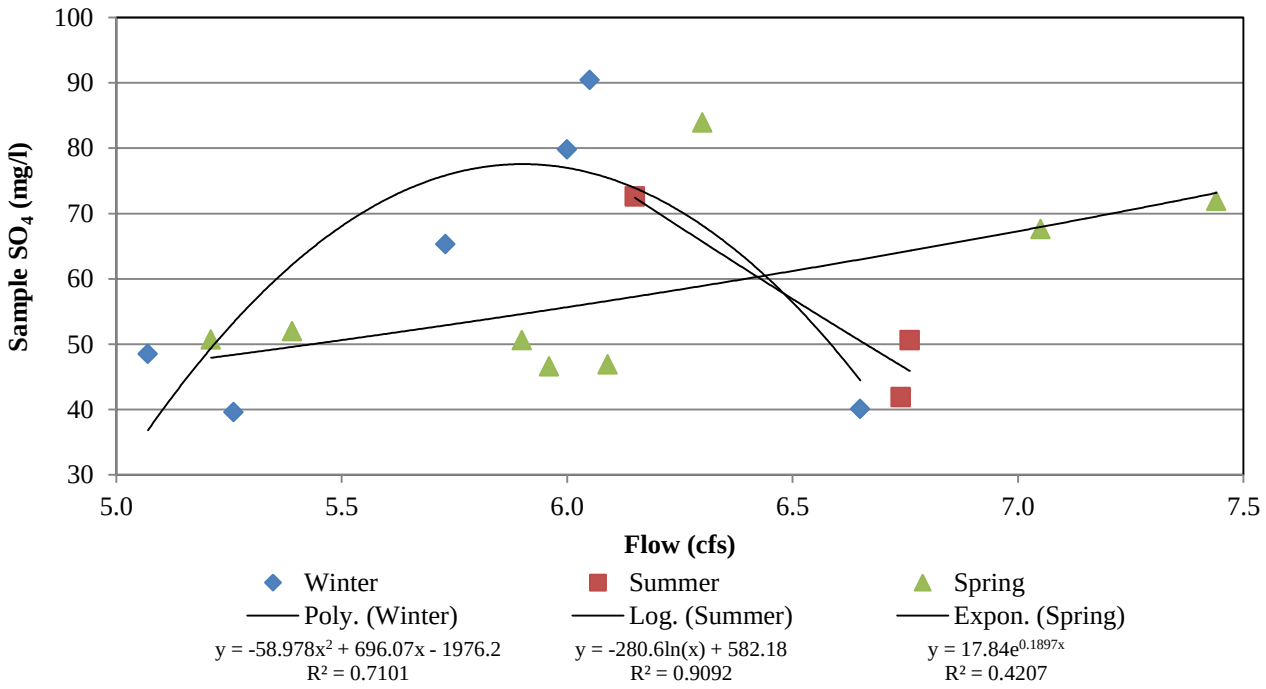

Figure 3-111: UT 43A Trendlines and Equations for SO_4

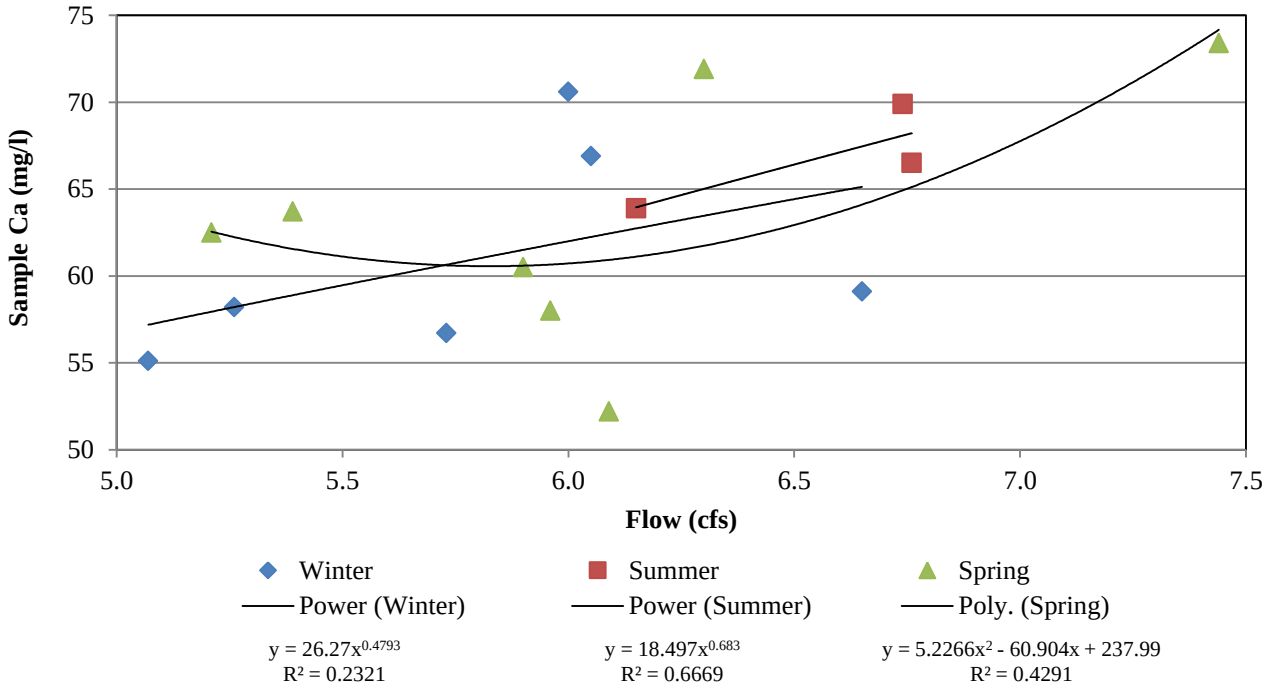

Figure 3-112: UT 43A Trendlines and Equations for Ca

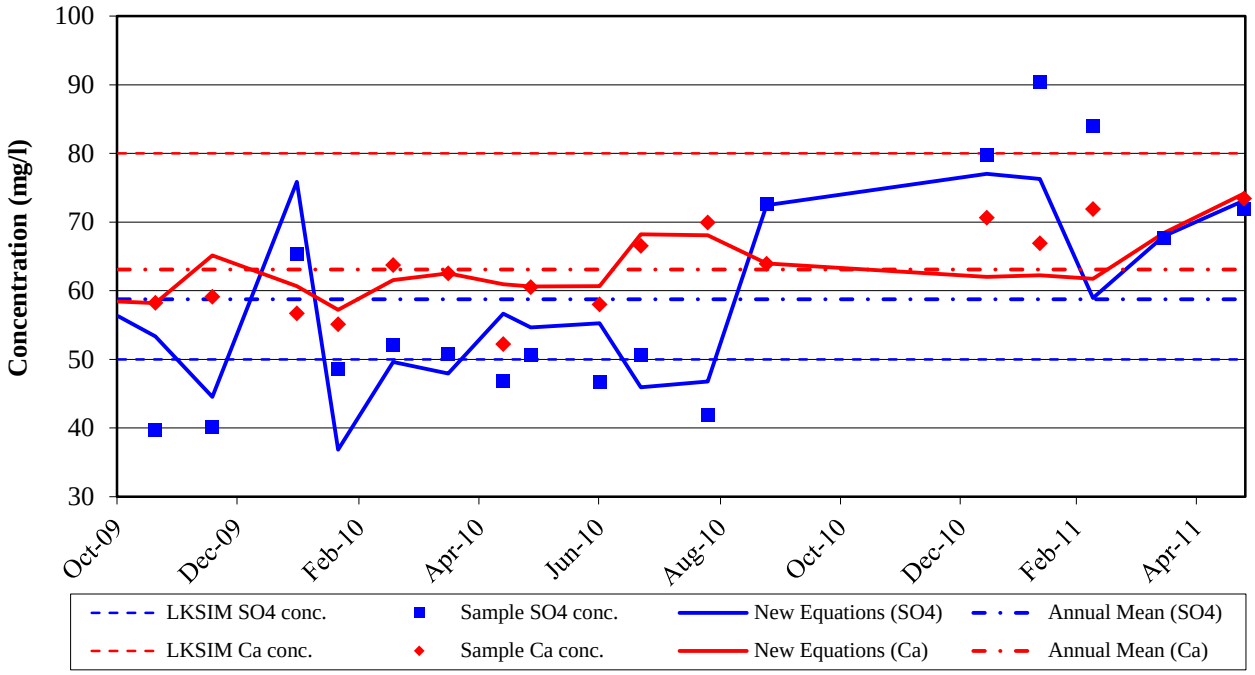

Figure 3-113: UT 43A Measured and Predicted Concentrations for SO_4 and Ca

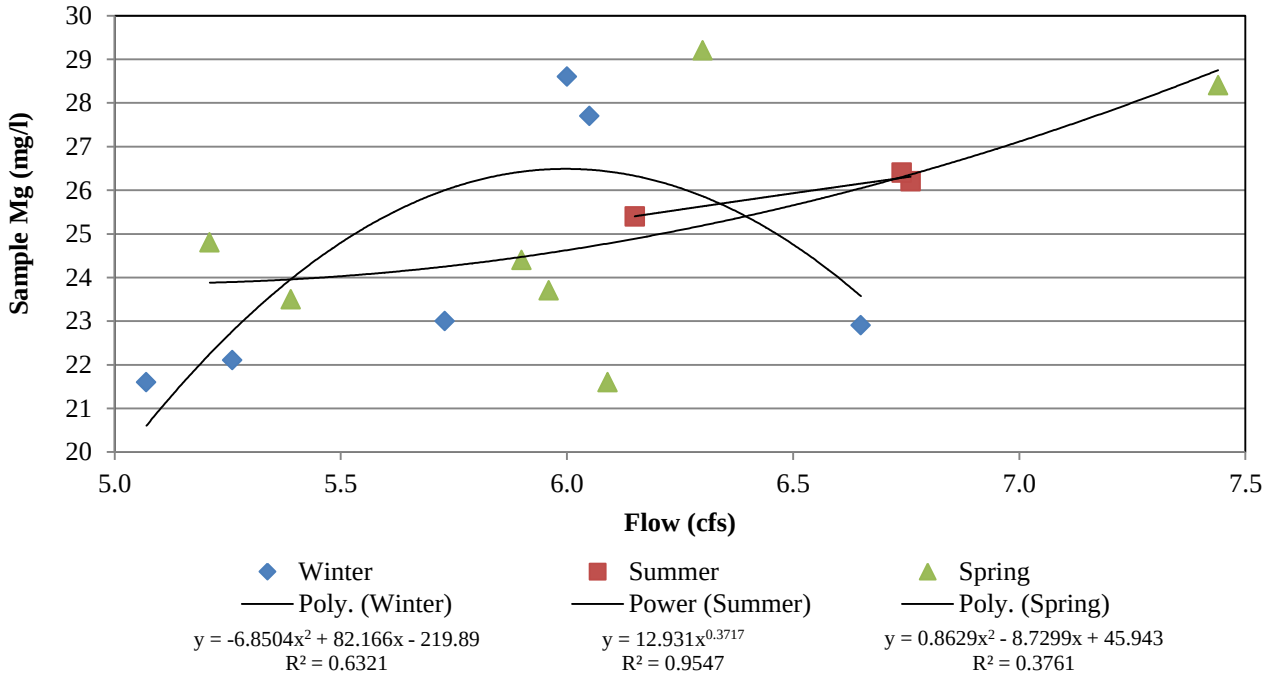

Figure 3-114: UT 43A Trendlines and Equations for Mg

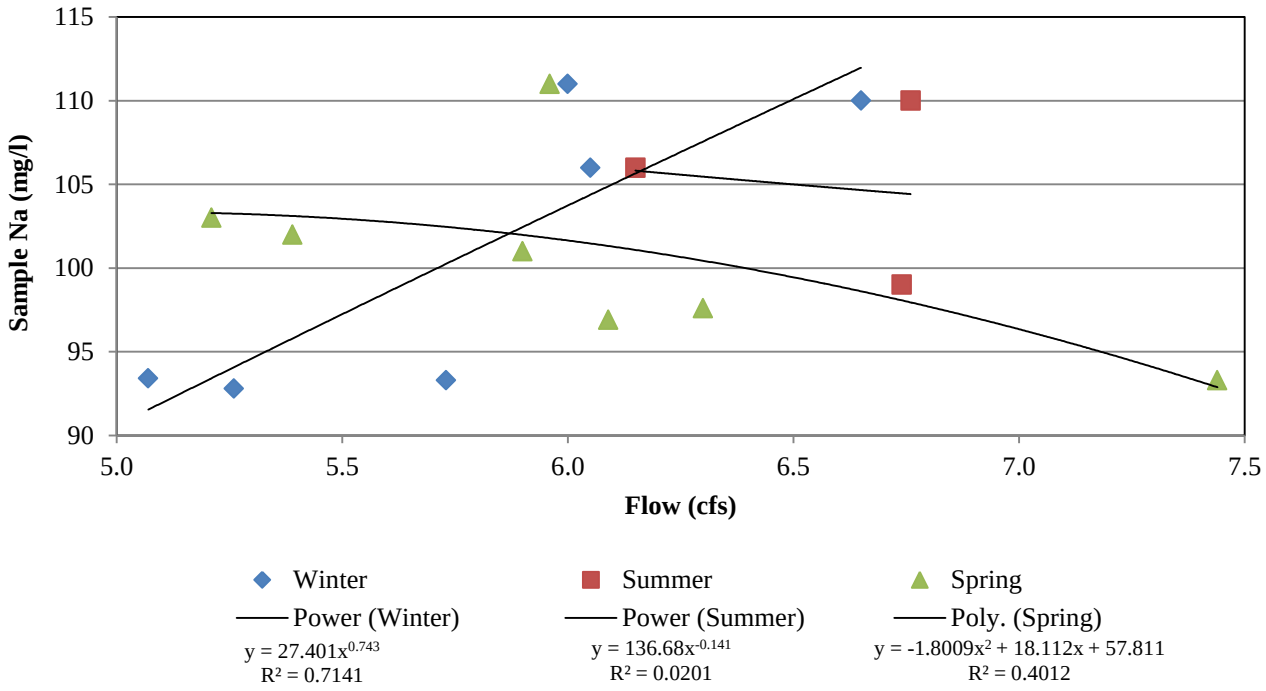

Figure 3-115: UT 43A Trendlines and Equations for Na

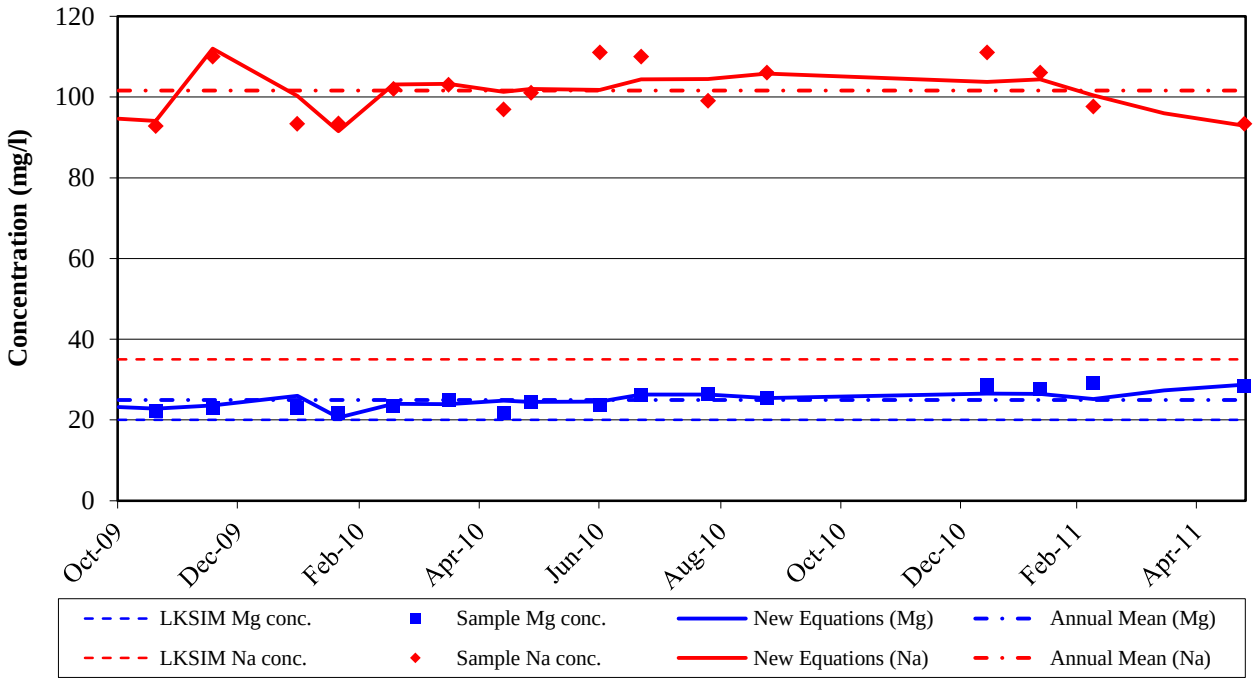

Figure 3-116: UT 43A Measured and Predicted Concentrations for Mg and Na

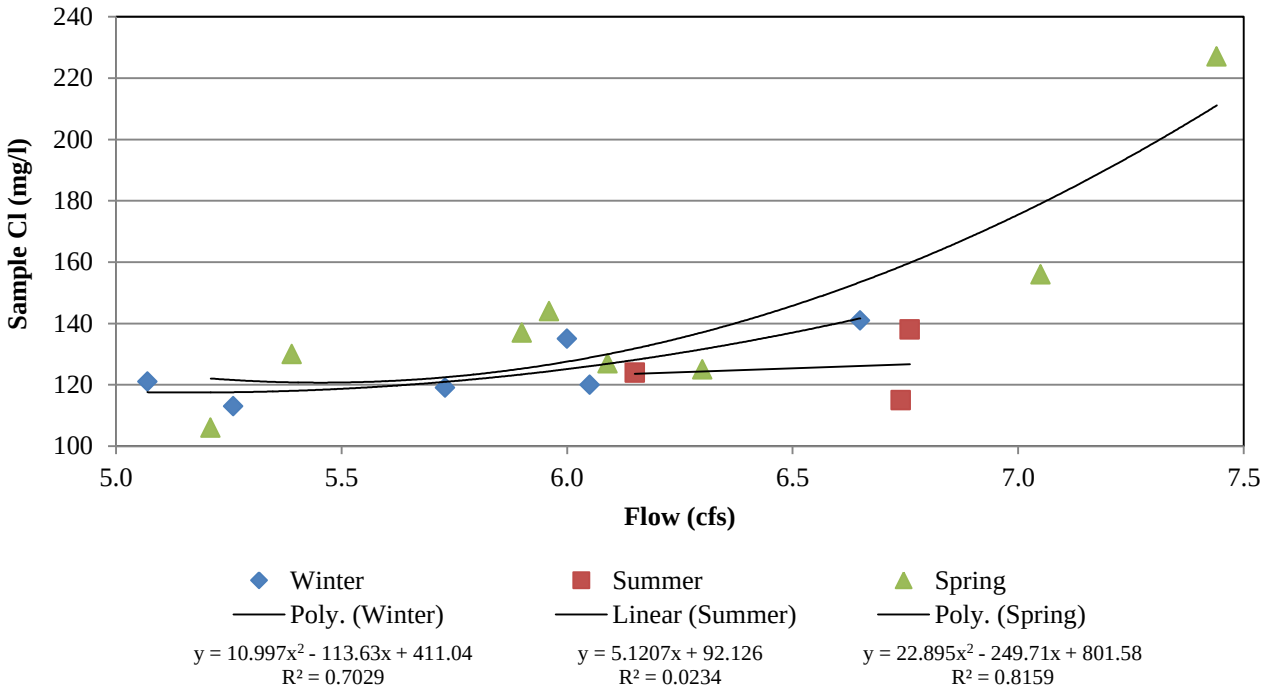

Figure 3-117: UT 43A Trendlines and Equations for Cl

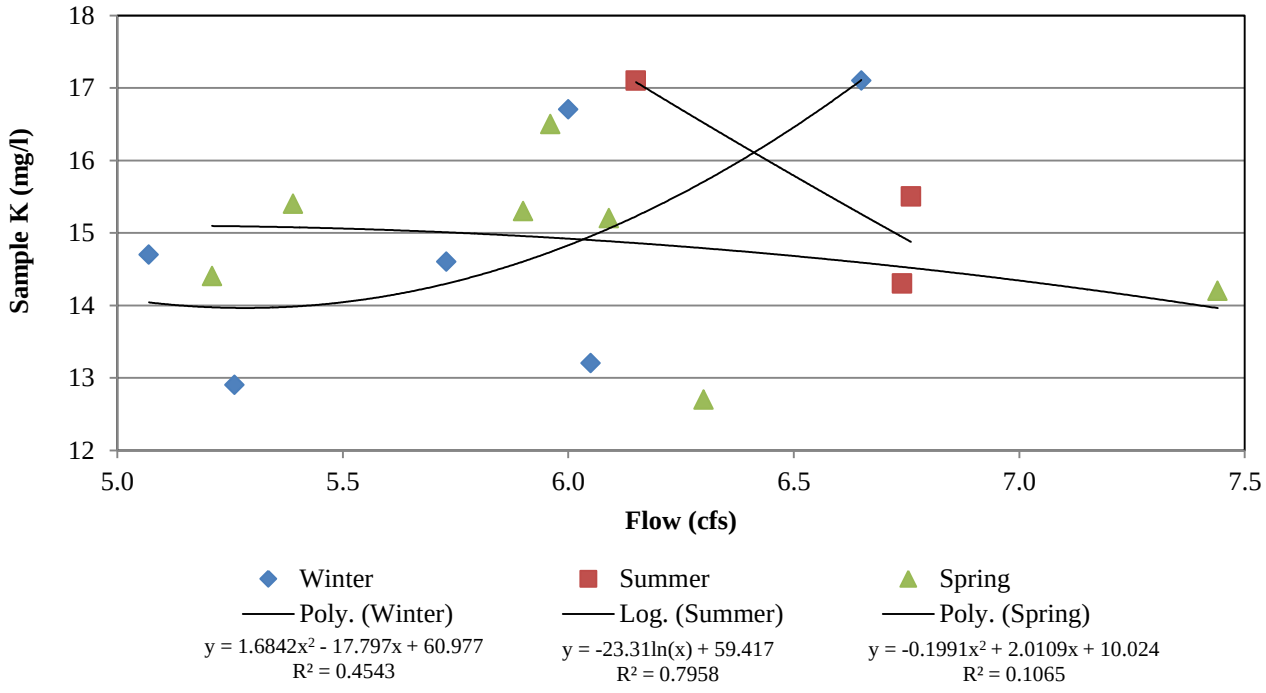

Figure 3-118: UT 43A Trendlines and Equations for K

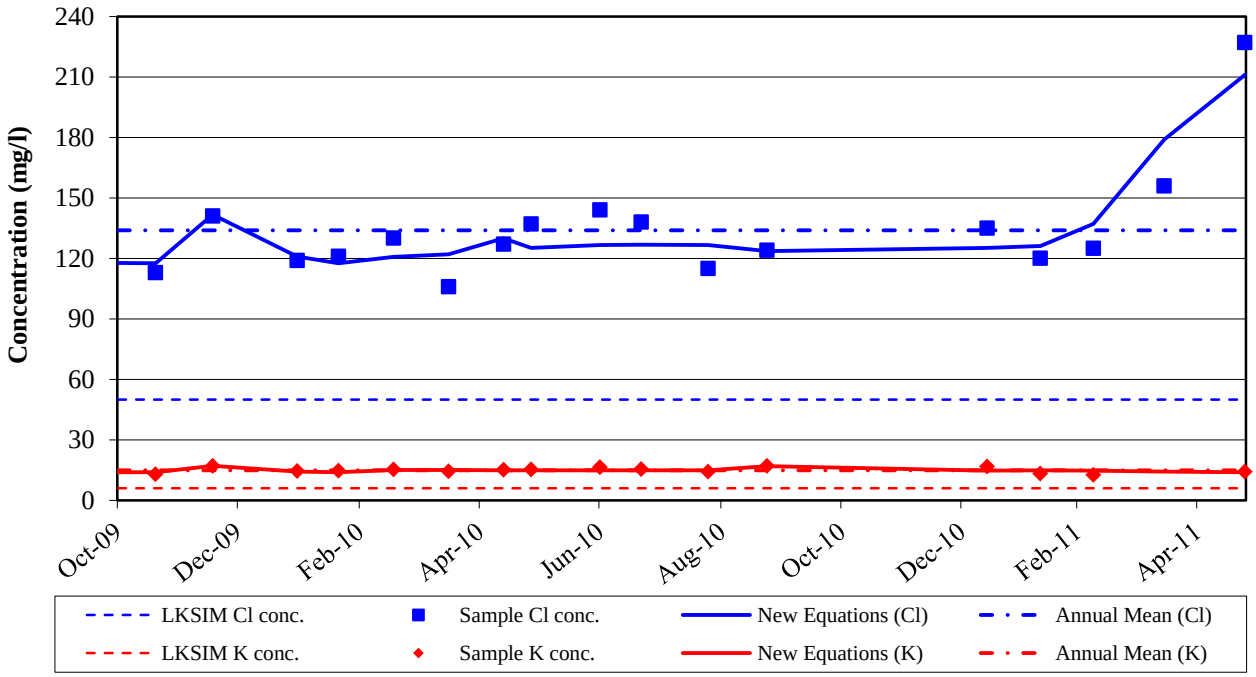

Figure 3-119: UT 43A Measured and Predicted Concentrations for Cl and K

Table 3-13: UT 43A Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	662	528	598	587	608	603	32.3	-
HCO_3	302	204	262	253	278	261	25.9	0.45
SO_4	90.4	39.6	58.8	60.6	52.9	60.5	16.2	0.64
Ca	73.4	52.2	63.1	61.1	64.6	64.0	6.38	0.43
Mg	29.2	21.6	25.0	24.3	25.4	25.3	2.55	0.54
Na	111	92.8	102	101	107	99.0	6.76	0.58
Cl	227	106	134	125	130	144	27.1	0.82
K	17.1	12.7	15.0	14.9	15.9	14.5	1.39	0.43

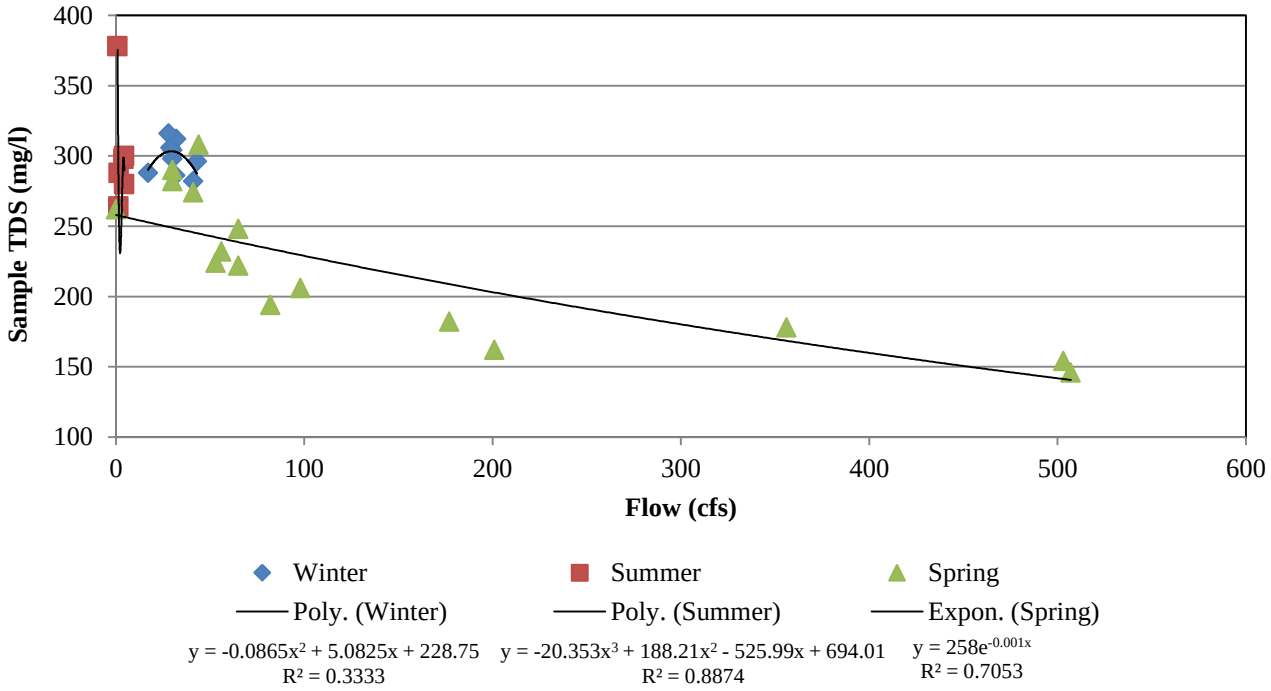

Figure 3-120: UT 44 Trendlines and Equations for TDS

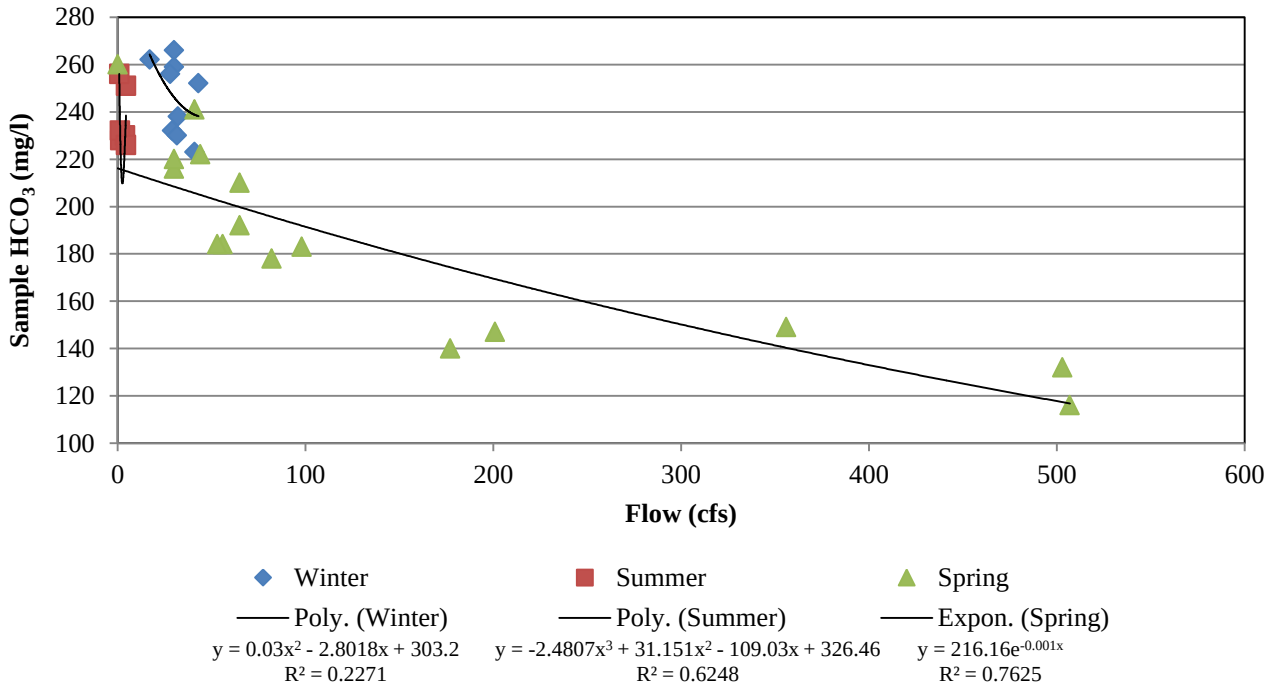

Figure 3-121: UT 44 Trendlines and Equations for HCO_3

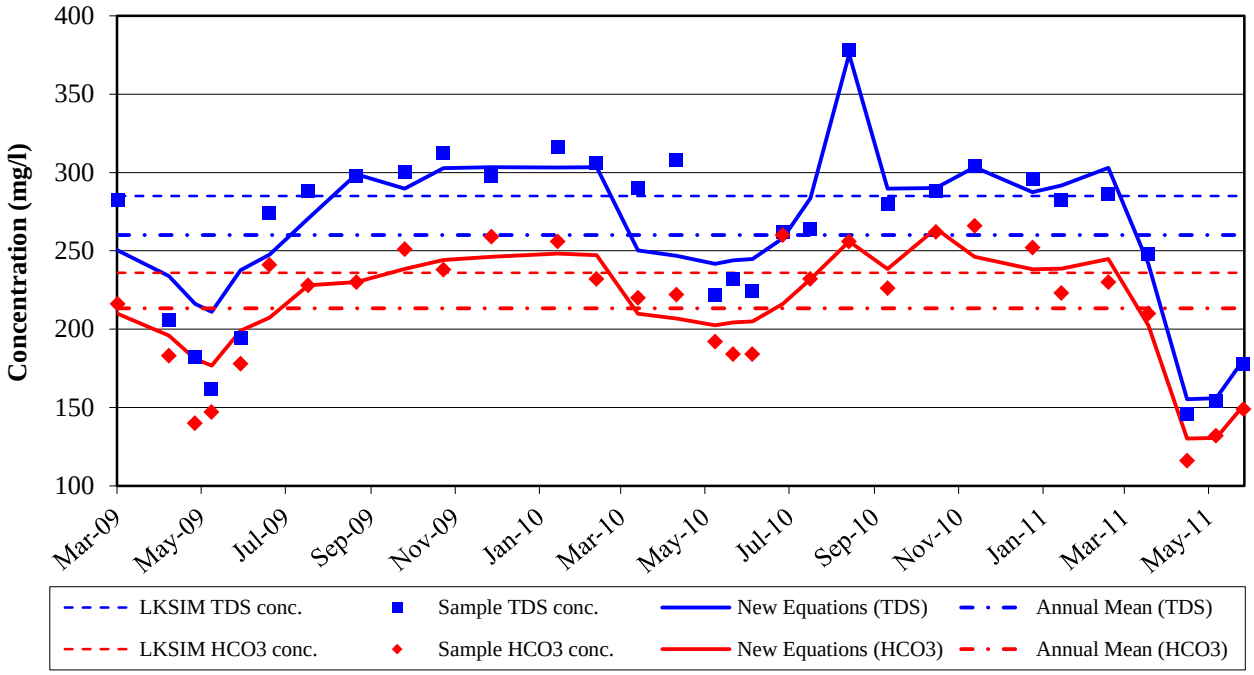

Figure 3-122: UT 44 Measured and Predicted Concentrations for TDS and HCO_3

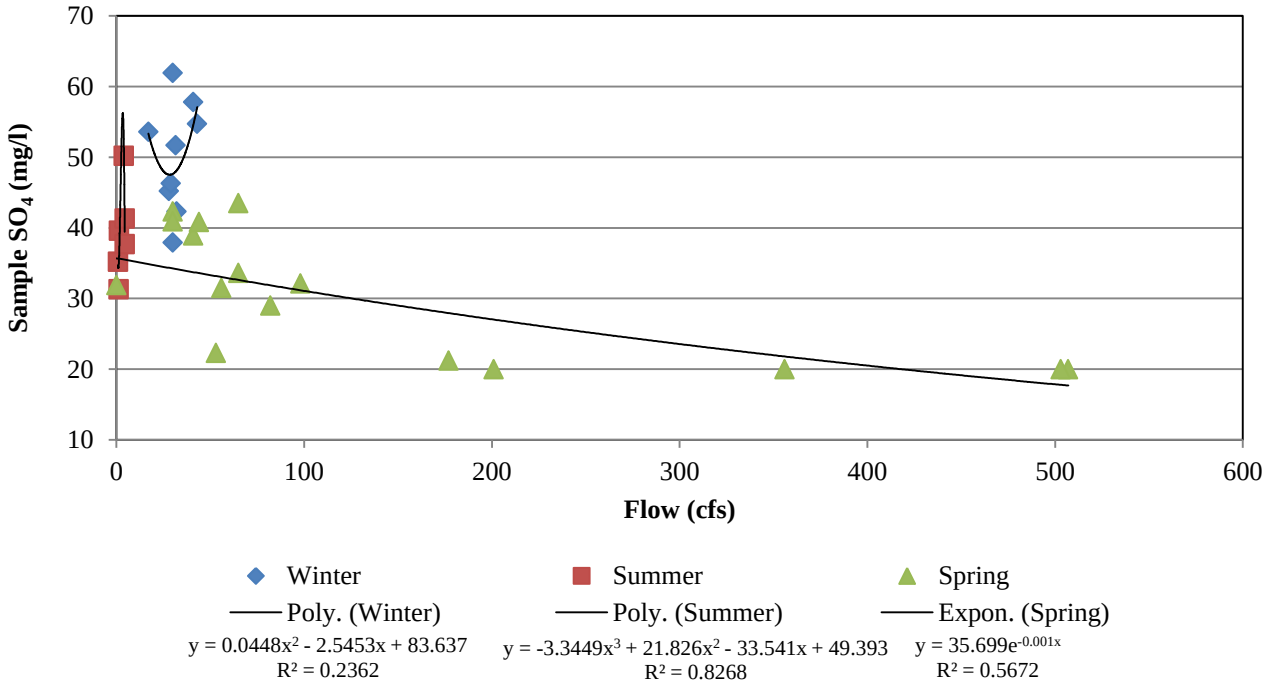

Figure 3-123: UT 44 Trendlines and Equations for SO_4

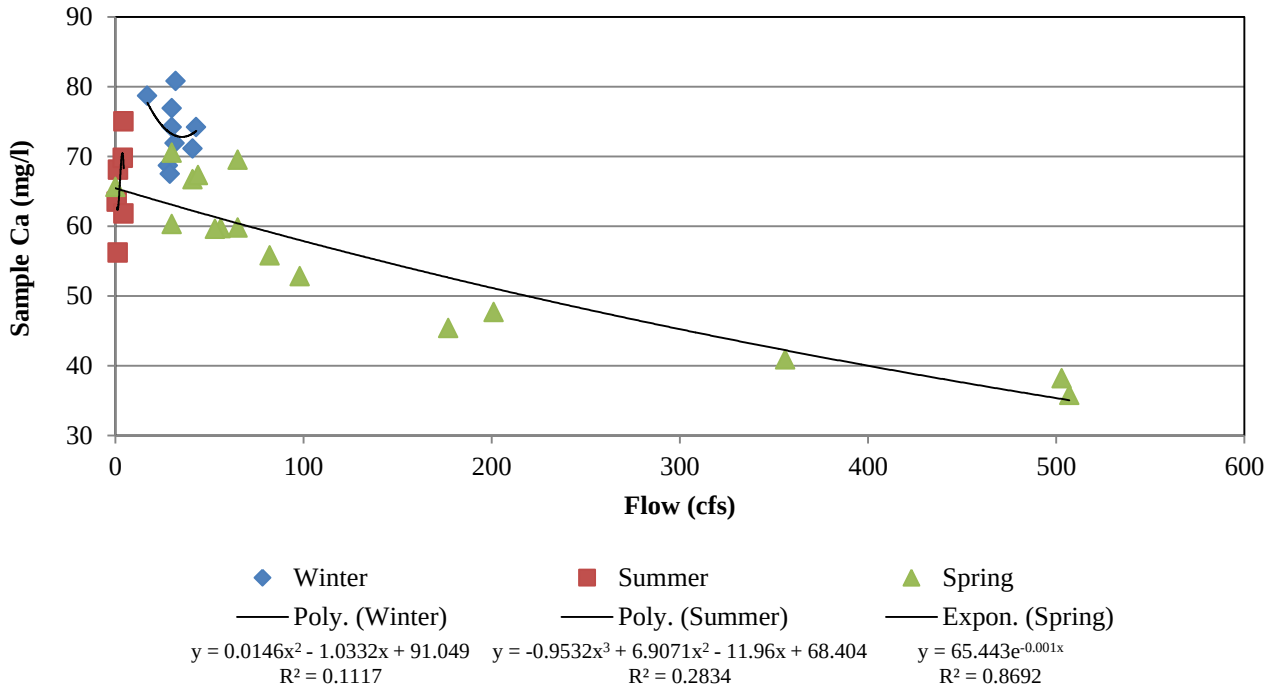

Figure 3-124: UT 44 Trendlines and Equations for Ca

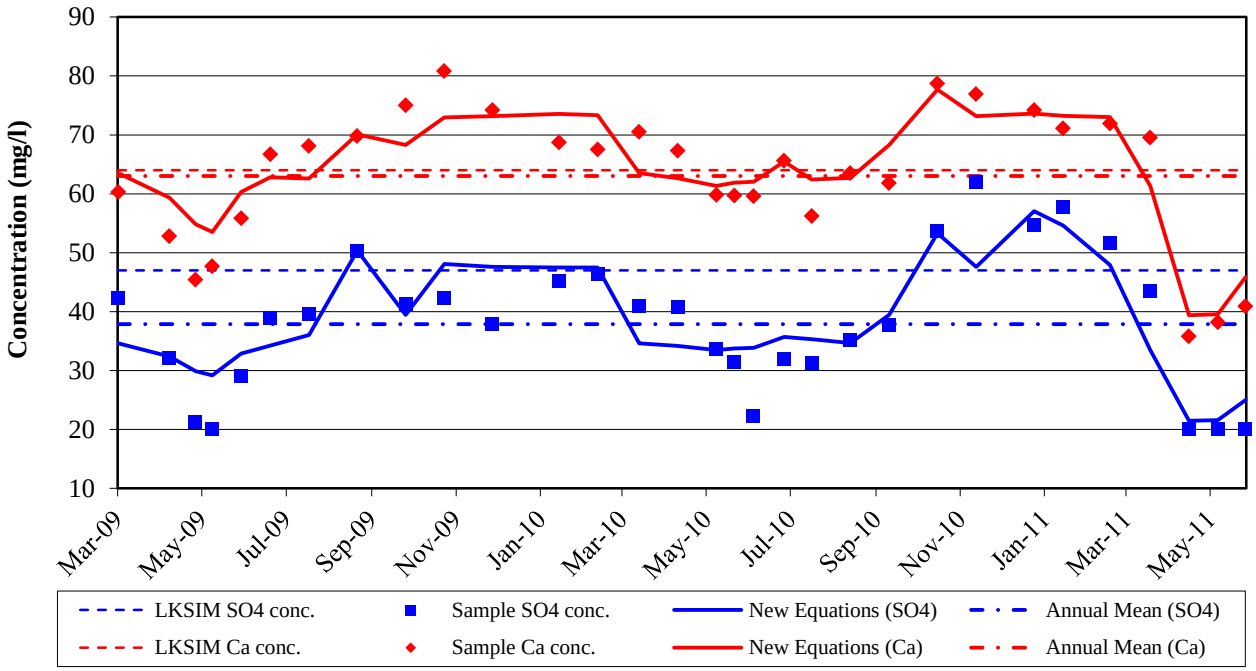

Figure 3-125: UT 44 Measured and Predicted Concentrations for SO_4 and Ca

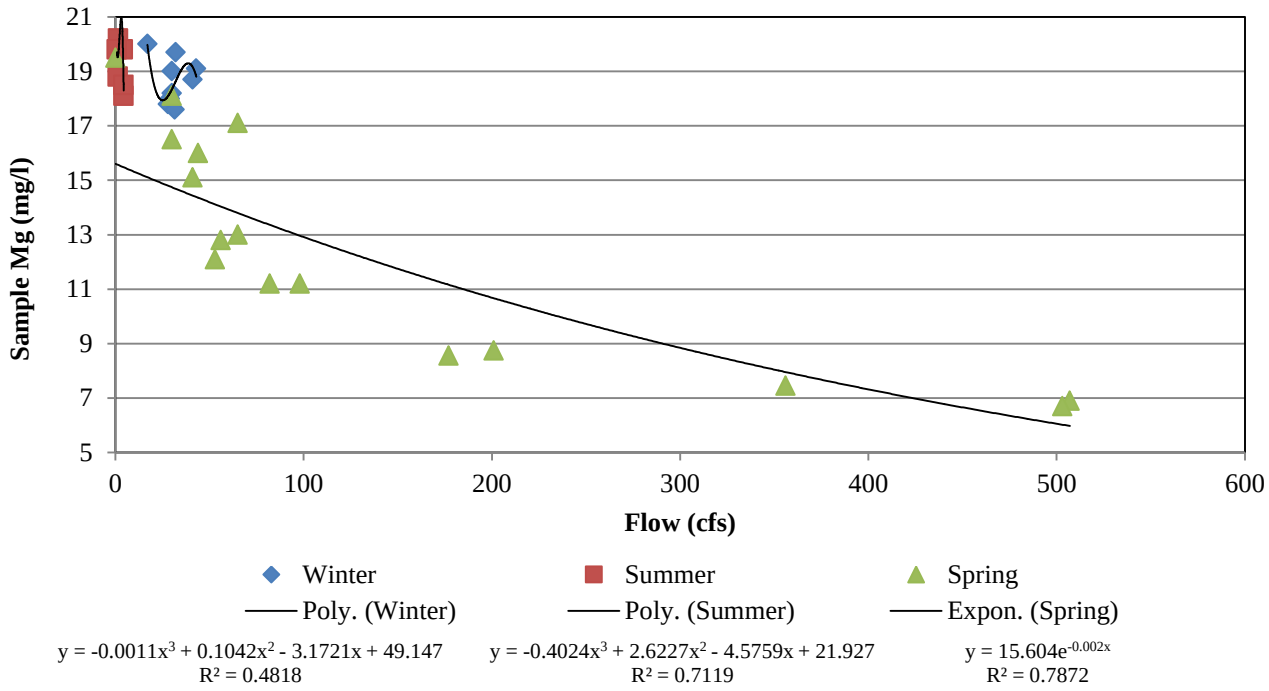

Figure 3-126: UT 44 Trendlines and Equations for Mg

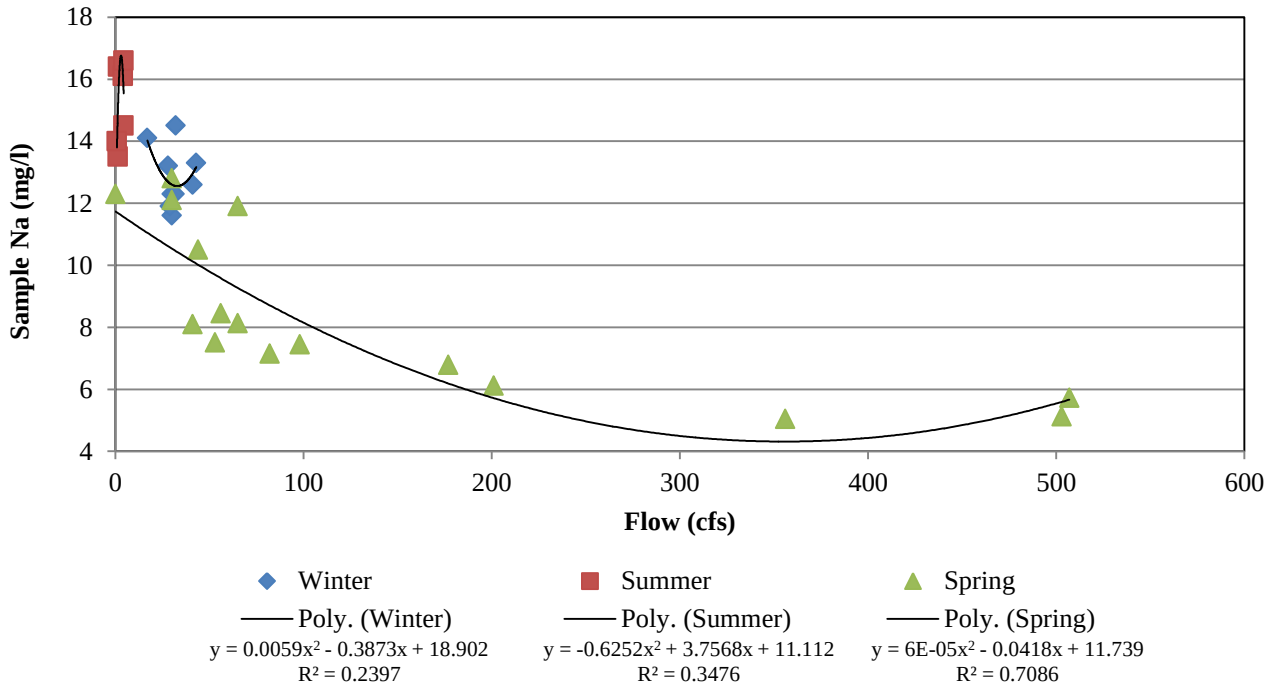

Figure 3-127: UT 44 Trendlines and Equations for Na

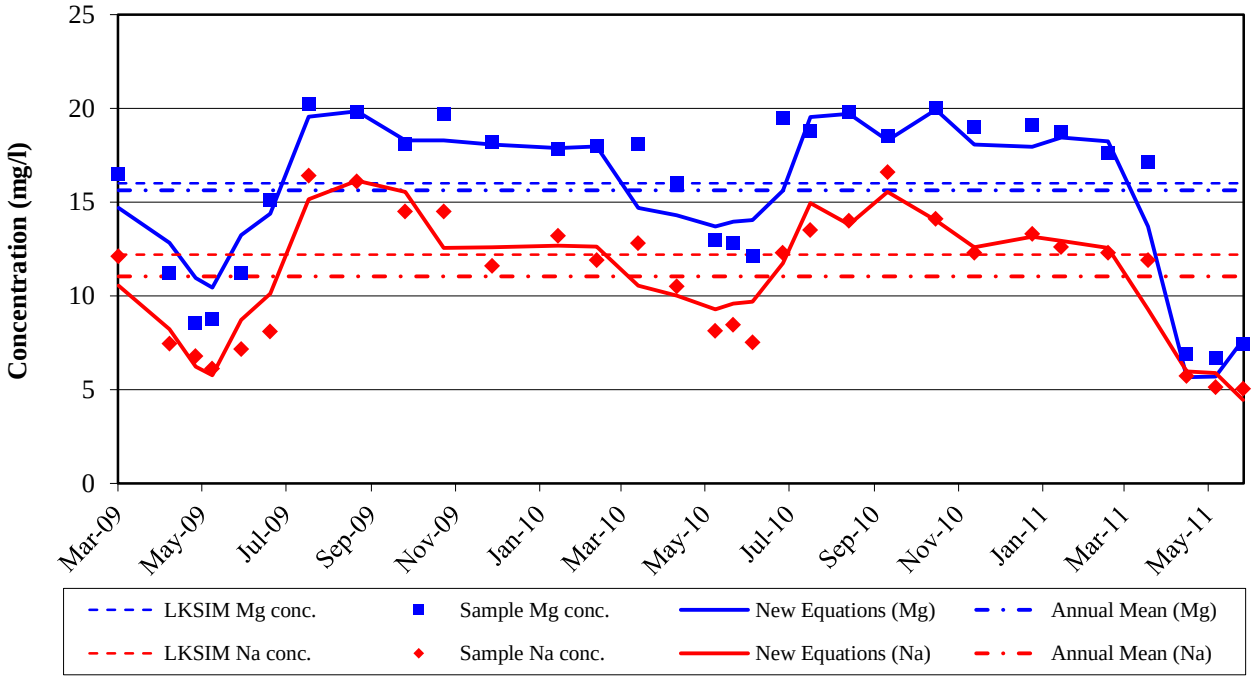

Figure 3-128: UT 44 Measured and Predicted Values for Mg and Na

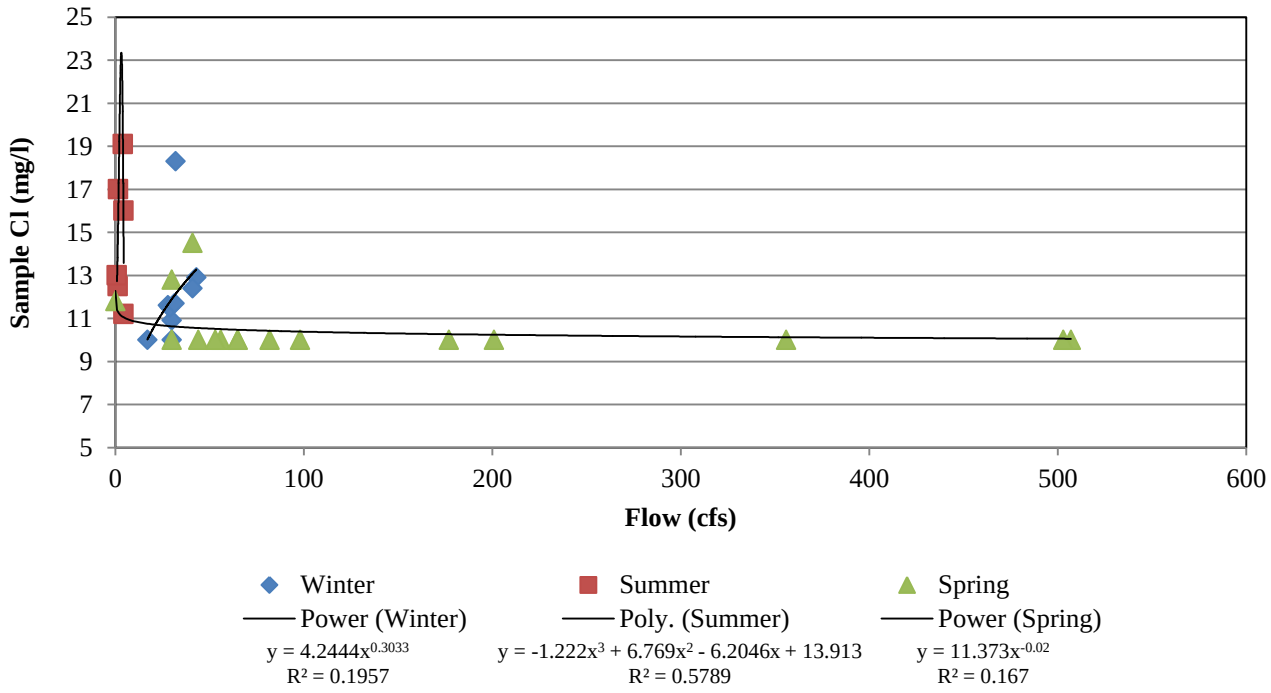

Figure 3-129: UT 44 Trendlines and Equations for Cl

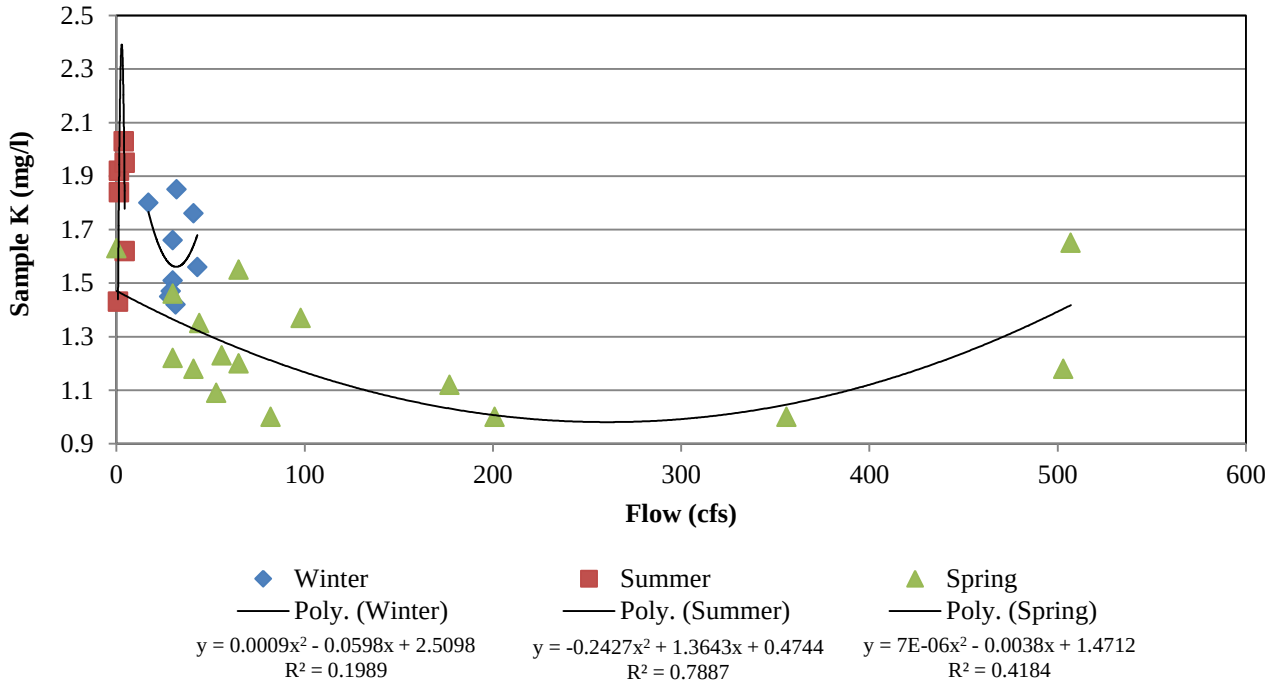

Figure 3-130: UT 44 Trendlines and Equations for K

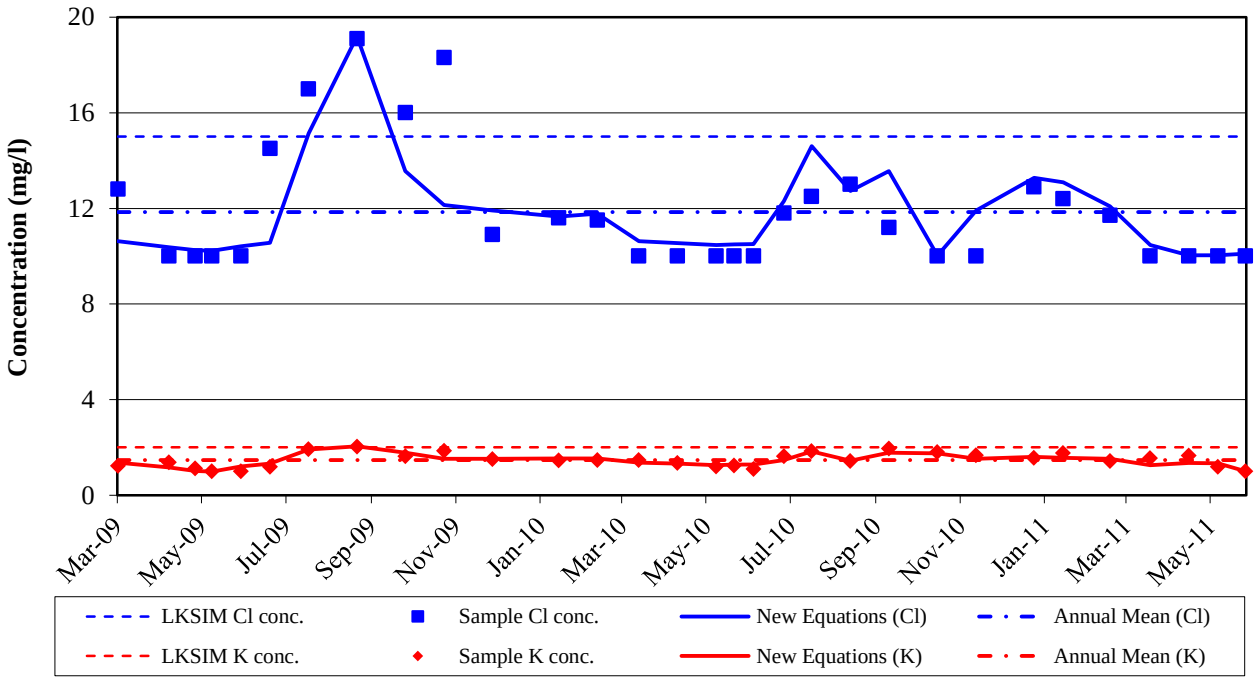

Figure 3-131: UT 44 Measured and Predicted Concentrations for Cl and K

Table 3-14: UT 44 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	378	146	260	299	301	223	56.0	0.84
HCO_3	266	116	213	246	237	186	42.2	0.83
SO_4	61.9	20.0	37.9	50.2	39.2	30.5	11.7	0.76
Ca	80.8	35.8	63.0	73.8	65.7	56.0	11.8	0.85
Mg	20.2	6.70	15.6	18.7	19.2	12.6	4.40	0.88
Na	16.6	5.04	11.0	12.9	15.2	8.45	3.48	0.88
Cl	19.1	10.0	11.8	12.1	14.8	10.6	2.59	0.58
K	2.03	1.00	1.47	1.61	1.80	1.26	0.299	0.76

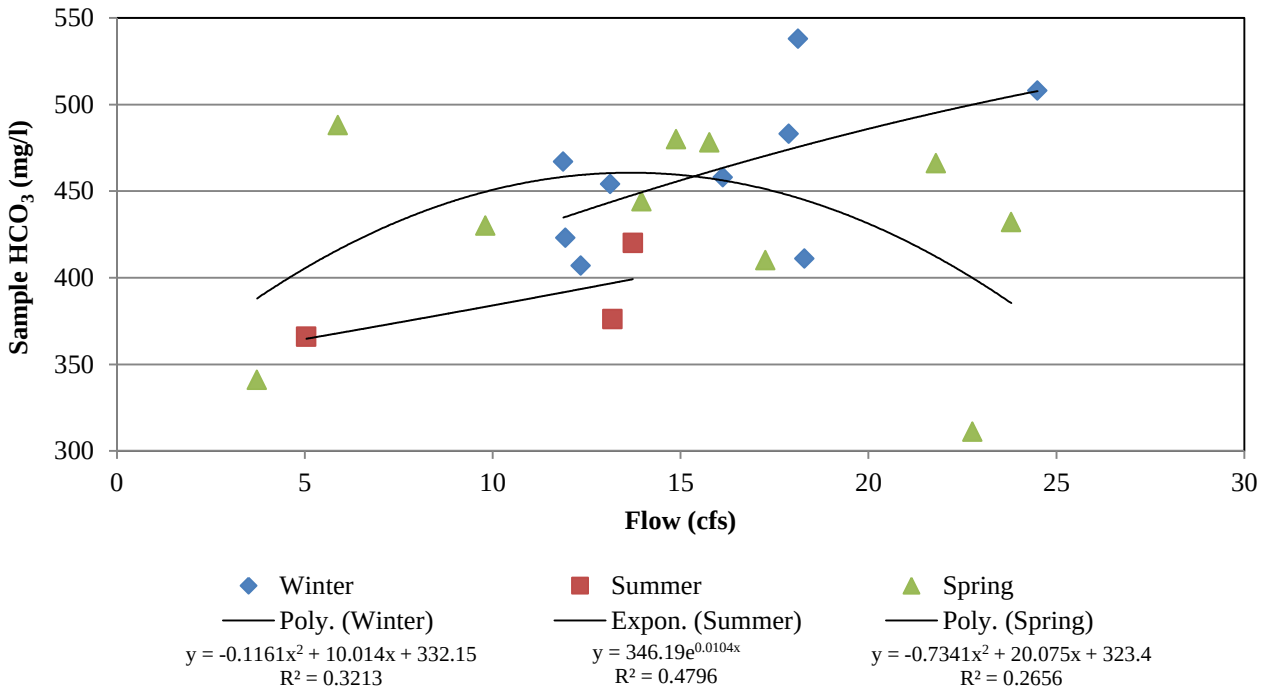

Figure 3-132: UT 47* Trendlines and Equations for HCO_3

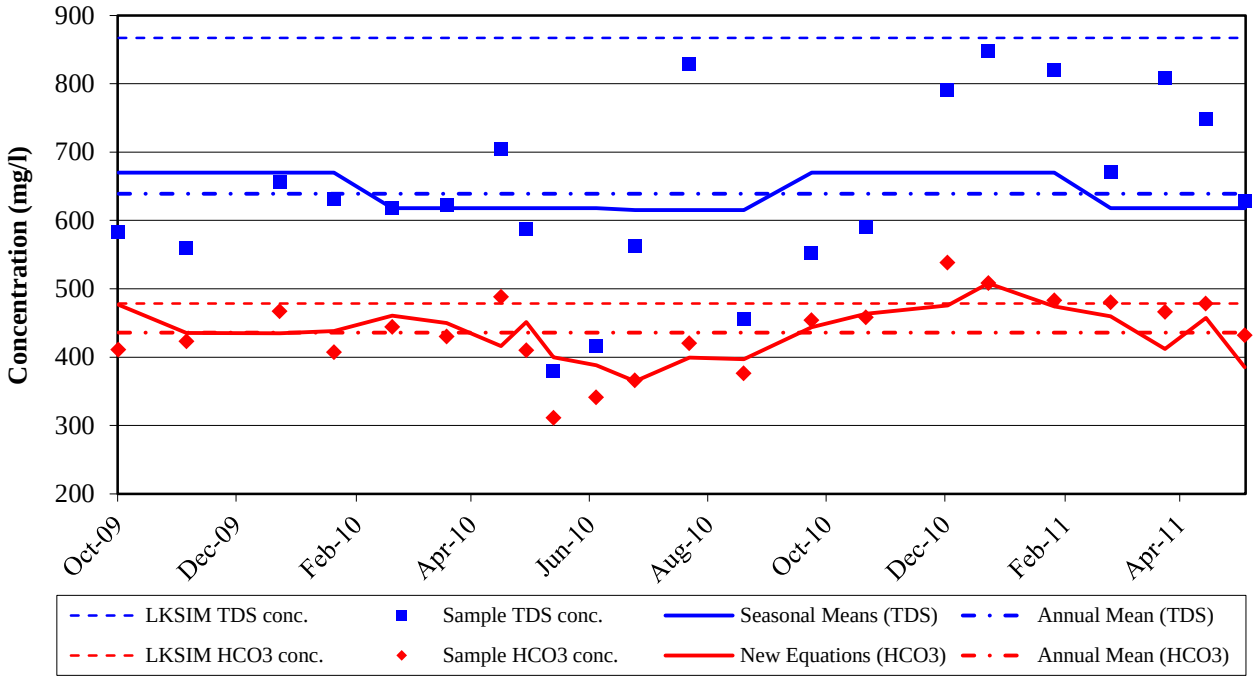

Figure 3-133: UT 47* Measured and Predicted Concentrations for TDS and HCO_3

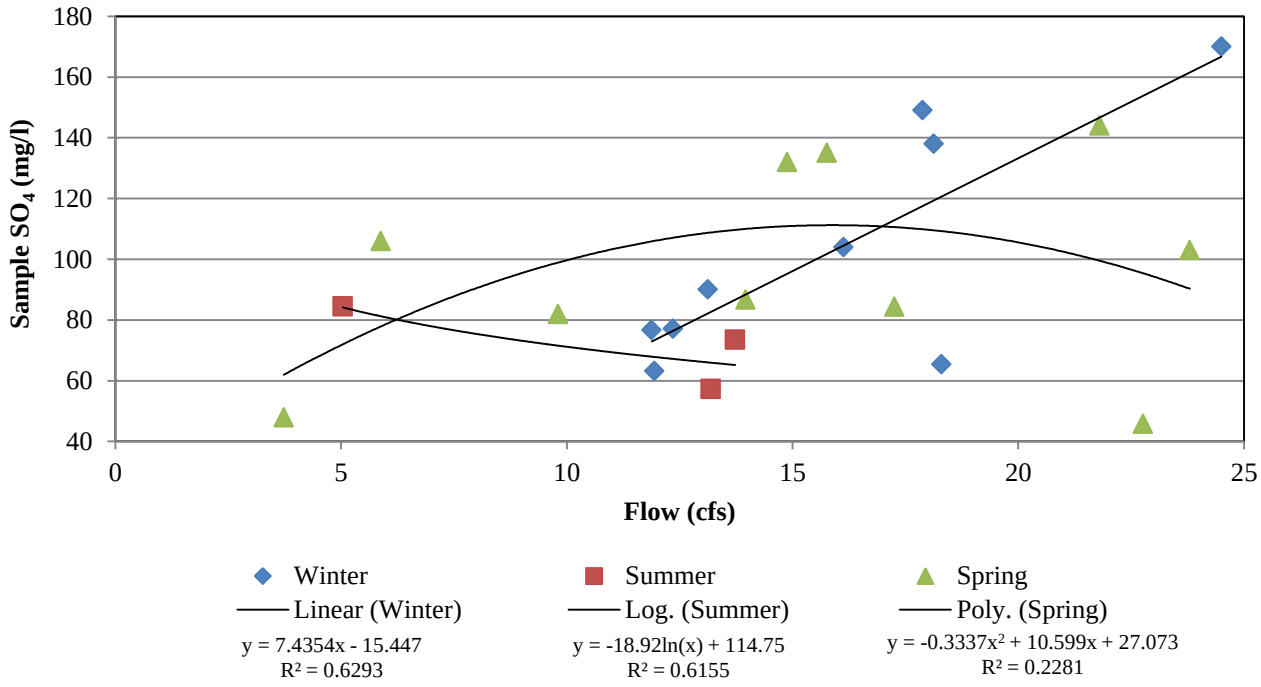

Figure 3-134: UT 47* Trendlines and Equations for SO_4

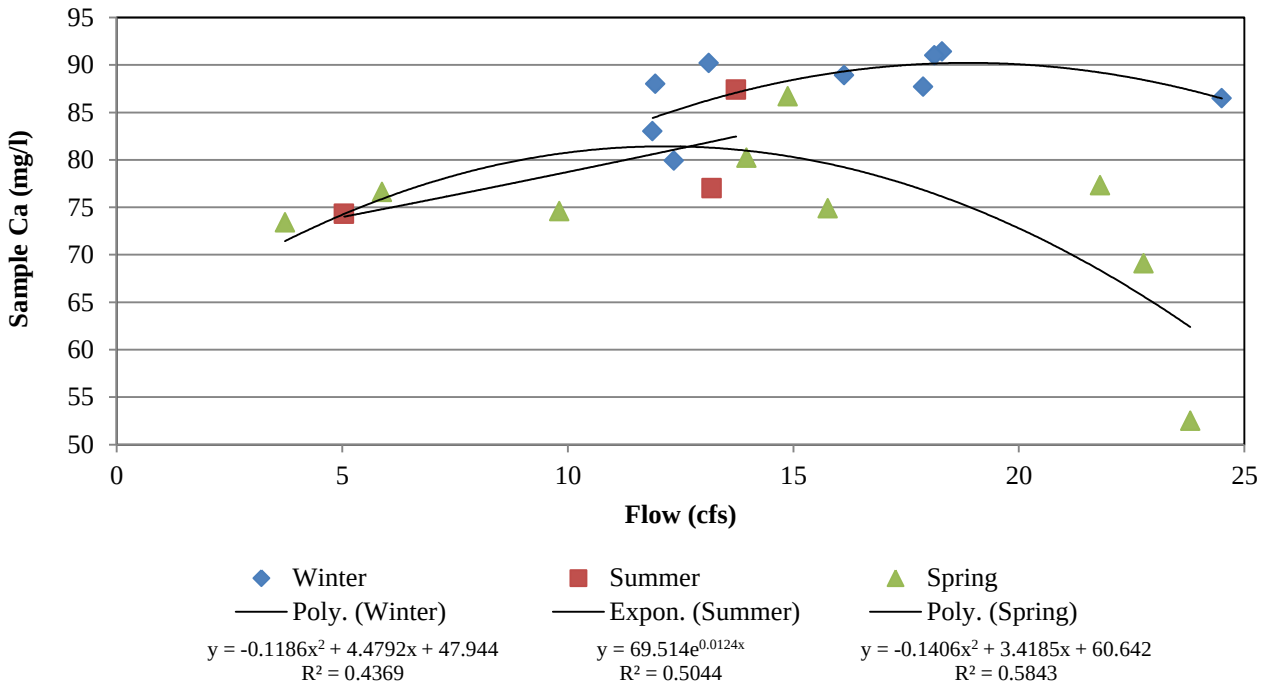

Figure 3-135: UT 47* Trendlines and Equations for Ca

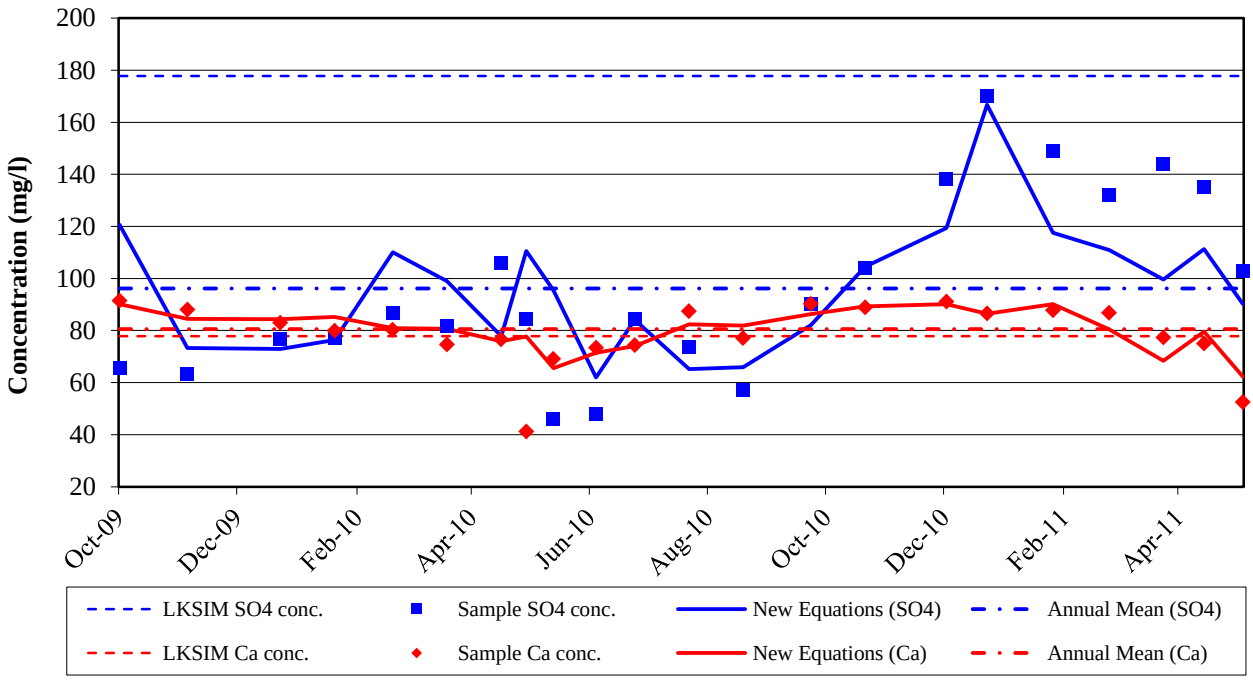

Figure 3-136: UT 47* Measured and Predicted Concentrations for SO_4 and Ca

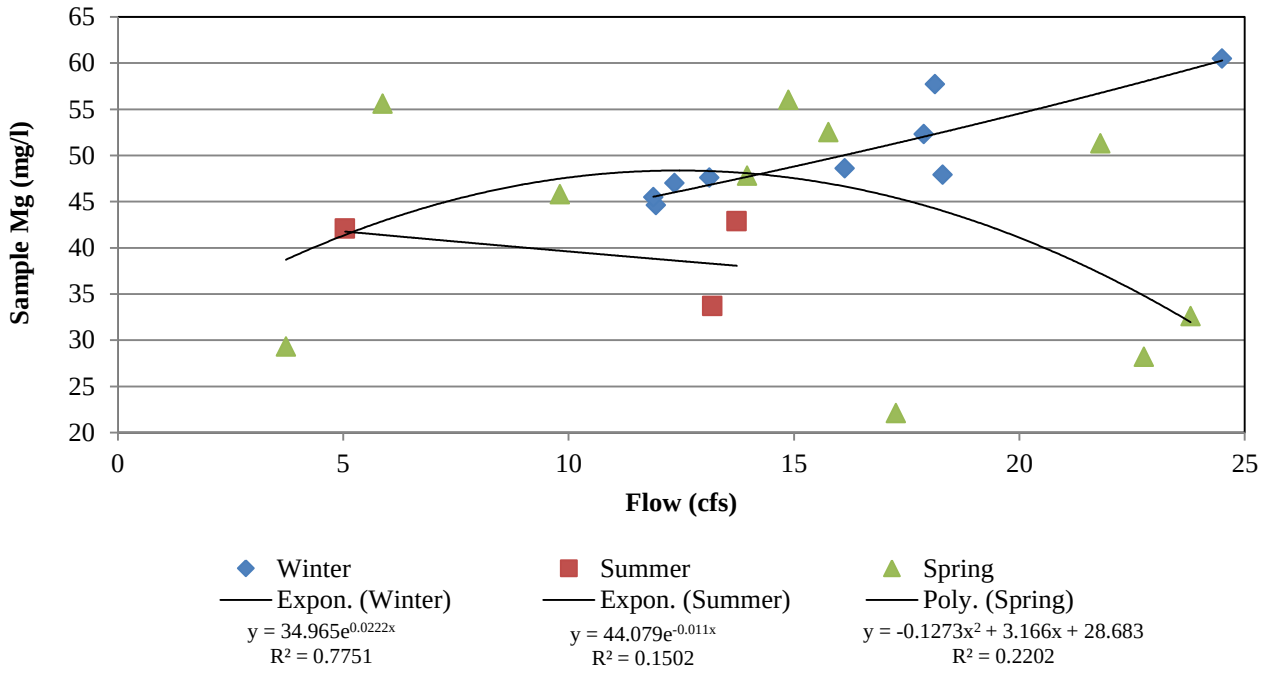

Figure 3-137: UT 47* Trendlines and Equations for Mg

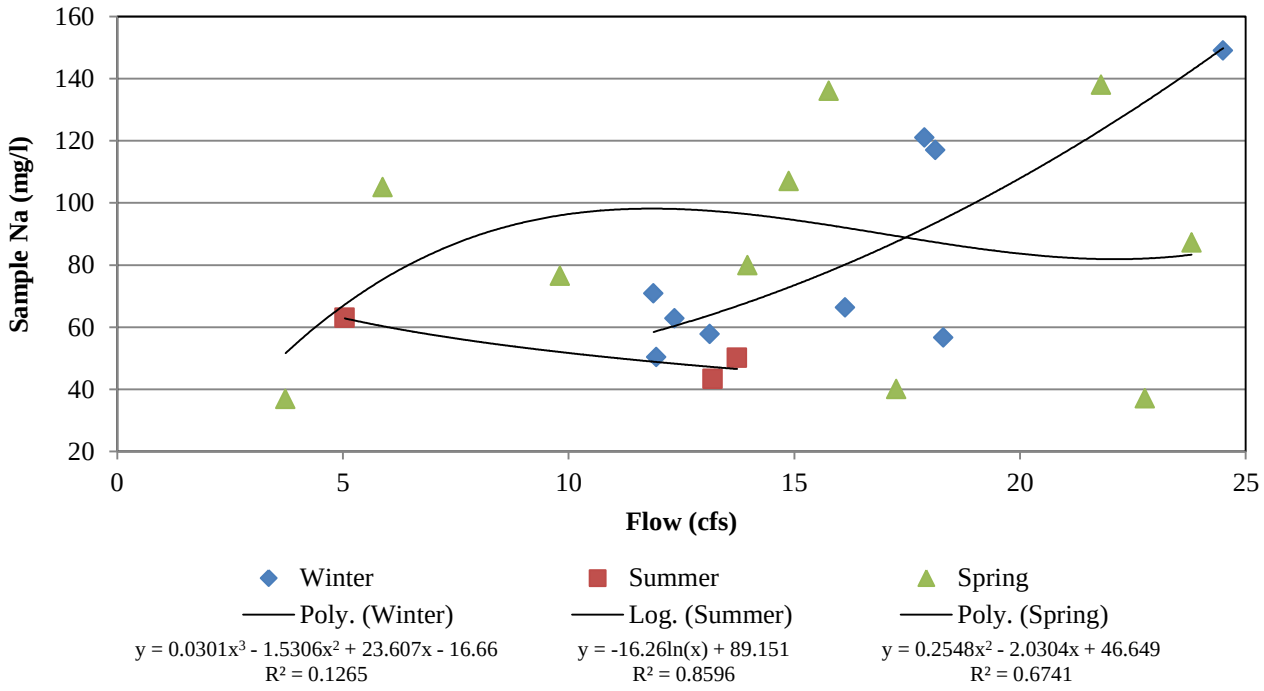

Figure 3-138: UT 47* Trendlines and Equations for Na

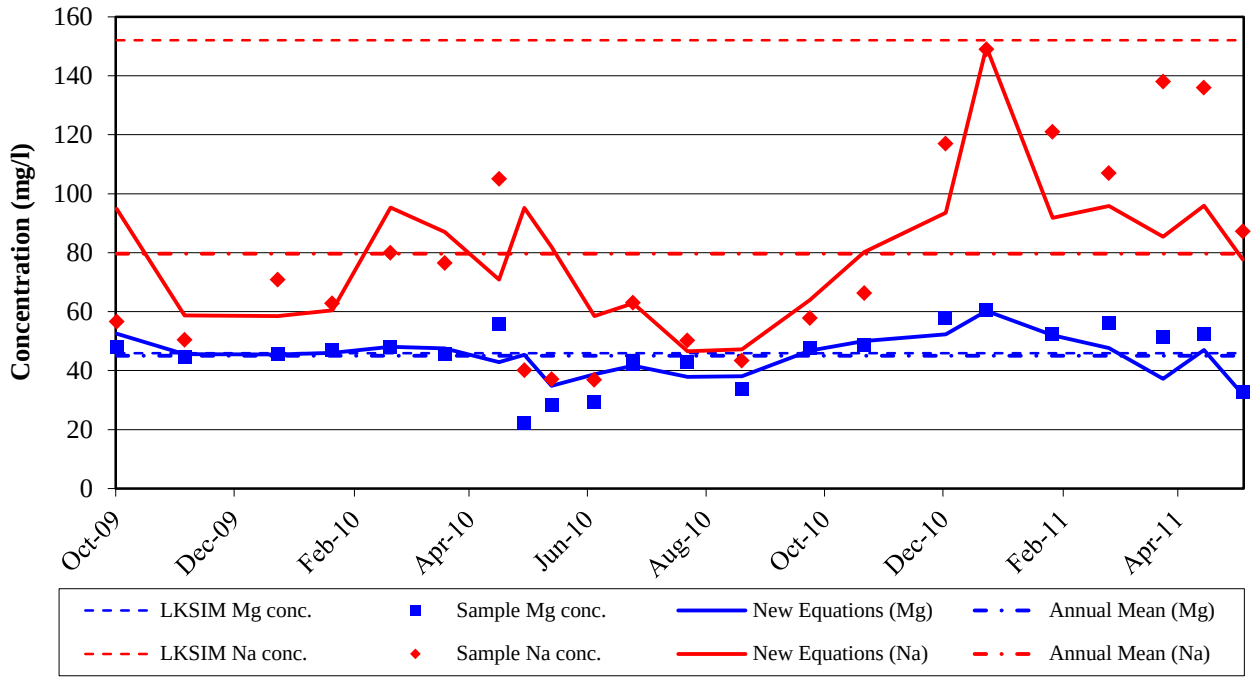

Figure 3-139: UT 47* Measured and Predicted Concentrations for Mg and Na

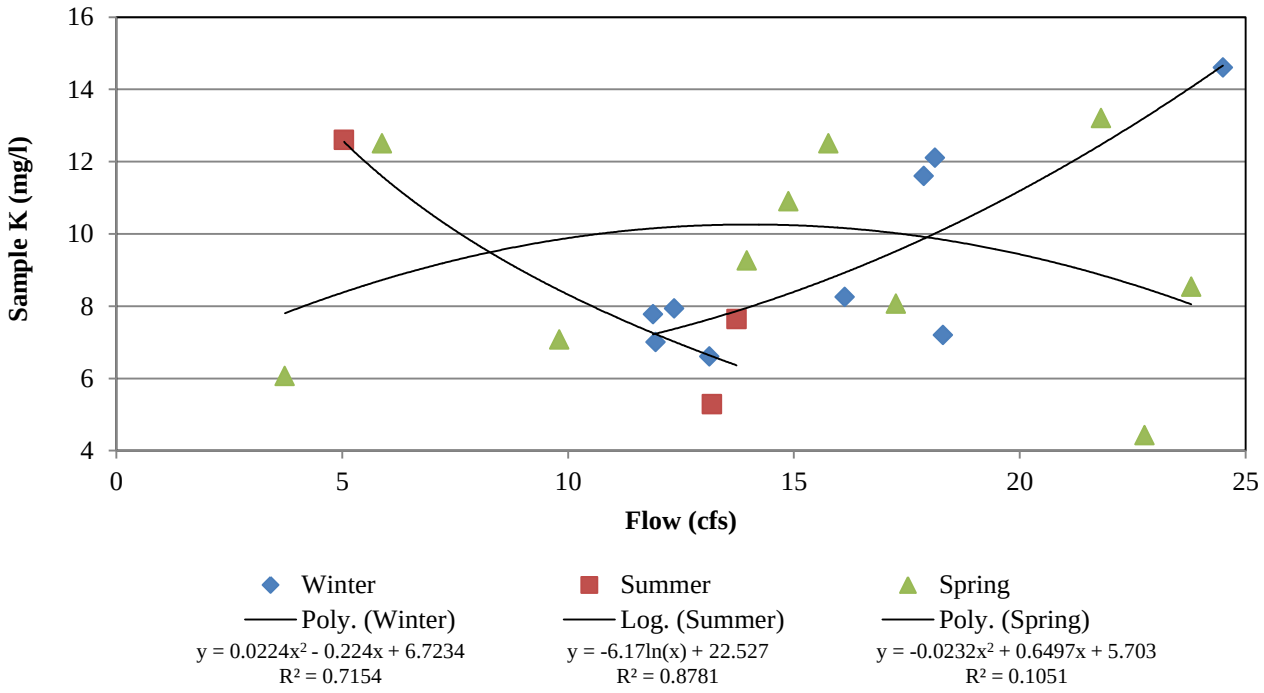

Figure 3-140: UT 47* Trendlines and Equations for K

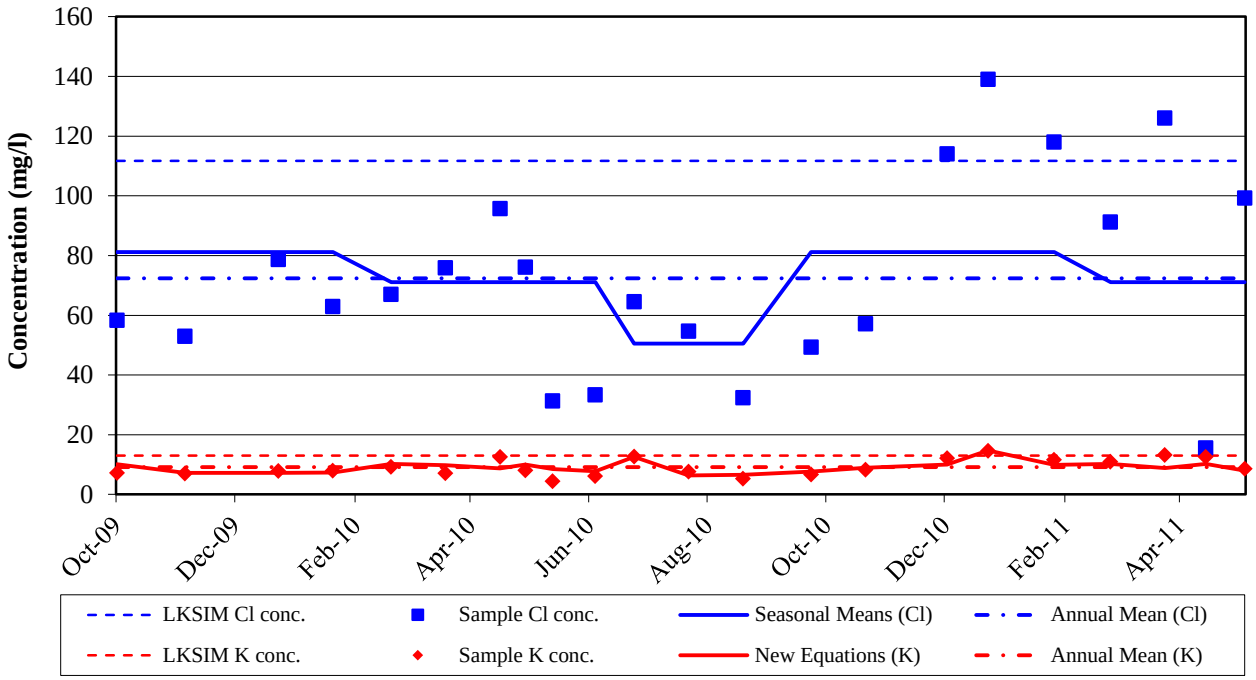

Figure 3-141: UT 47* Measured and Predicted Concentrations for Cl and K

Table 3-15: UT 47* Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	848	380	639	670	615	618	131	-
HCO_3	538	311	436	461	387	428	54.6	0.44
SO_4	170	45.8	96.2	104	71.8	96.7	34.9	0.50
Ca	91.4	41.1	80.5	87.4	79.6	73.9	9.32	0.77
Mg	60.5	22.1	45.1	50.2	39.6	42.1	10.2	0.43
Na	149	36.9	79.6	83.5	52.2	84.4	35.2	0.43
Cl	139	15.5	72.4	81.1	50.5	71.1	32.9	-
K	14.6	4.42	9.14	9.23	8.51	9.25	2.87	0.46

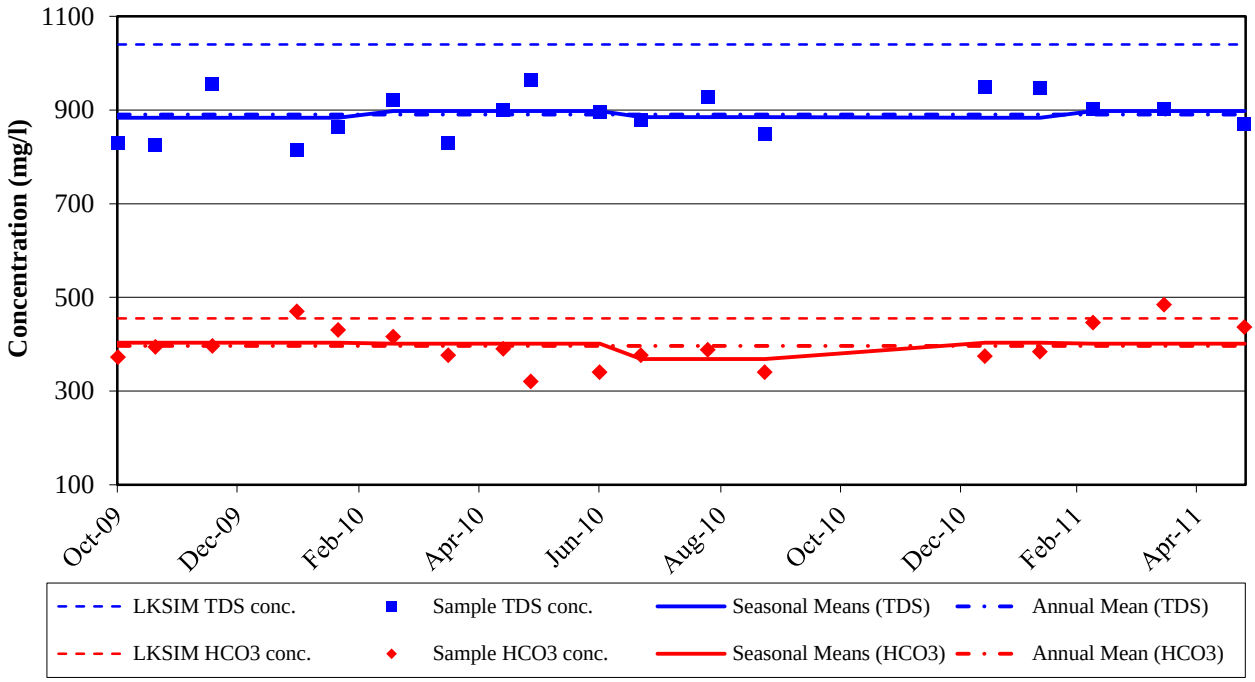

Figure 3-142: UT 47A Measured and Predicted Concentrations for TDS and HCO_3

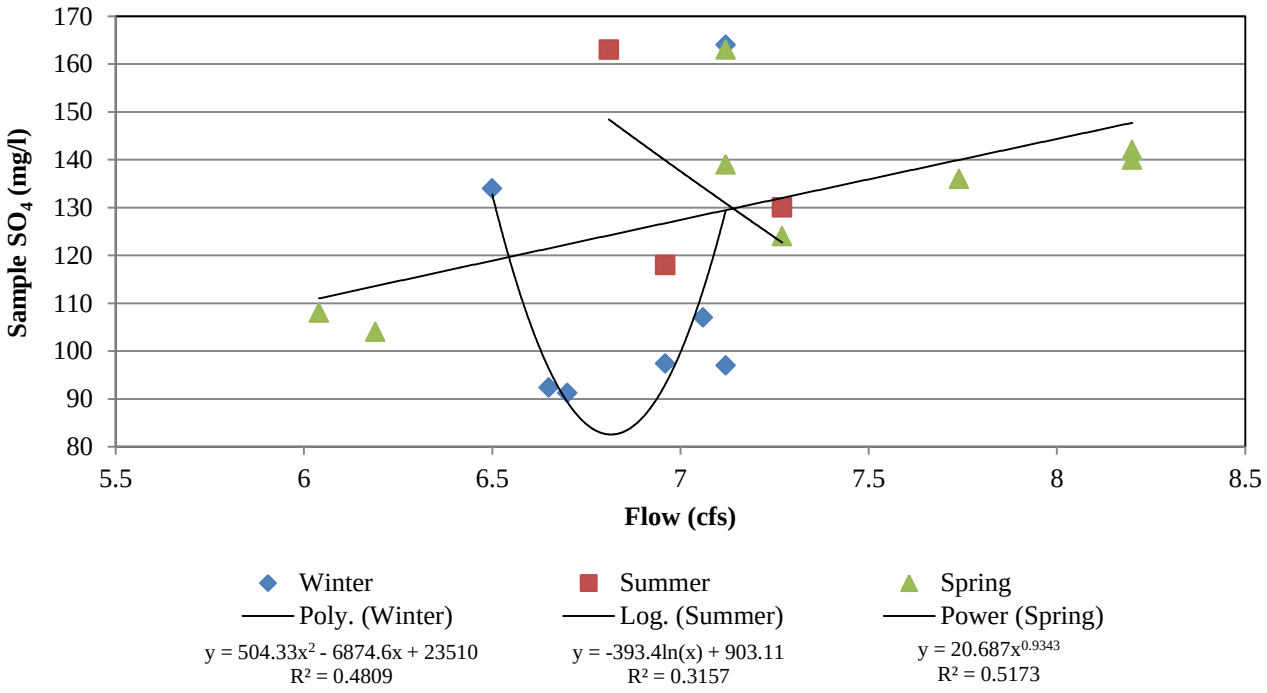

Figure 3-143: UT 47A Trendlines and Equations for SO_4

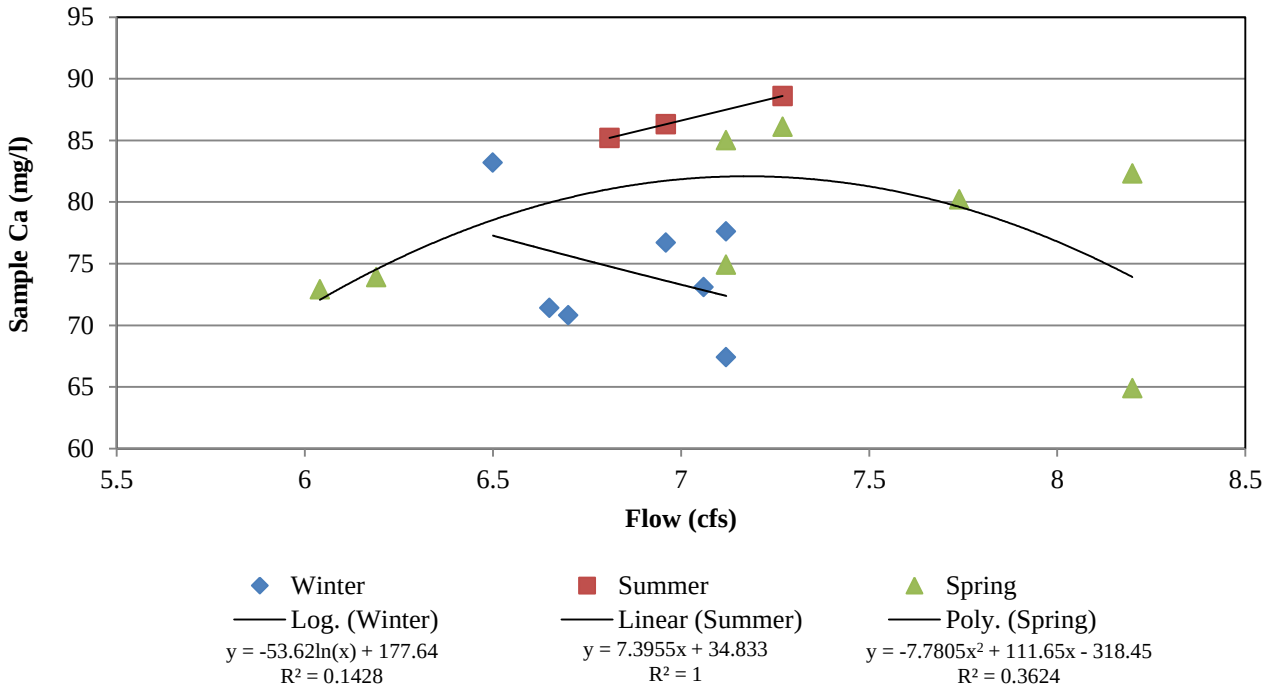

Figure 3-144: UT 47A Trendlines and Equations for Ca

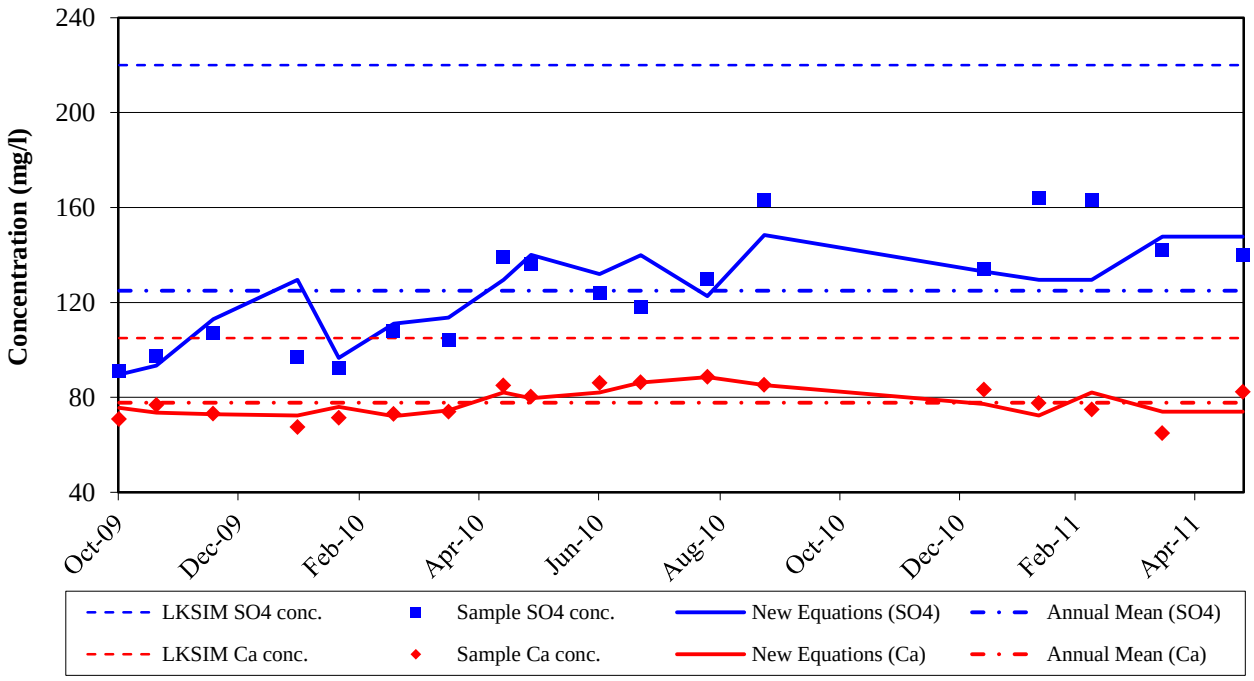

Figure 3-145: UT 47A Measured and Predicted Concentrations for SO_4 and Ca

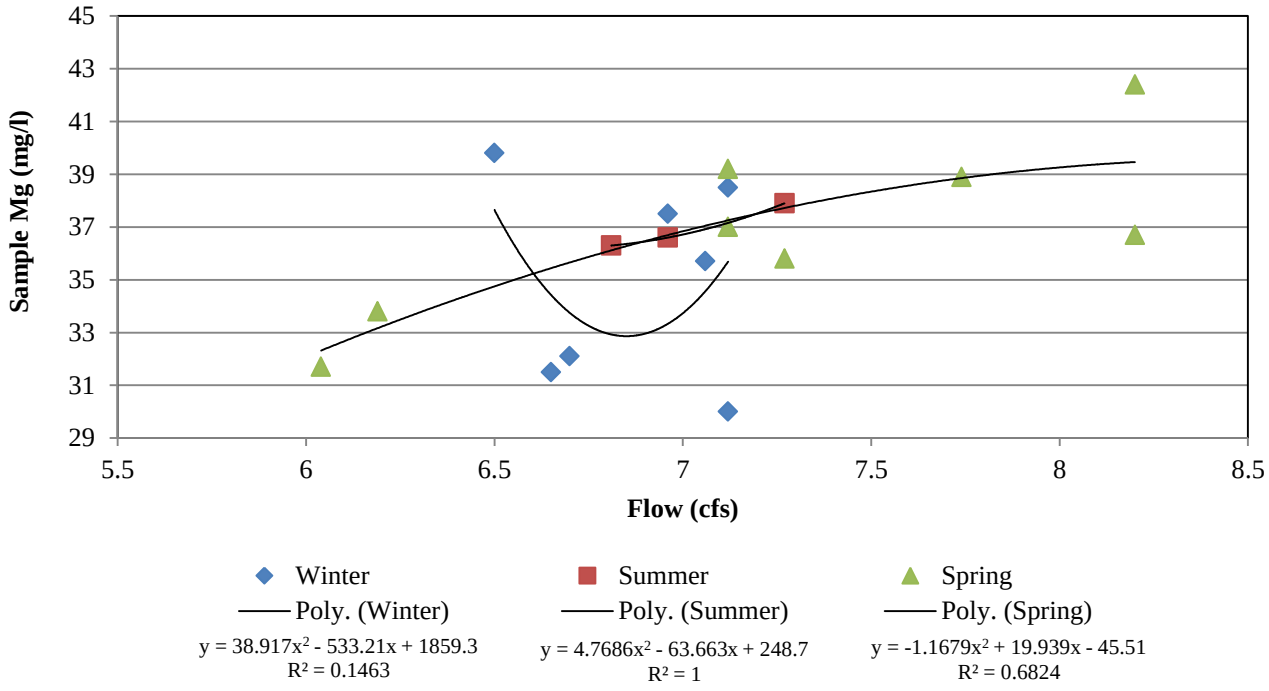

Figure 3-146: UT 47A Trendlines and Equations for Mg

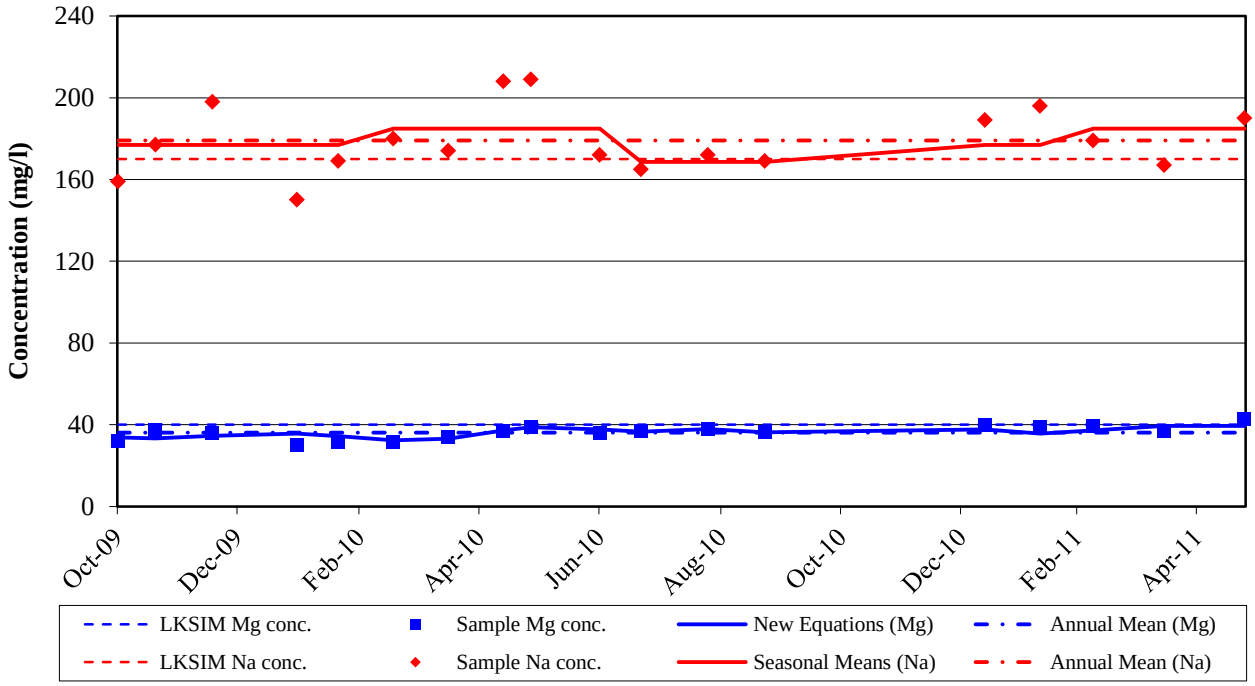

Figure 3-147: UT 47A Measured and Predicted Concentrations for Mg and Na

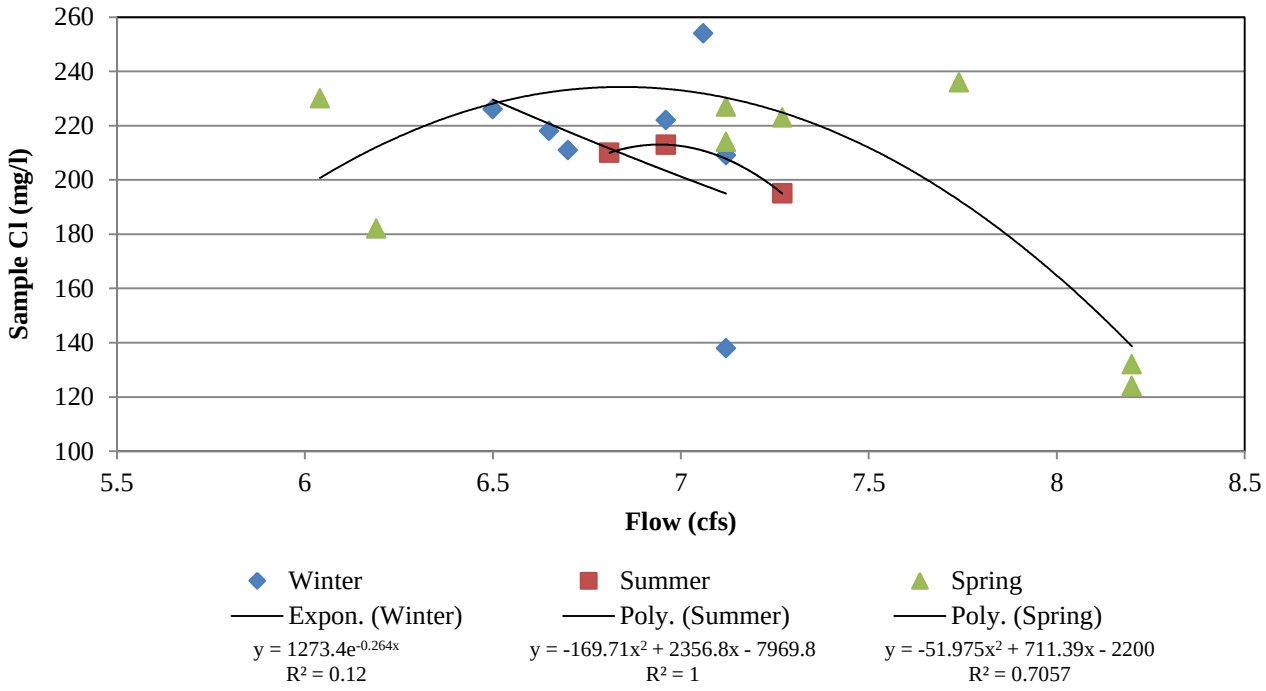

Figure 3-148: UT 47A Trendlines and Equations for Cl

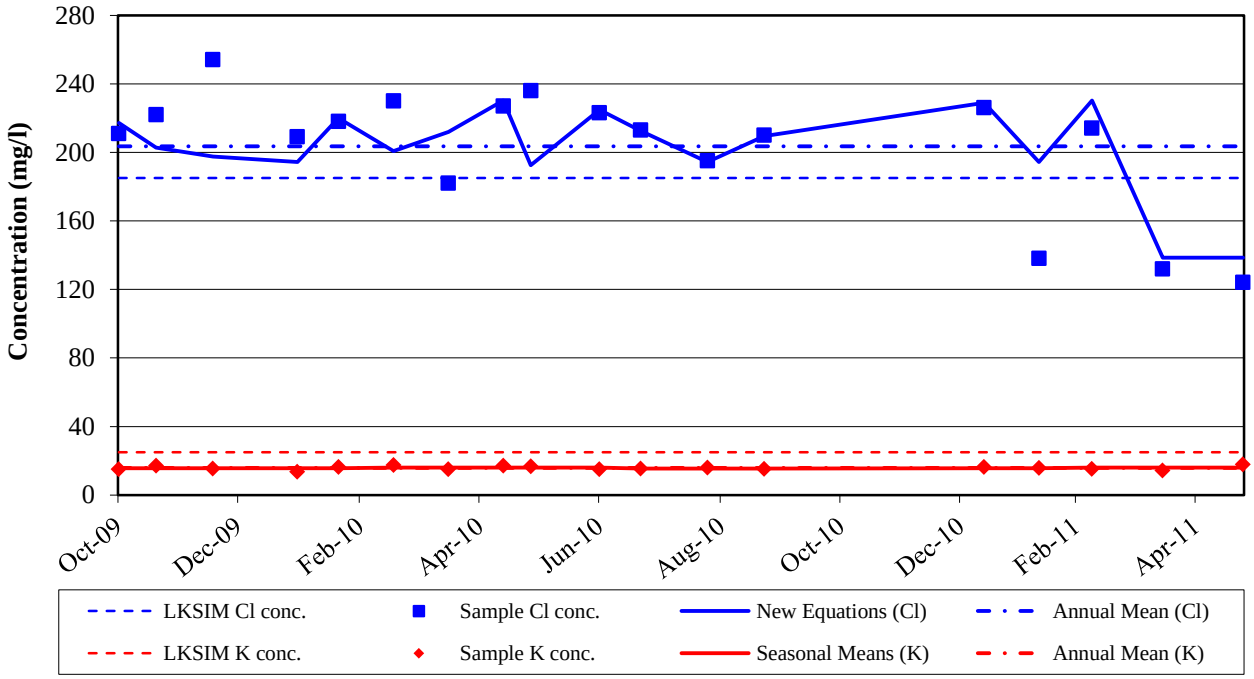

Figure 3-149: UT 47A Measured and Predicted Concentration for Cl and K

Table 3-16: UT 47A Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	964	814	890	883	885	898	48.1	-
HCO_3	484	320	396	403	368	401	44.1	-
SO_4	164	91.2	125	112	137	132	24.5	0.55
Ca	88.6	64.9	77.8	74.3	86.7	77.5	7.09	0.57
Mg	42.4	30.0	36.2	35.0	36.9	36.9	3.28	0.45
Na	209	150	179	177	169	185	16.3	-
Cl	254	124	204	211	206	196	36.7	0.51
K	17.8	13.4	15.8	15.6	15.5	16.0	1.14	-

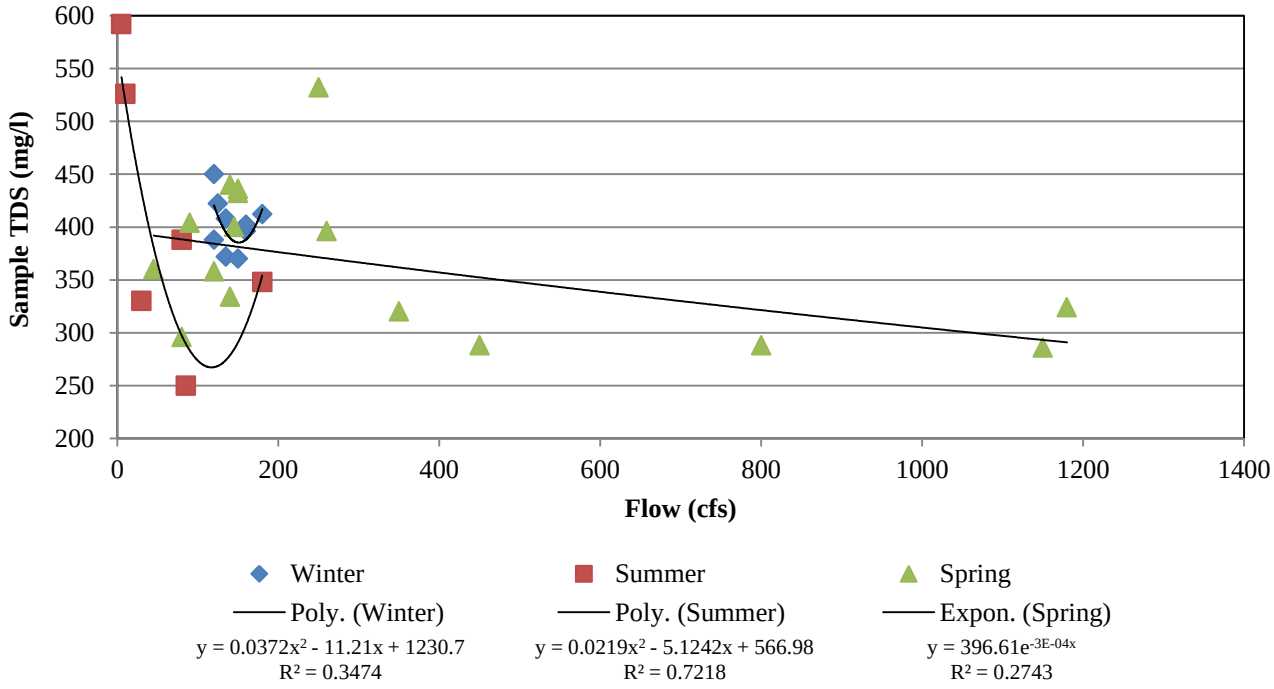

Figure 3-150: UT 48 Trendlines and Equations for TDS

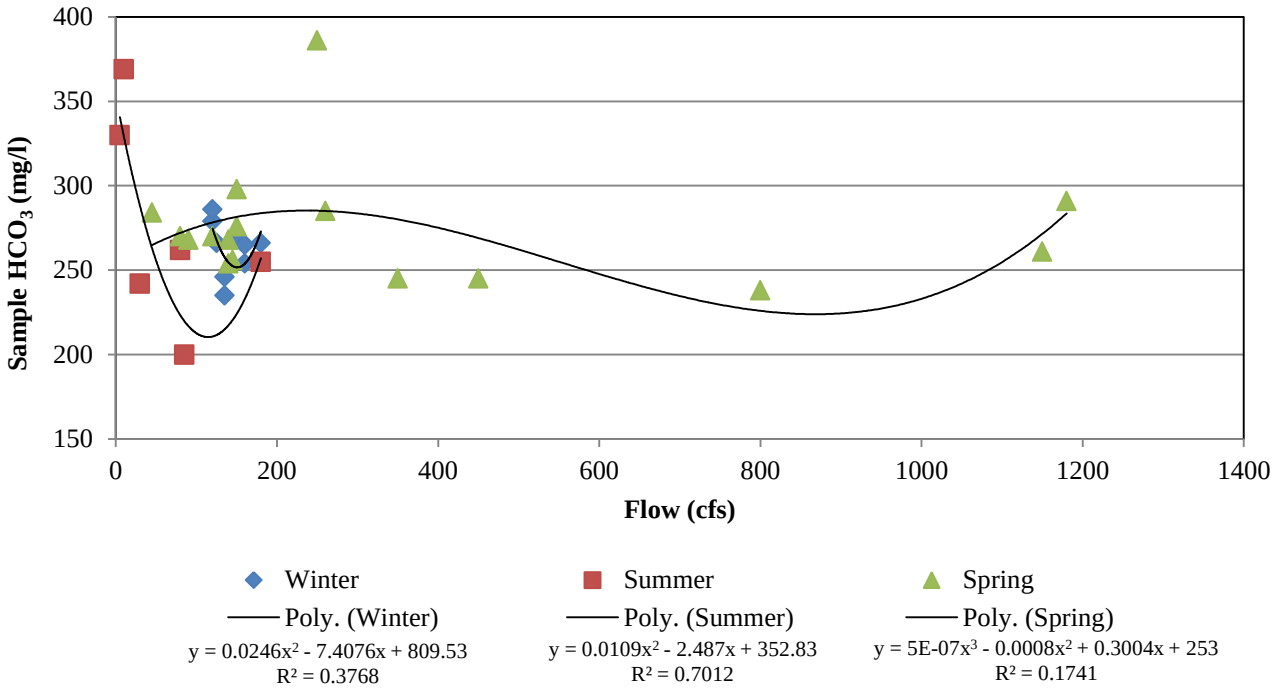

Figure 3-151: UT 48 Trendlines and Equations for HCO_3

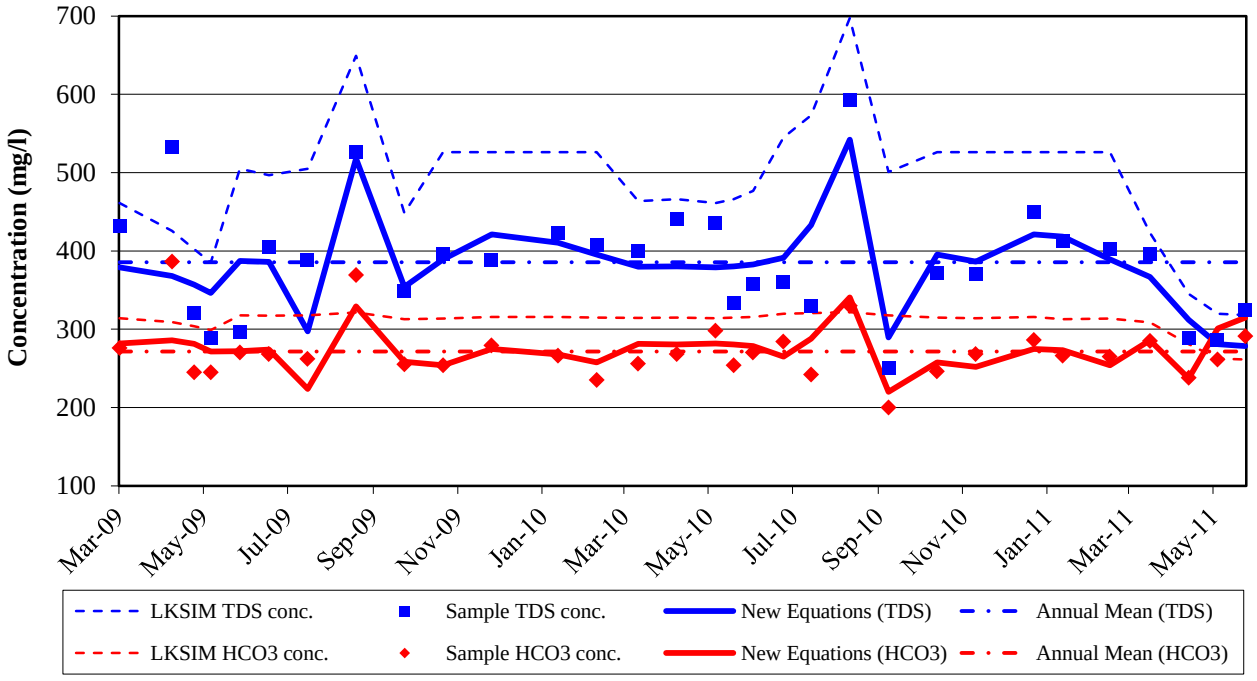

Figure 3-152: UT 48 Measured and Predicted Concentrations for TDS and HCO_3

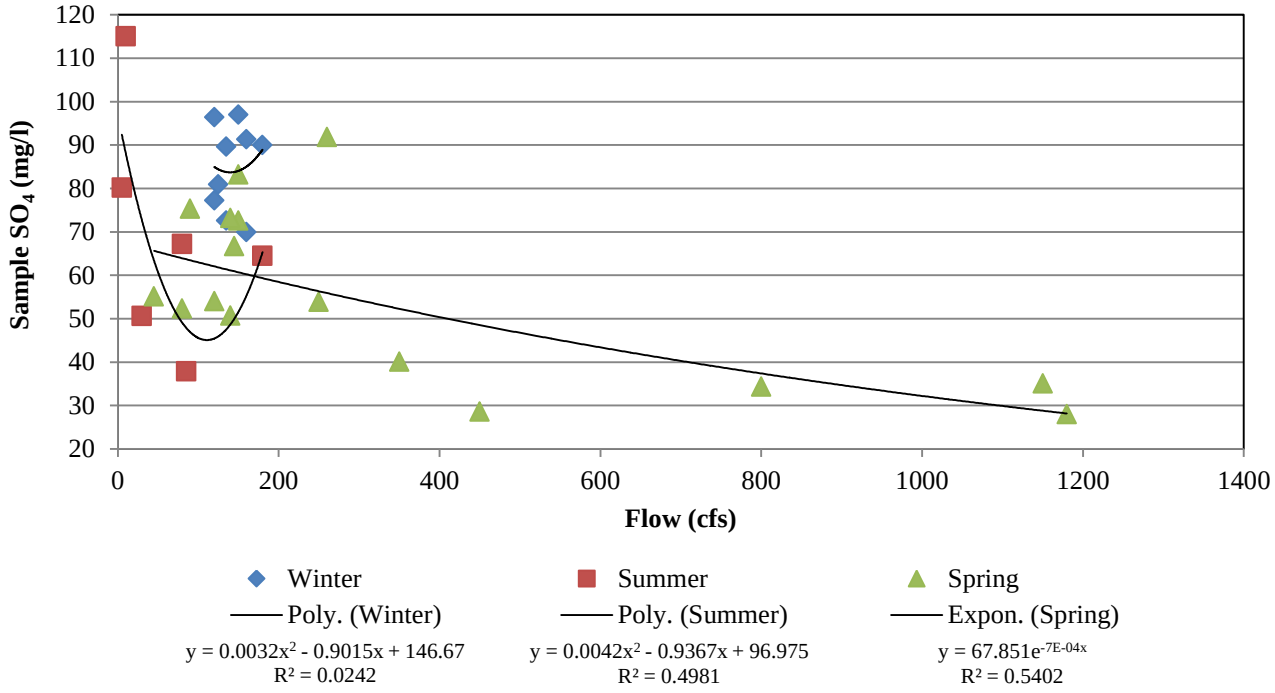

Figure 3-153: UT 48 Trendlines and Equations for SO_4

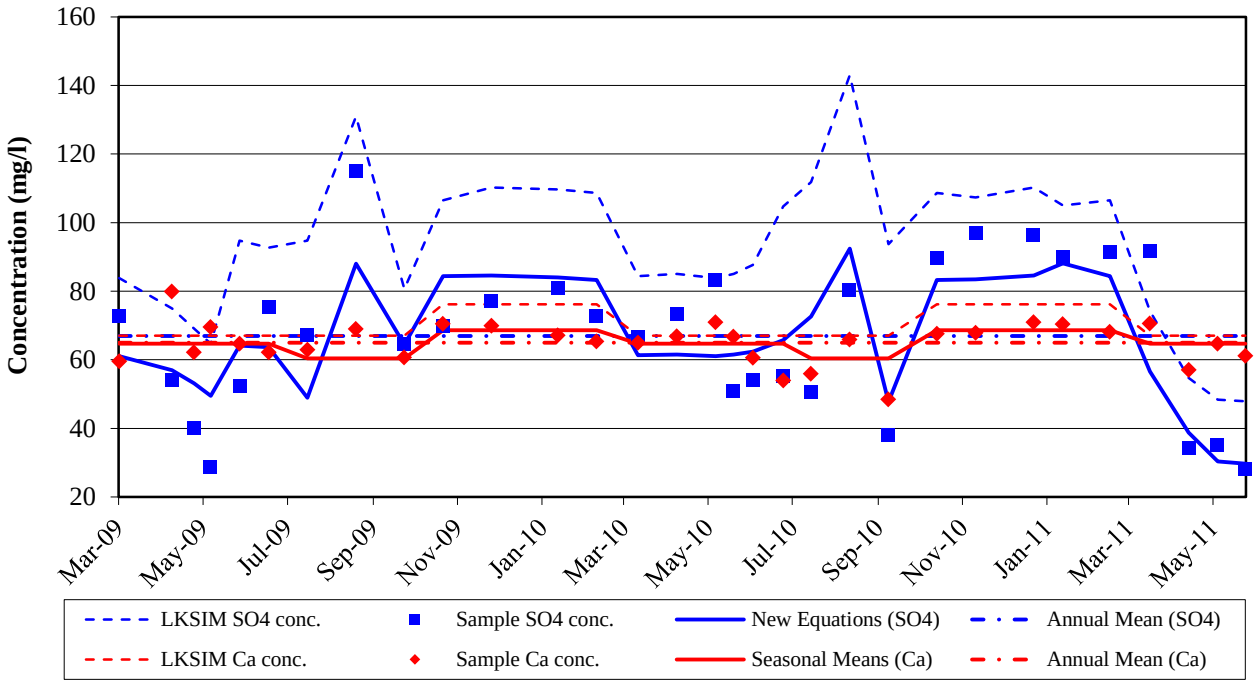

Figure 3-154: UT 48 Measured and Predicted Concentrations for SO_4 and Ca

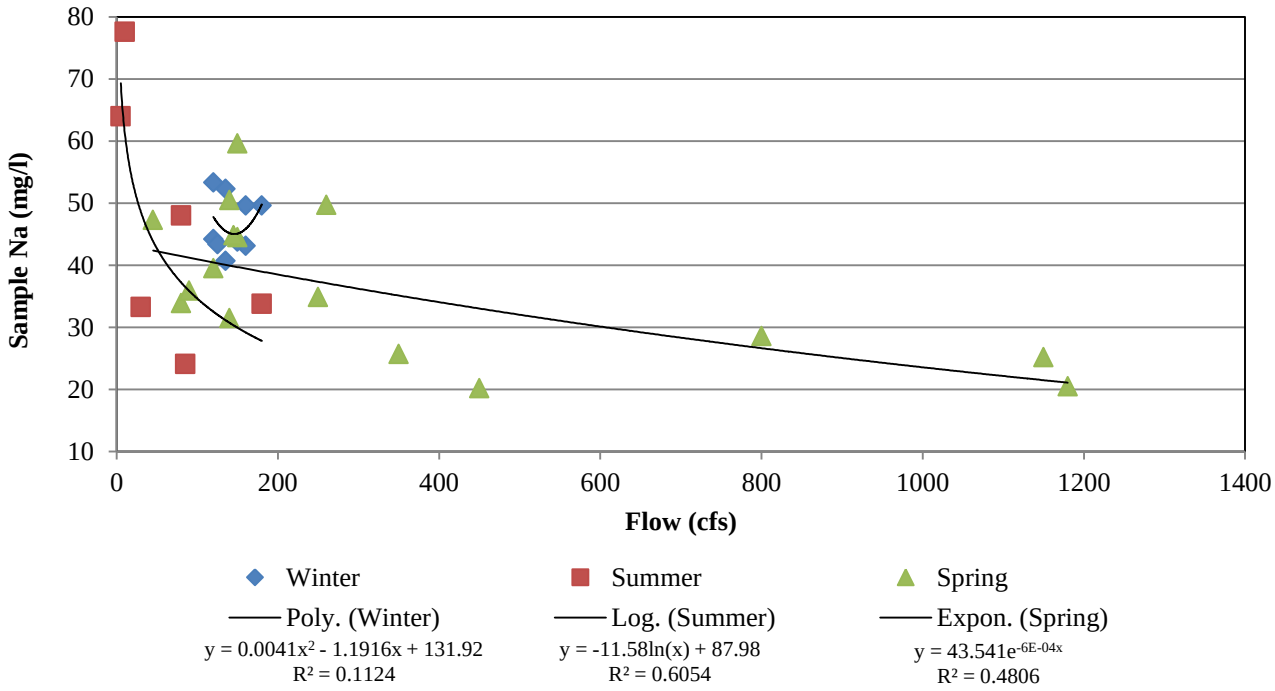

Figure 3-155: UT 48 Trendlines and Equations for Na

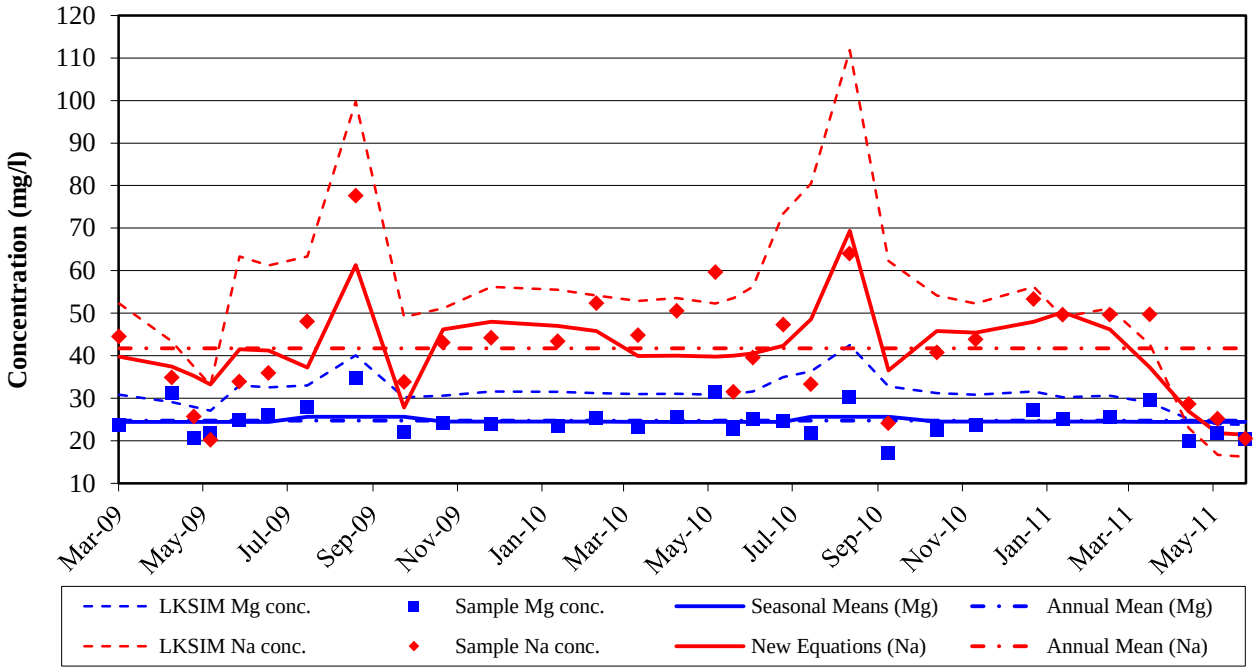

Figure 3-156: UT 48 Measured and Predicted Concentrations for Mg and Na

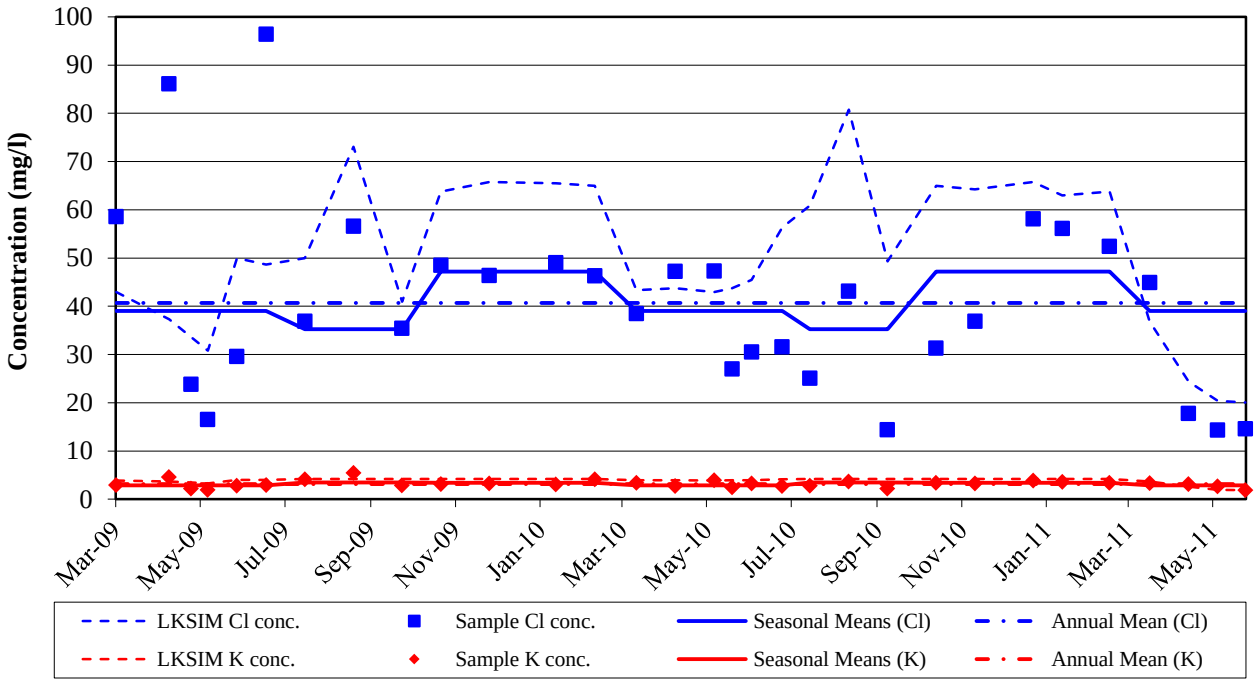

Figure 3-157: UT 48 Measured and Predicted Concentrations for Cl and K

Table 3-17: UT 48 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	592	250	385	402	406	368	75.6	0.52
HCO_3	386	200	272	263	276	275	36.4	0.42
SO_4	115	28.0	66.9	85.0	69.2	55.9	22.4	0.61
Ca	79.9	48.4	65.0	68.6	60.4	64.7	6.13	-
Mg	34.8	17.1	24.7	24.5	25.7	24.5	3.78	-
Na	77.6	20.2	41.7	46.7	46.8	37.0	12.9	0.57
Cl	96.4	14.3	40.7	47.2	35.3	39.0	19.2	-
K	5.44	1.87	3.18	3.44	3.51	2.91	0.761	-

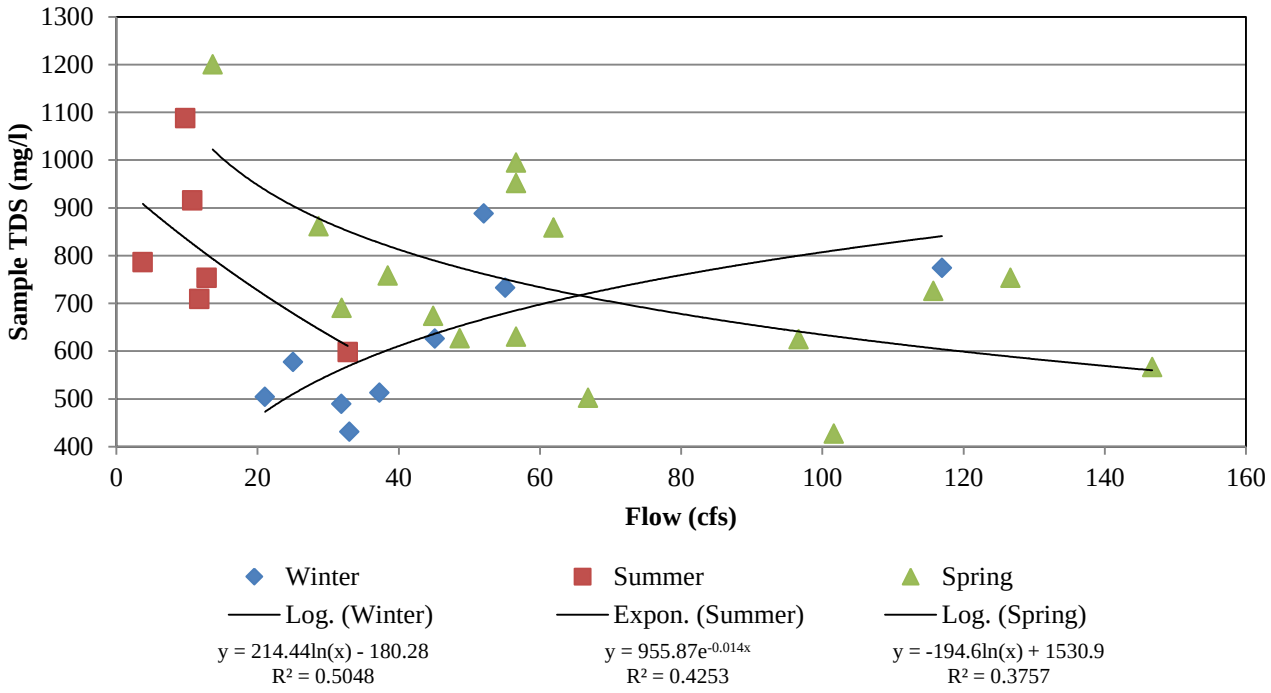

Figure 3-158: UT 51* Trendlines and Equations for TDS

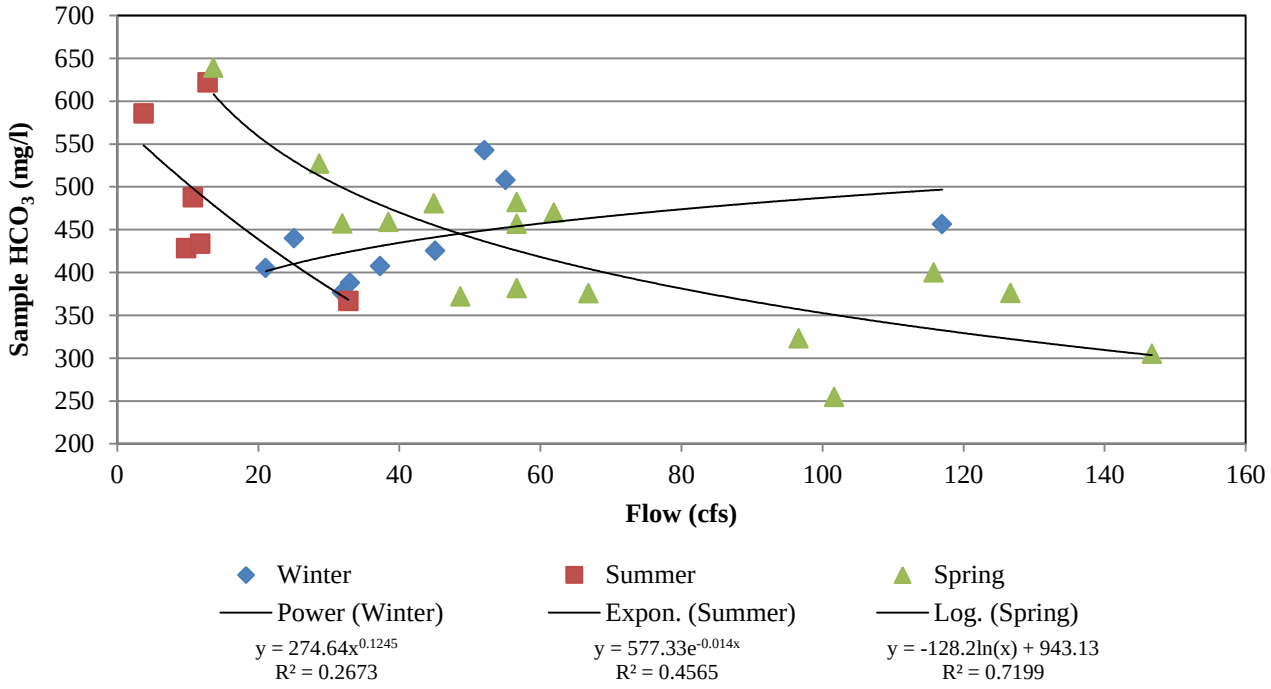

Figure 3-159: UT 51* Trendlines and Equations for HCO_3

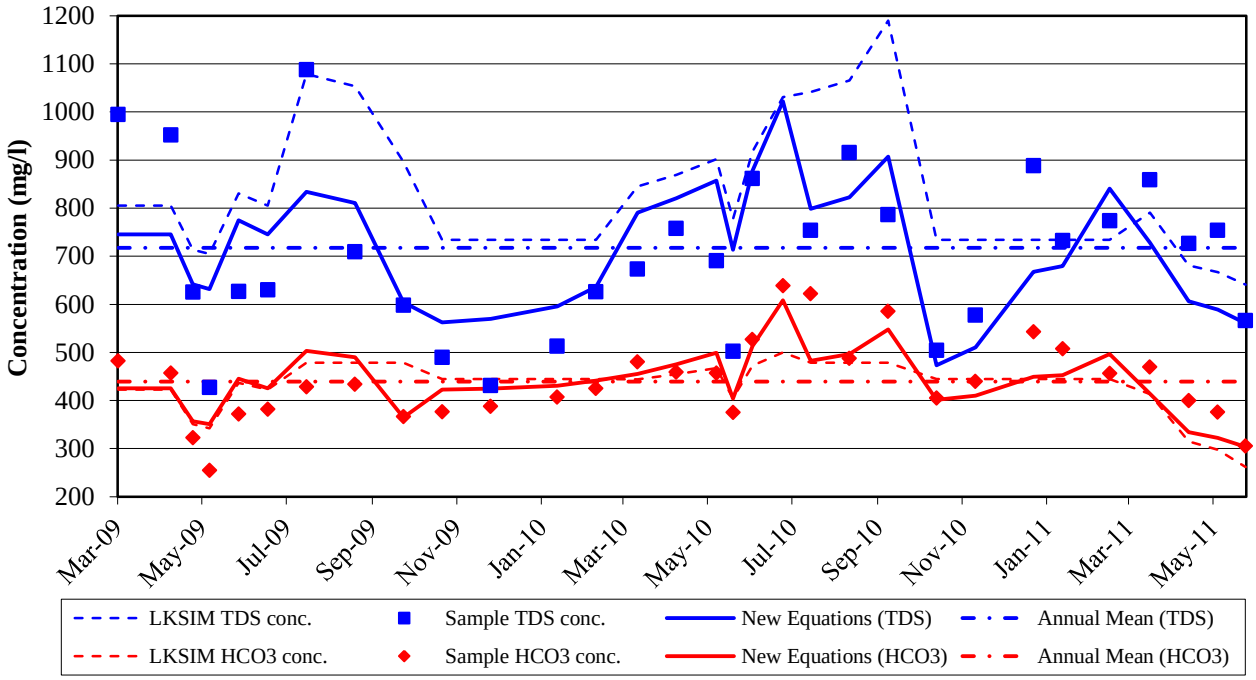

Figure 3-160: UT 51* Measured and Predicted Concentrations for TDS and HCO_3

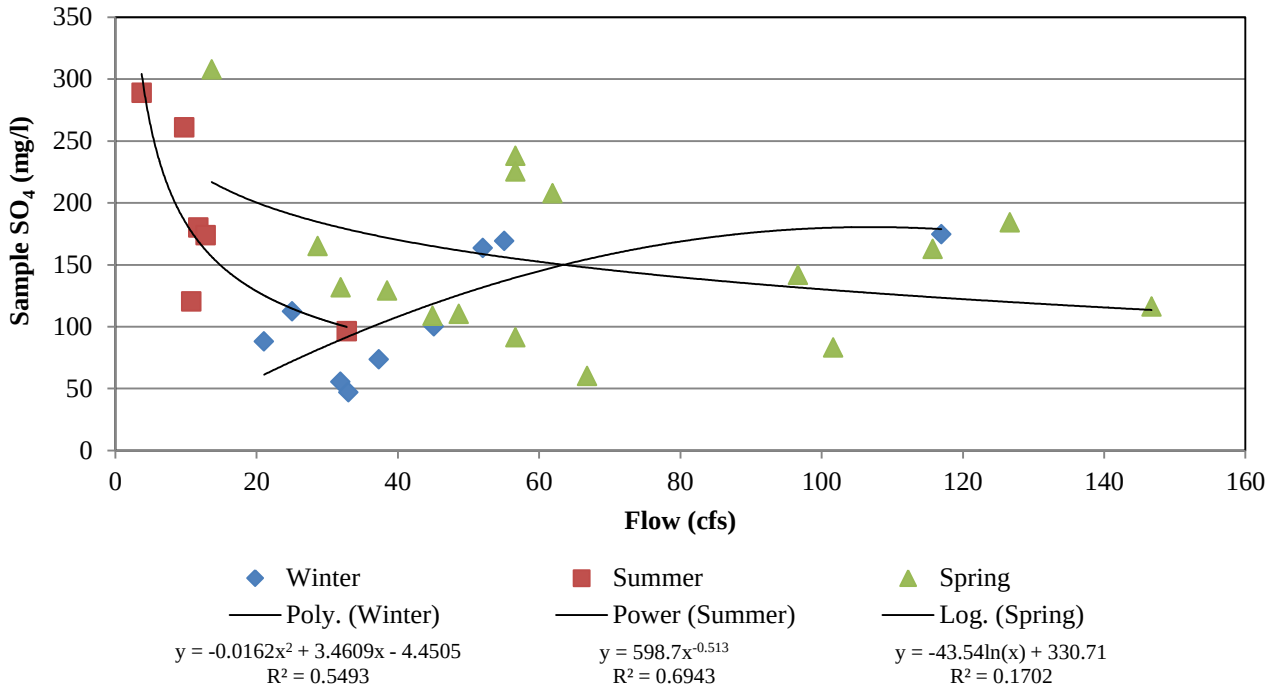

Figure 3-161: UT 51* Trendlines and Equations for SO_4

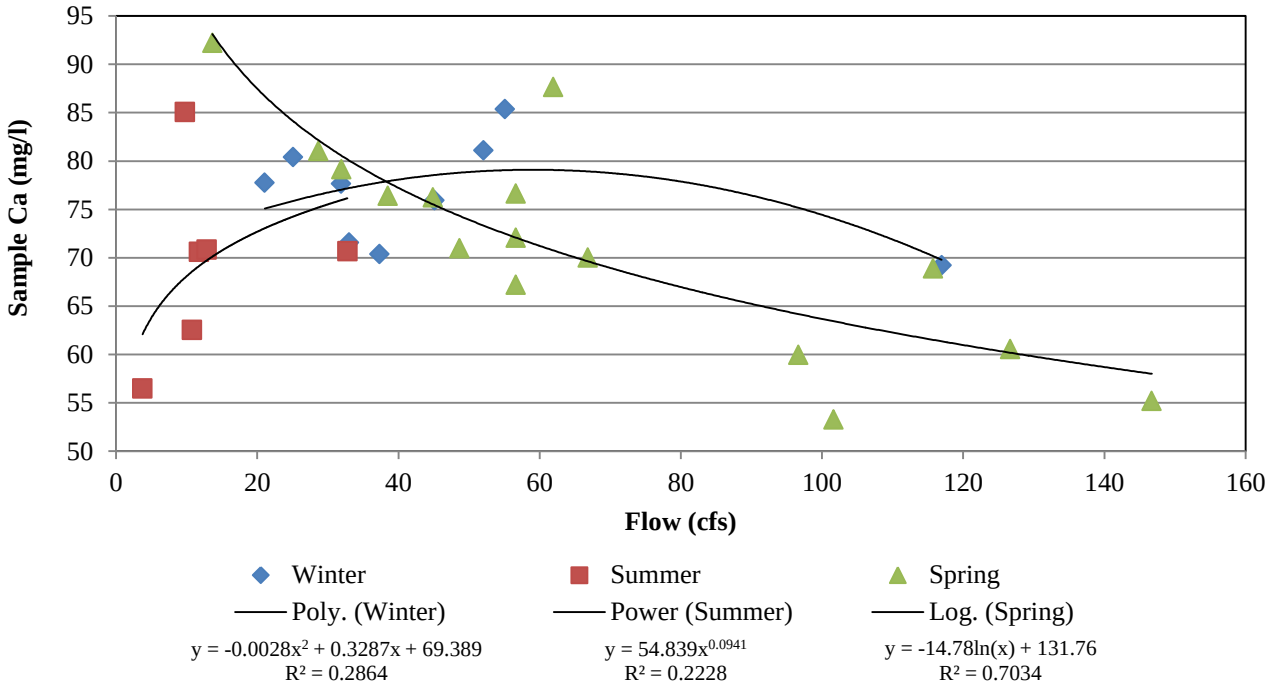

Figure 3-162: UT 51* Trendlines and Equations for Ca

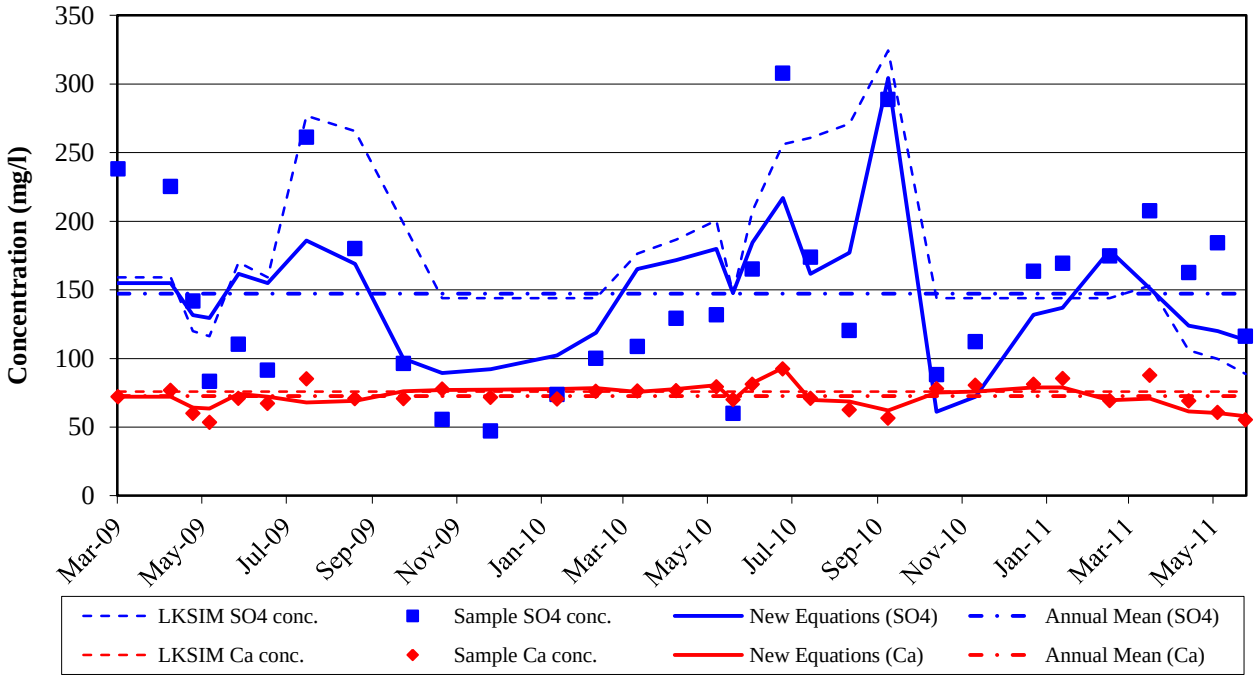

Figure 3-163: UT 51* Measured and Predicted Concentrations for SO_4 and Ca

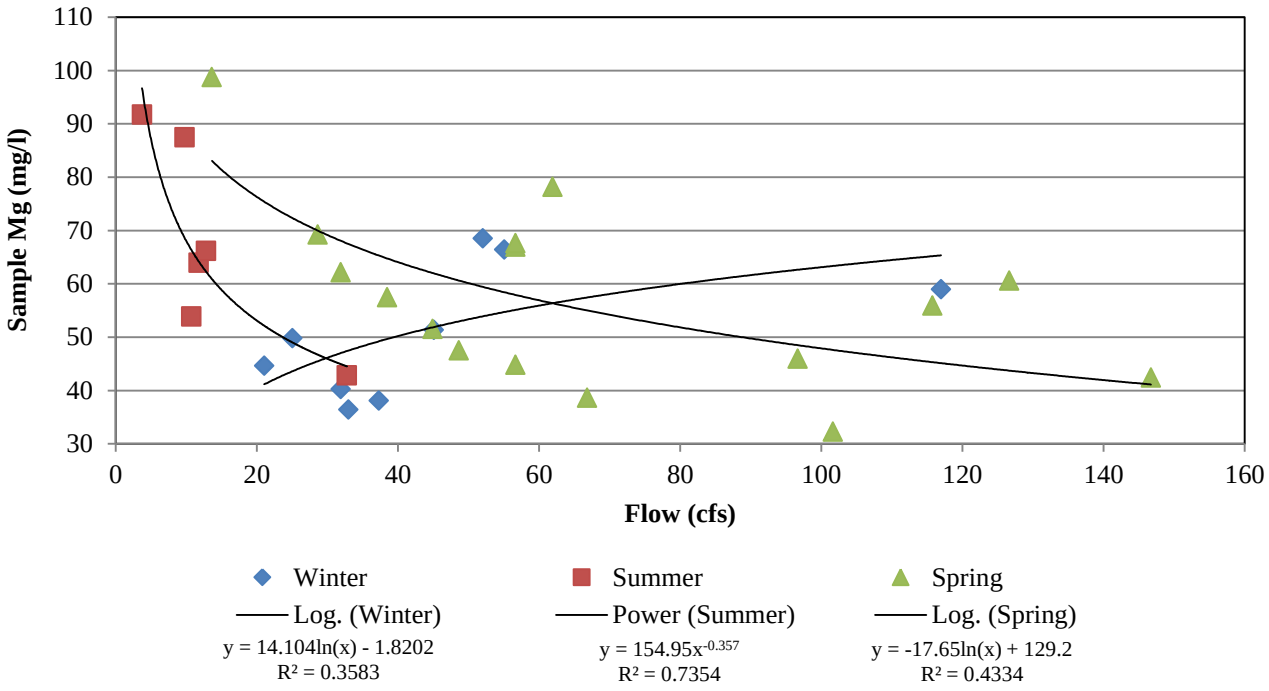

Figure 3-164: UT 51* Trendlines and Equations for Mg

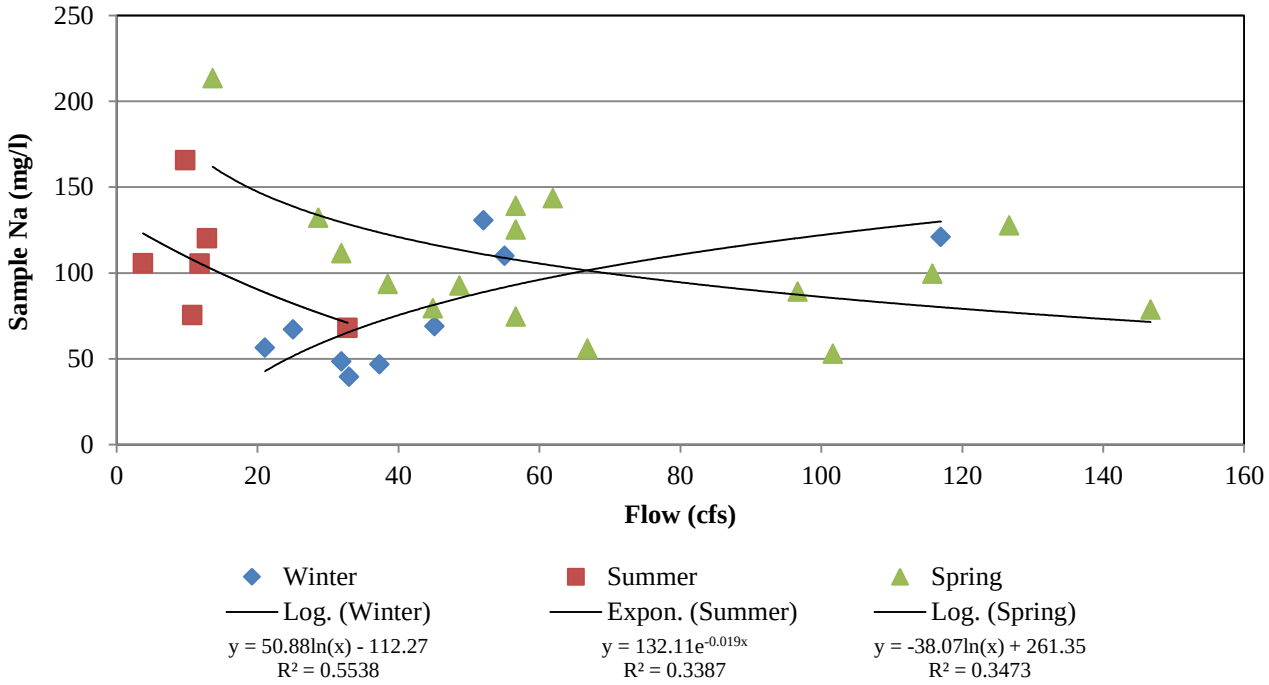

Figure 3-165: UT 51* Trendlines and Equations for Na

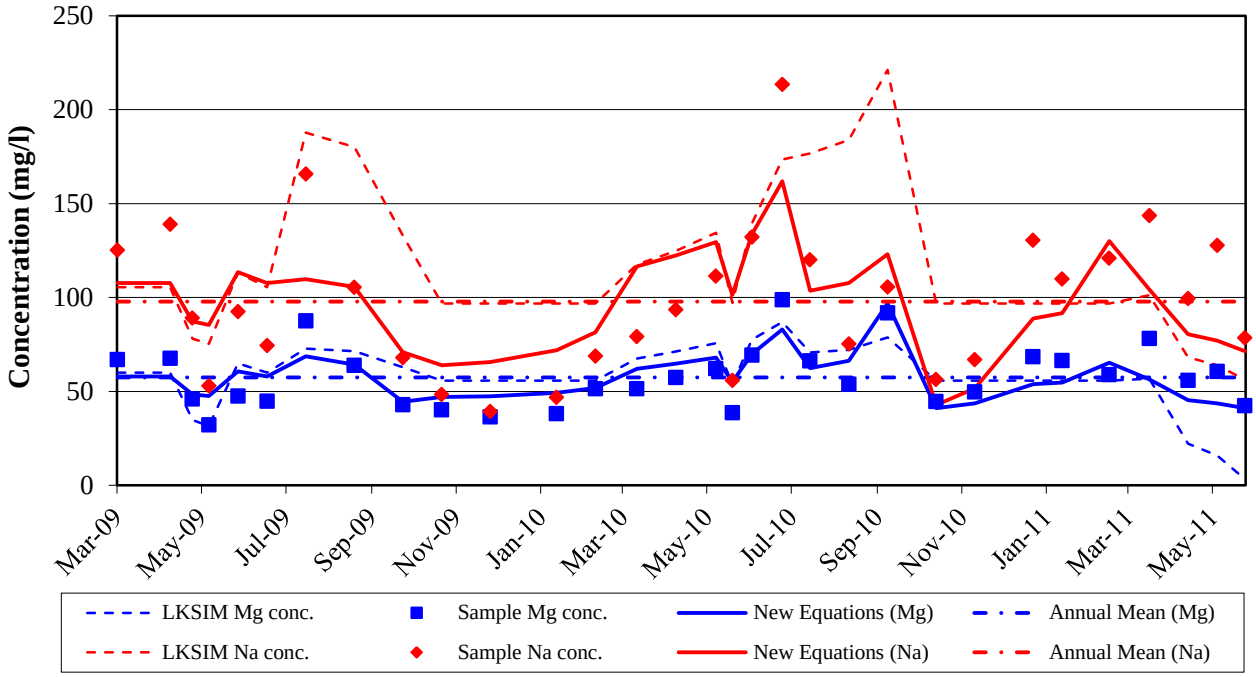

Figure 3-166: UT 51* Measured and Predicted Concentrations for Mg and Na

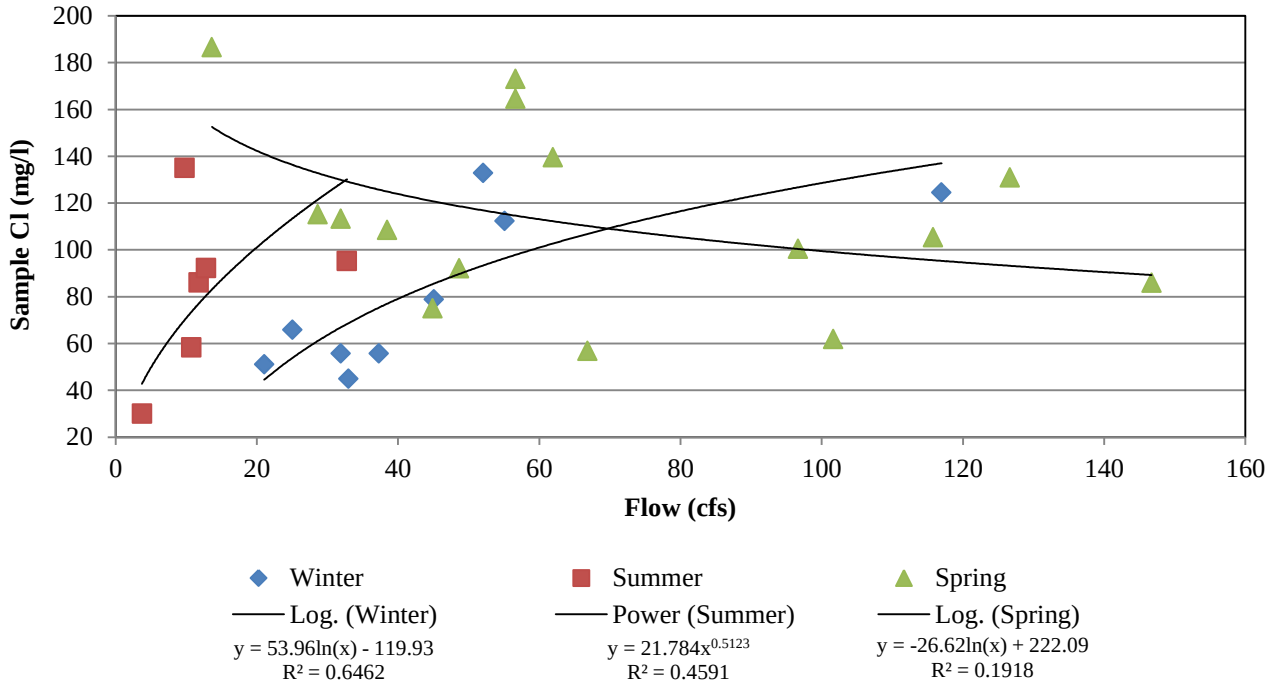

Figure 3-167: UT 51* Trendlines and Equations for Cl

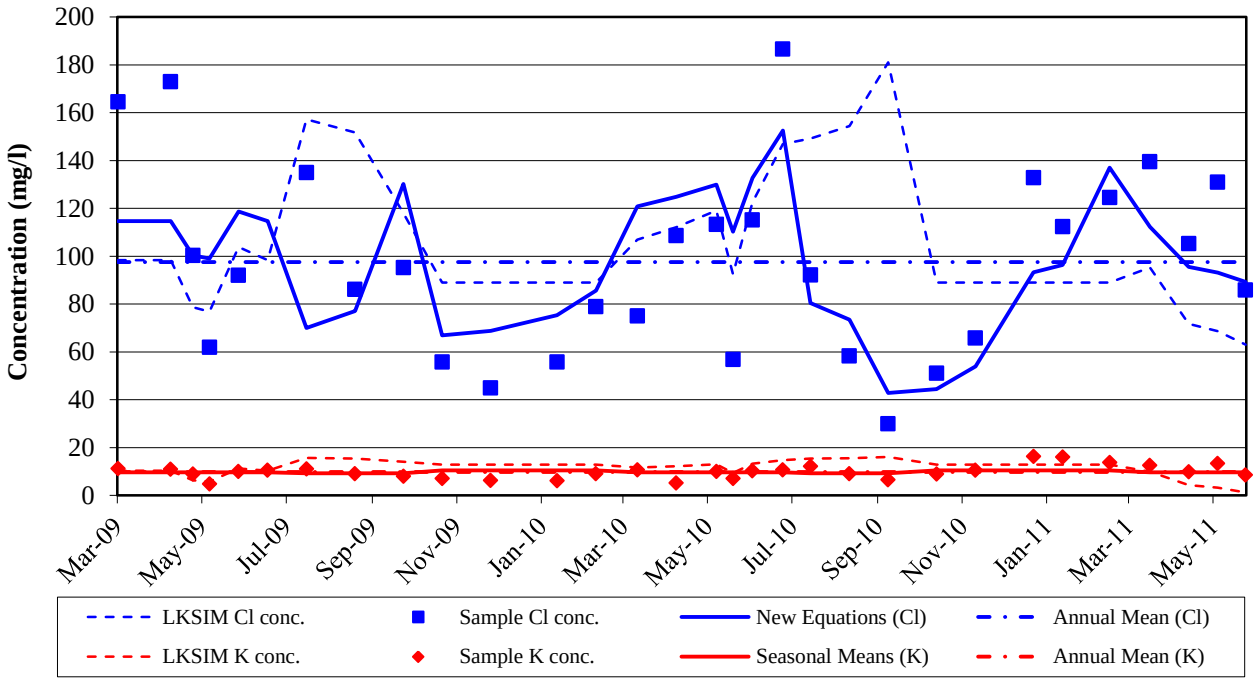

Figure 3-168: UT 51* Measured and Predicted Concentrations for Cl and K

Table 3-18: UT 51* Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	1201	427	717	615	808	740	189	0.48
HCO_3	639	255	440	439	487	422	86.3	0.62
SO_4	308	47.0	147	109	187	154	67.1	0.47
Ca	92.2	53.3	72.7	76.6	69.4	71.7	9.50	0.60
Mg	98.8	32.3	57.4	50.5	67.7	57.5	16.5	0.55
Na	213	39.3	97.9	76.4	107	107	39.0	0.46
Cl	187	29.9	97.6	80.2	82.8	114	39.4	0.41
K	16.3	4.73	9.81	10.4	9.30	9.65	2.82	-

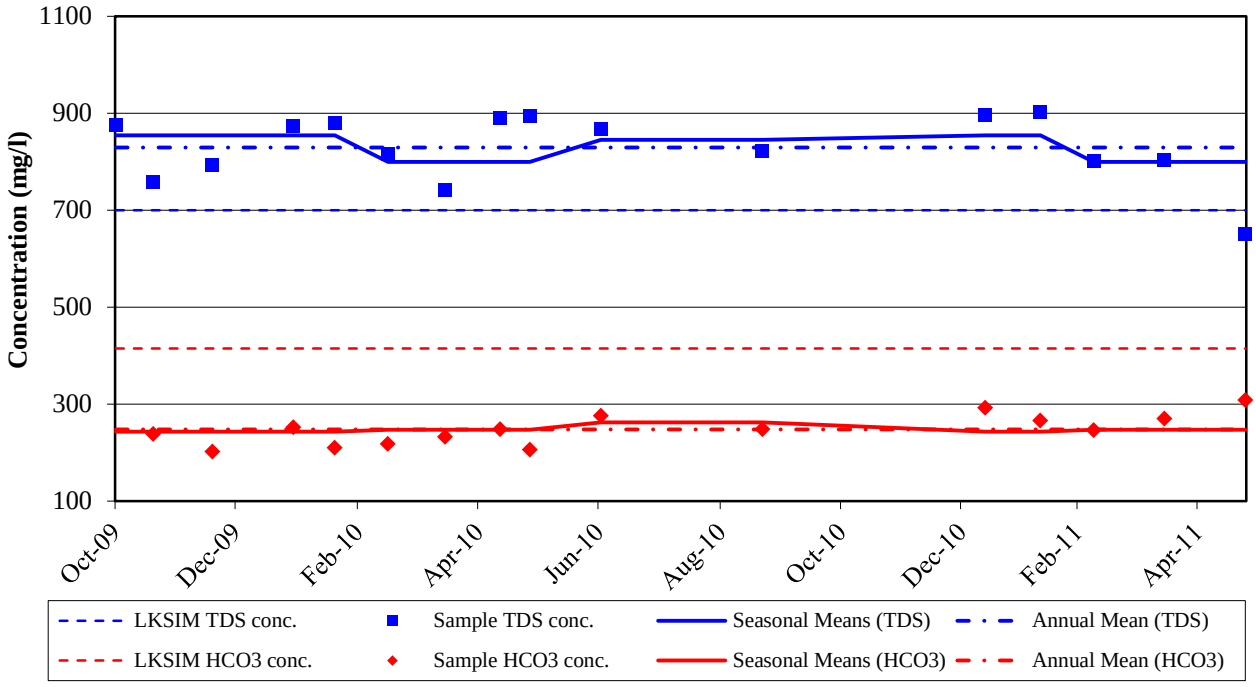

Figure 3-169: UT 51A Measured and Predicted Concentrations for TDS and HCO_3

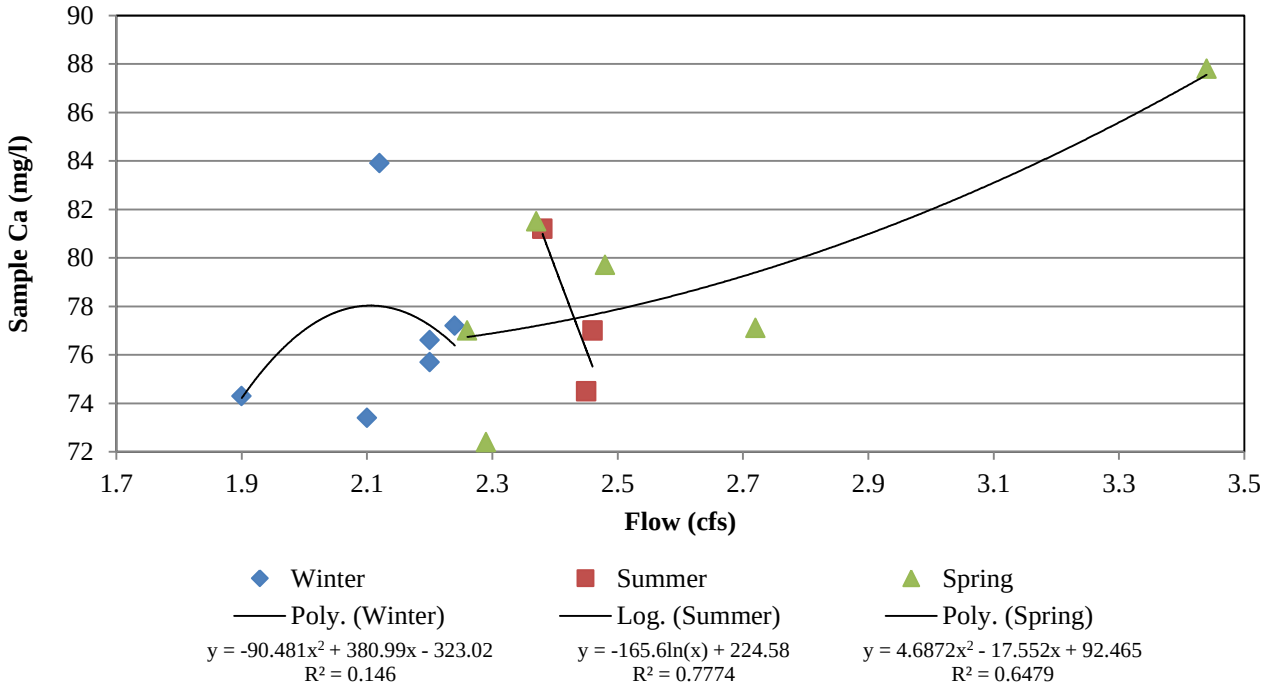

Figure 3-170: UT 51A Trendlines and Equations for Ca

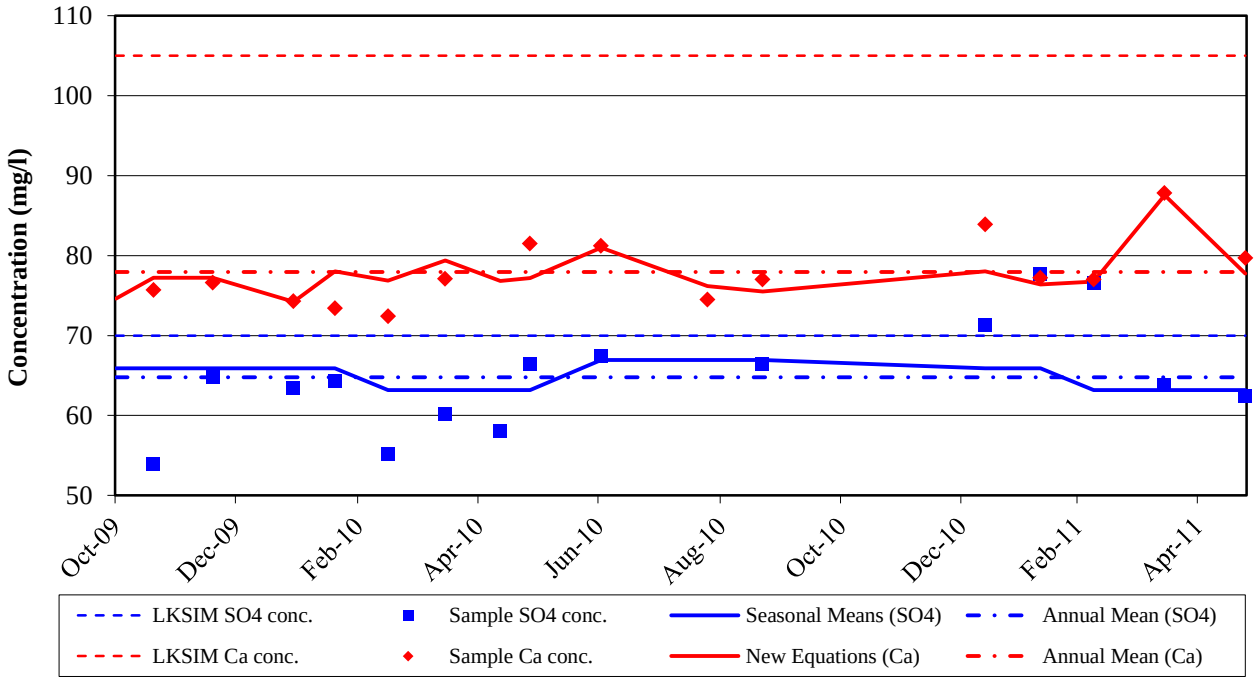

Figure 3-171: UT 51A Measured and Predicted Concentrations for SO_4 and Ca

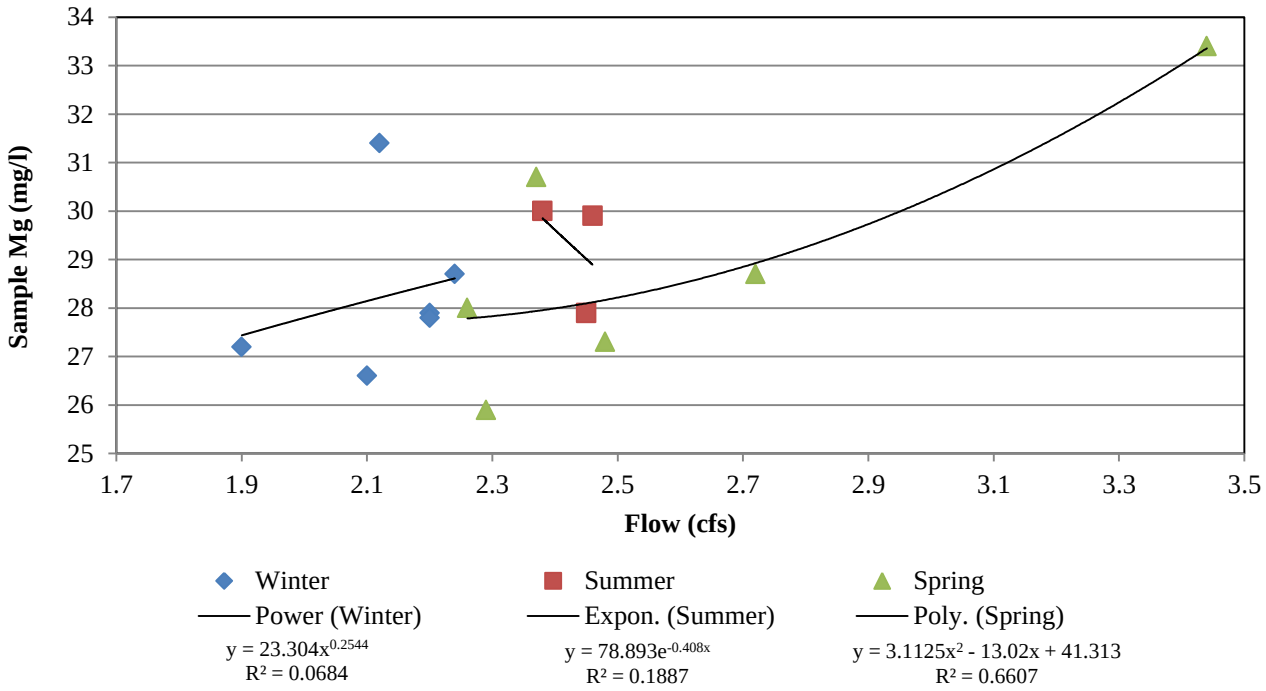

Figure 3-172: UT 51A Trendlines and Equations for Mg

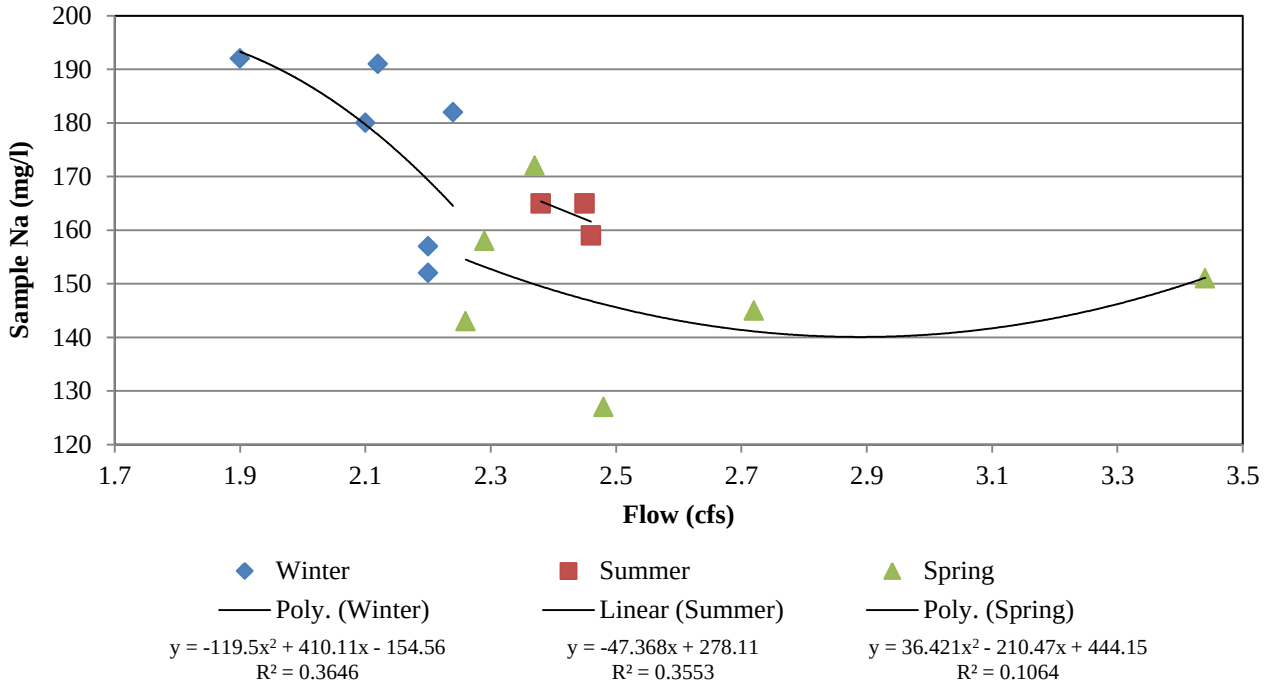

Figure 3-173: UT 51A Trendlines and Equations for Na

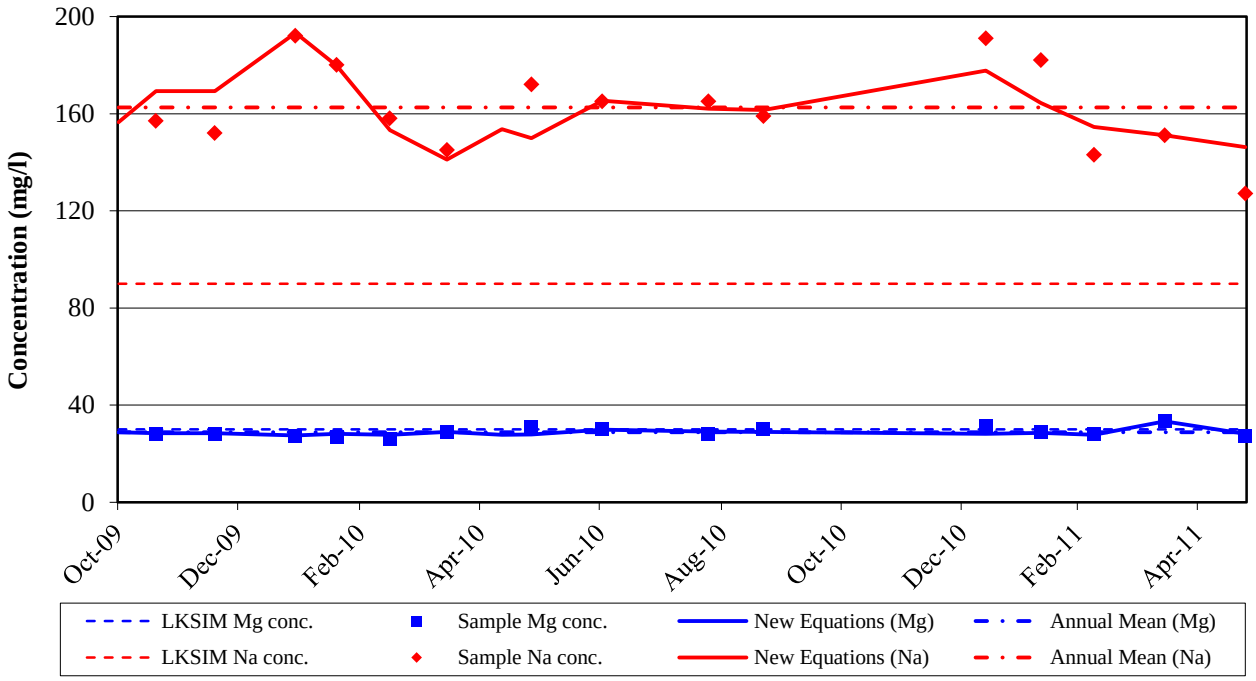

Figure 3-174: UT 51A Measured and Predicted Concentrations for Mg and Na

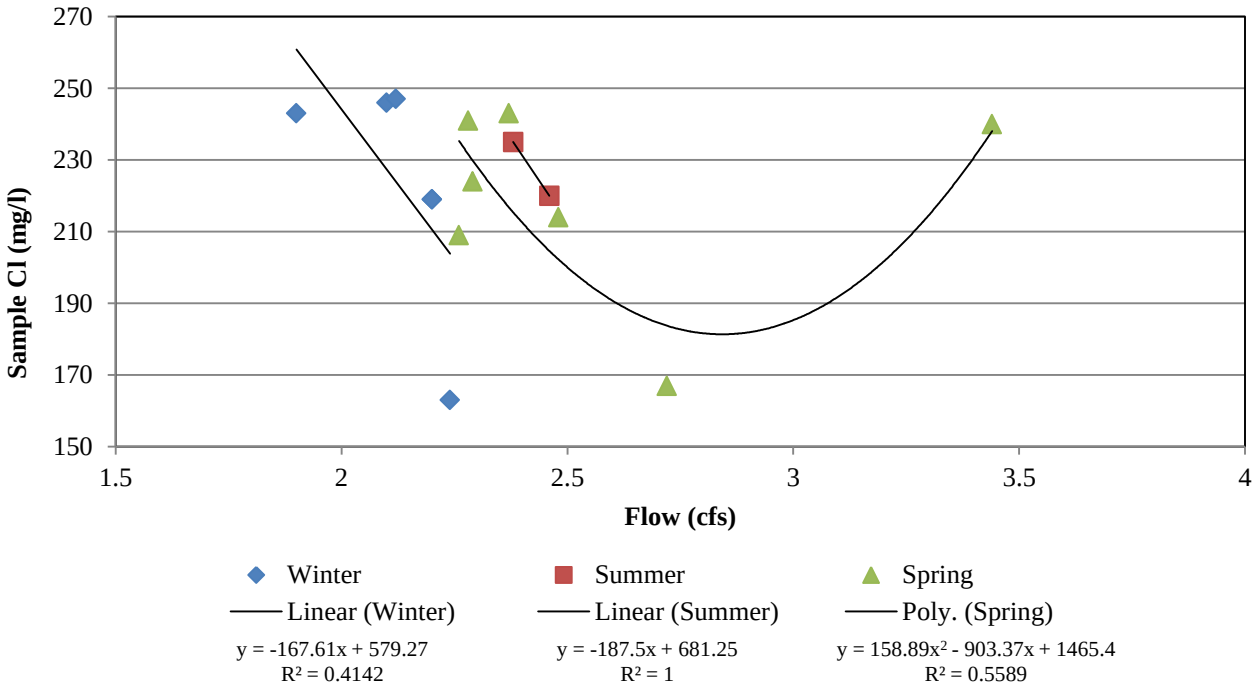

Figure 3-175: UT 51A Trendlines and Equations for Cl

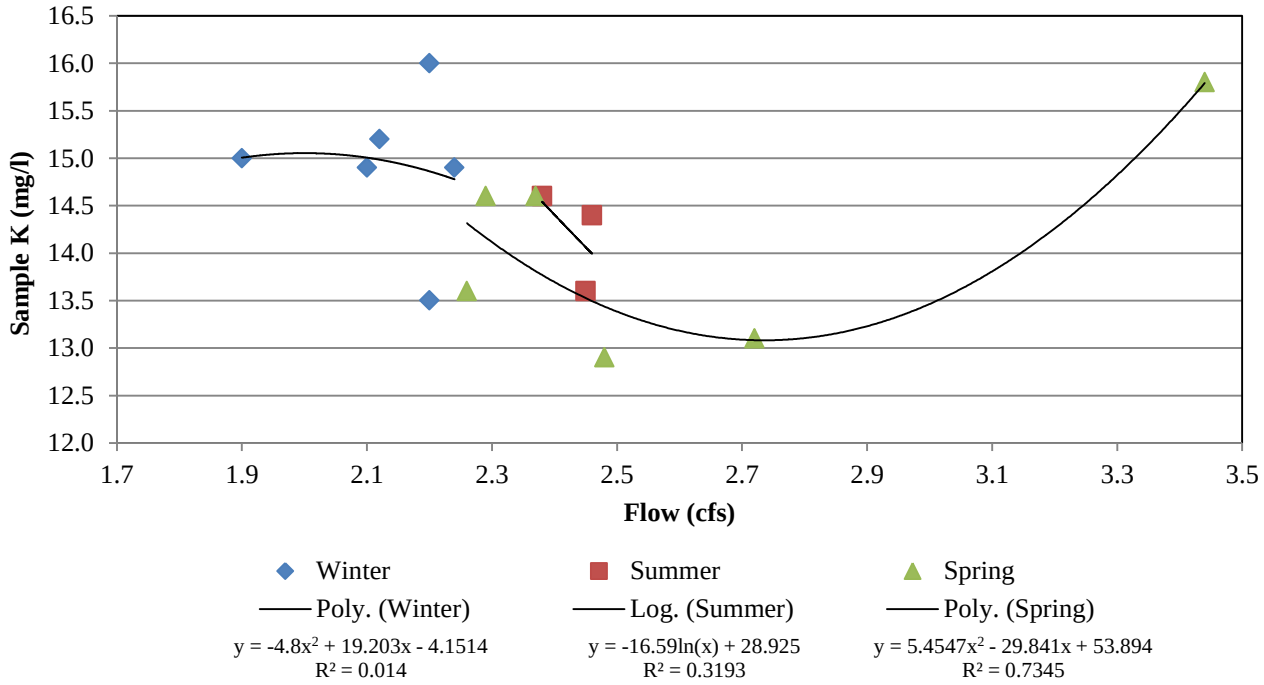

Figure 3-176: UT 51A Trendlines and Equations for K

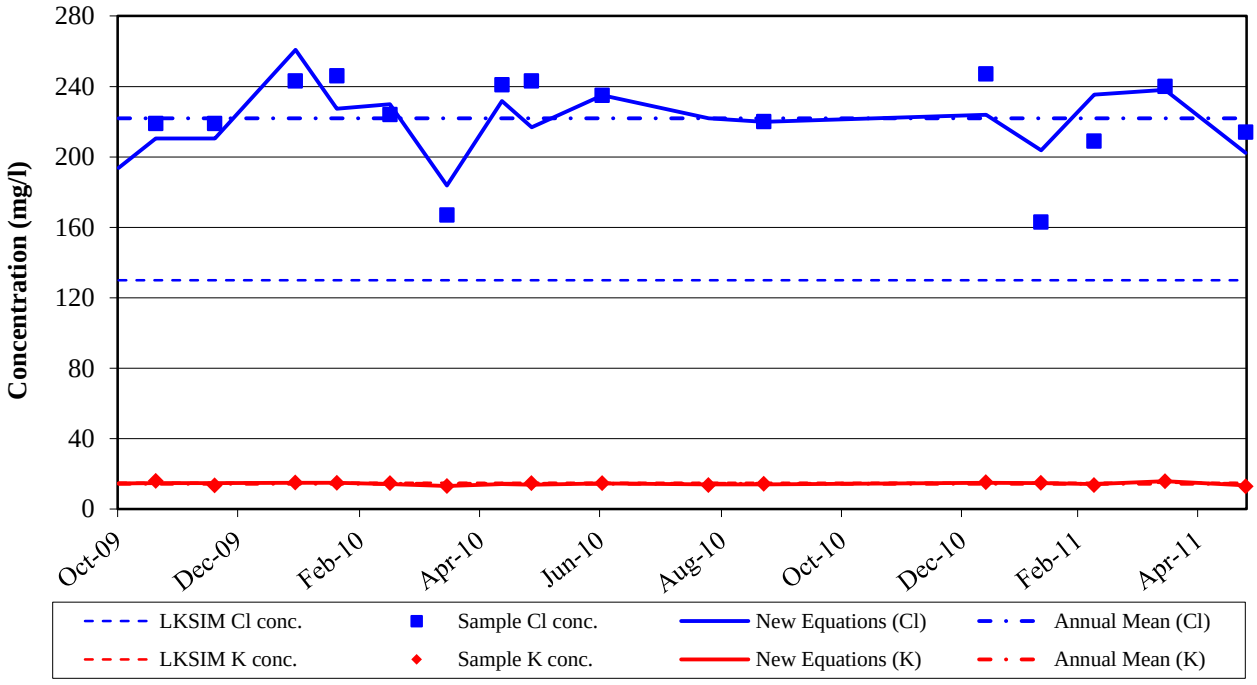

Figure 3-177: UT 51A Measured and Predicted Concentrations for Cl and K

Table 3-19: UT 51A Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	902	650	829	854	845	800	70.1	-
HCO_3	308	202	247	243	262	247	31.3	-
SO_4	77.7	53.9	64.8	65.9	67.0	63.2	6.82	-
Ca	87.8	72.4	78.0	76.9	77.6	79.3	4.19	0.54
Mg	33.4	25.9	28.8	28.3	29.3	29.0	1.99	0.50
Na	192	127	163	176	163	149	18.4	0.58
Cl	247	163	222	223	228	220	26.3	0.49
K	16.0	12.9	14.4	14.9	14.2	14.1	0.931	0.57

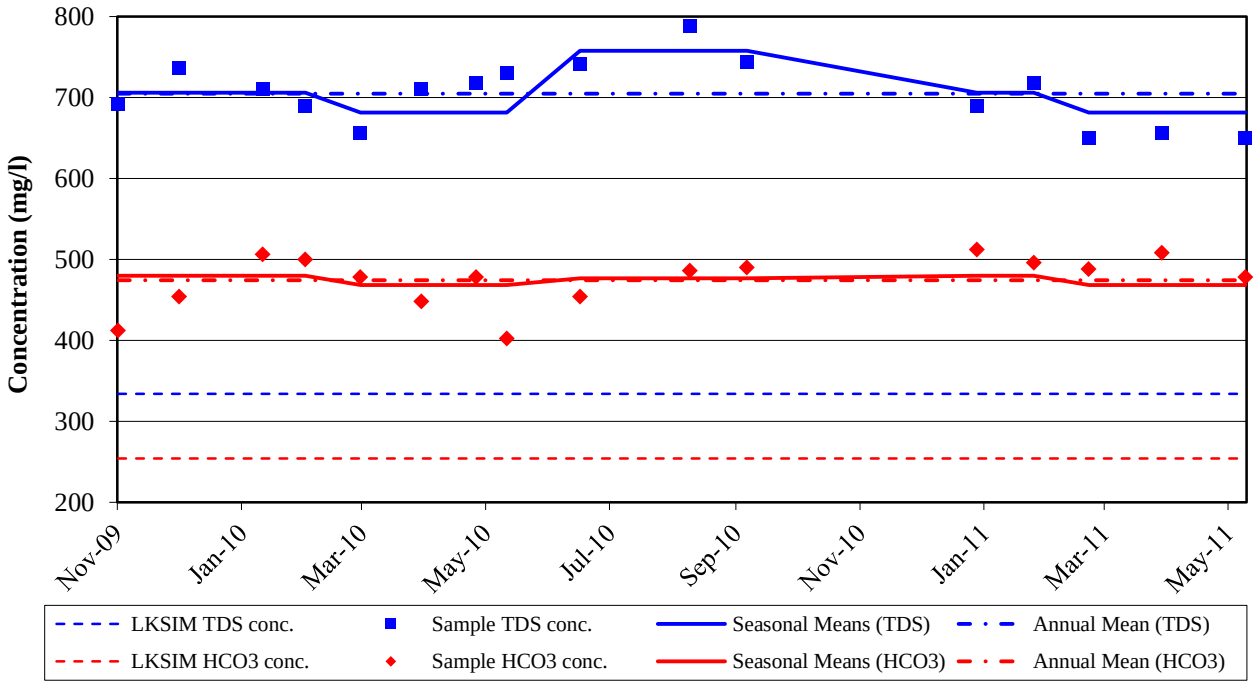

Figure 3-178: UT 51C Measured and Predicted Concentrations for TDS and HCO_3

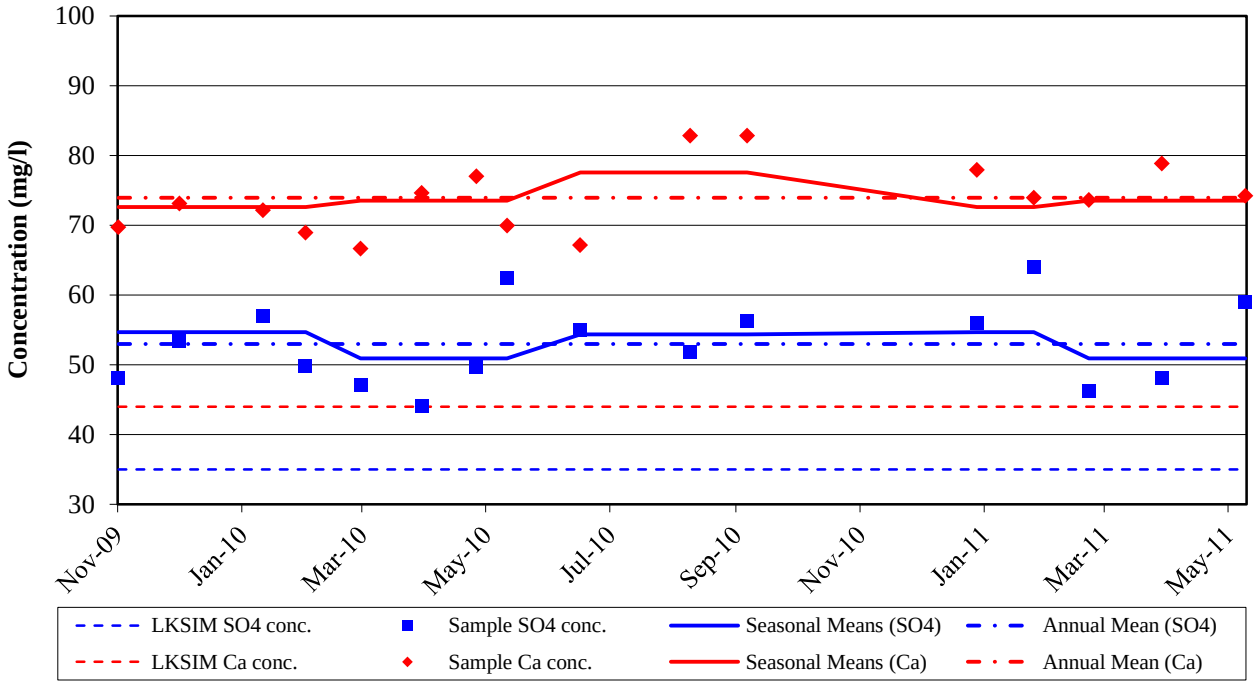

Figure 3-179: UT 51C Measured and Predicted Concentrations for SO_4 and Ca

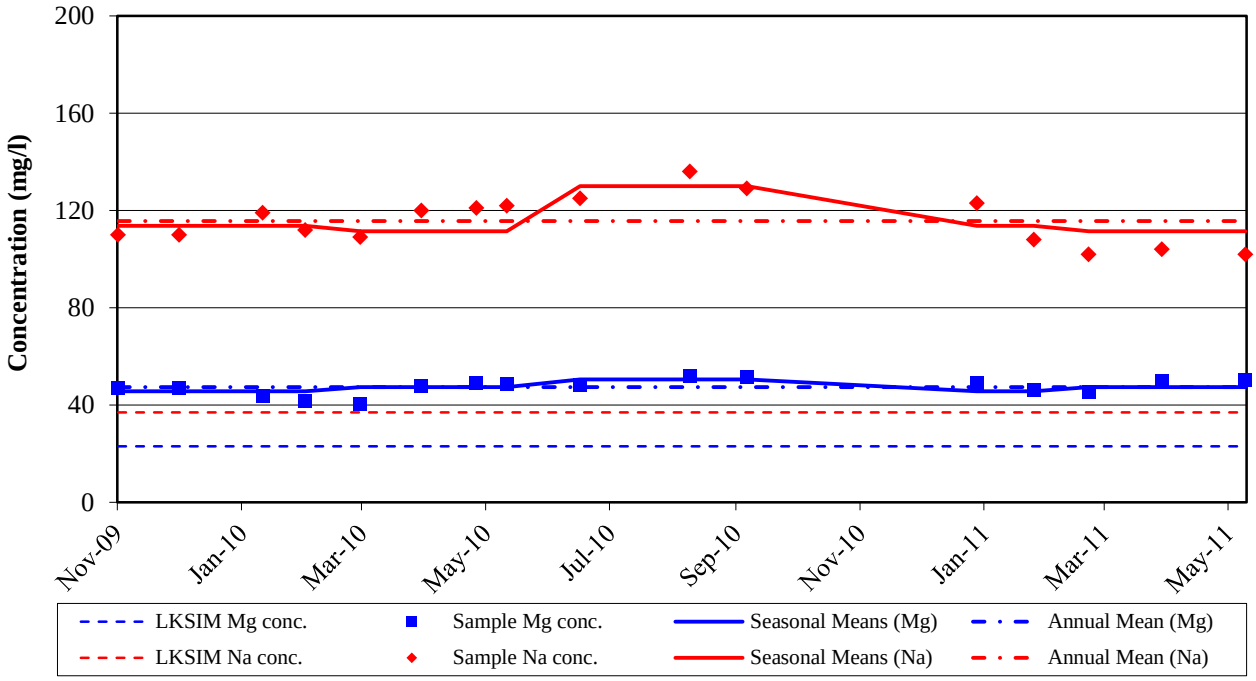

Figure 3-180: UT 51C Measured and Predicted Concentrations for Mg and Na

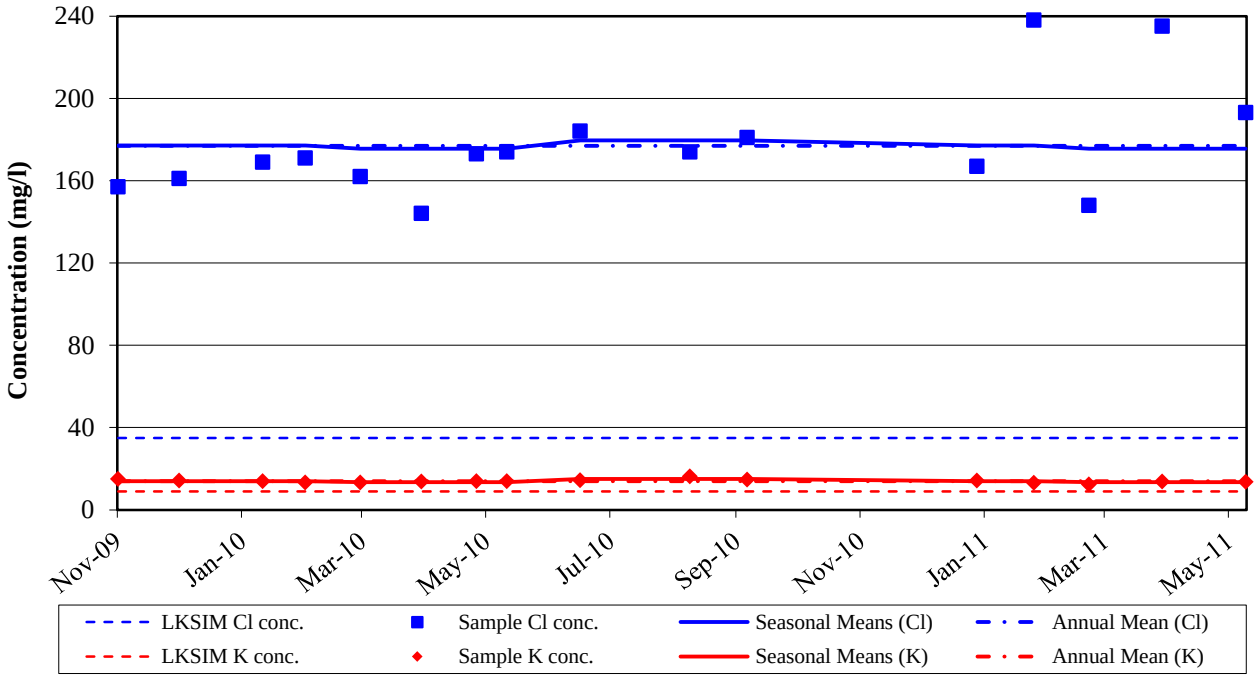

Figure 3-181: UT 51C Measured and Predicted Concentrations for Cl and K

Table 3-20: UT 51C Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	788	650	705	706	758	681	39.3	-
HCO_3	512	402	474	480	477	469	32.6	-
SO_4	63.9	44.0	53.0	54.7	54.4	50.9	5.86	-
Ca	82.8	66.6	73.9	72.6	77.6	73.5	4.97	-
Mg	52.0	40.3	47.3	45.7	50.5	47.4	3.32	-
Na	136	102	116	114	130	111	10.1	-
Cl	238	144	177	177	180	176	26.4	-
K	16.2	12.3	13.9	13.9	15.1	13.5	0.871	-

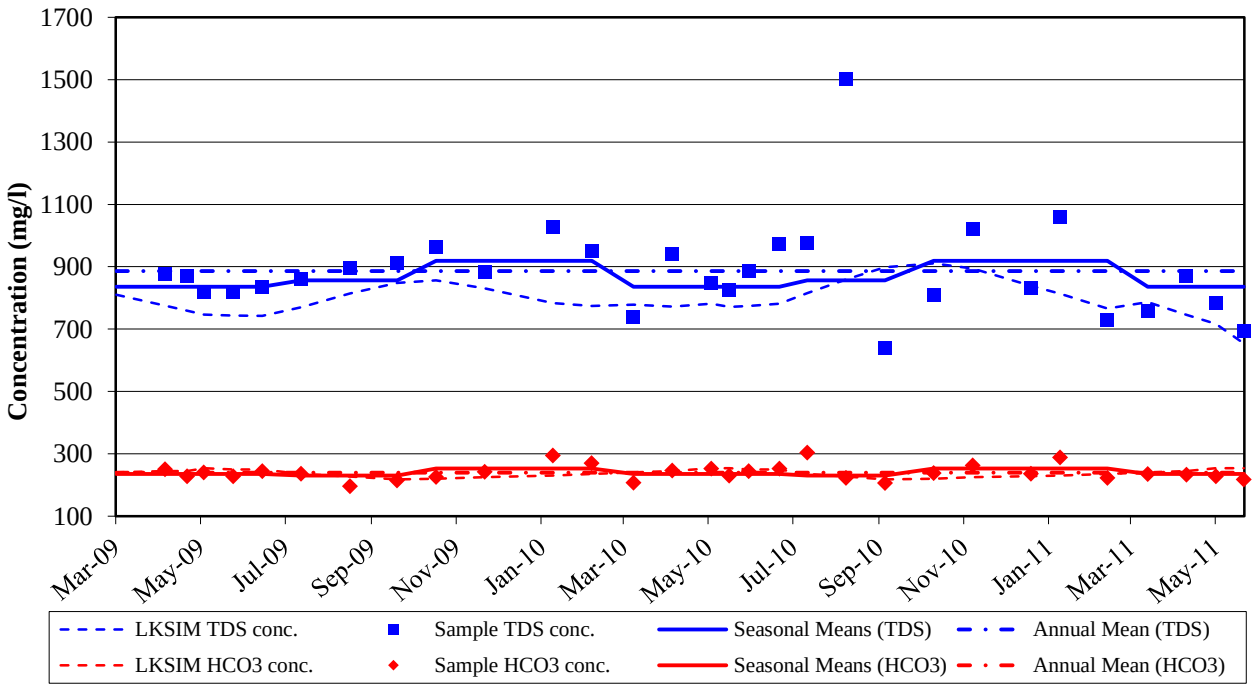

Figure 3-182: UT 53 Measured and Predicted Concentrations for TDS and HCO_3

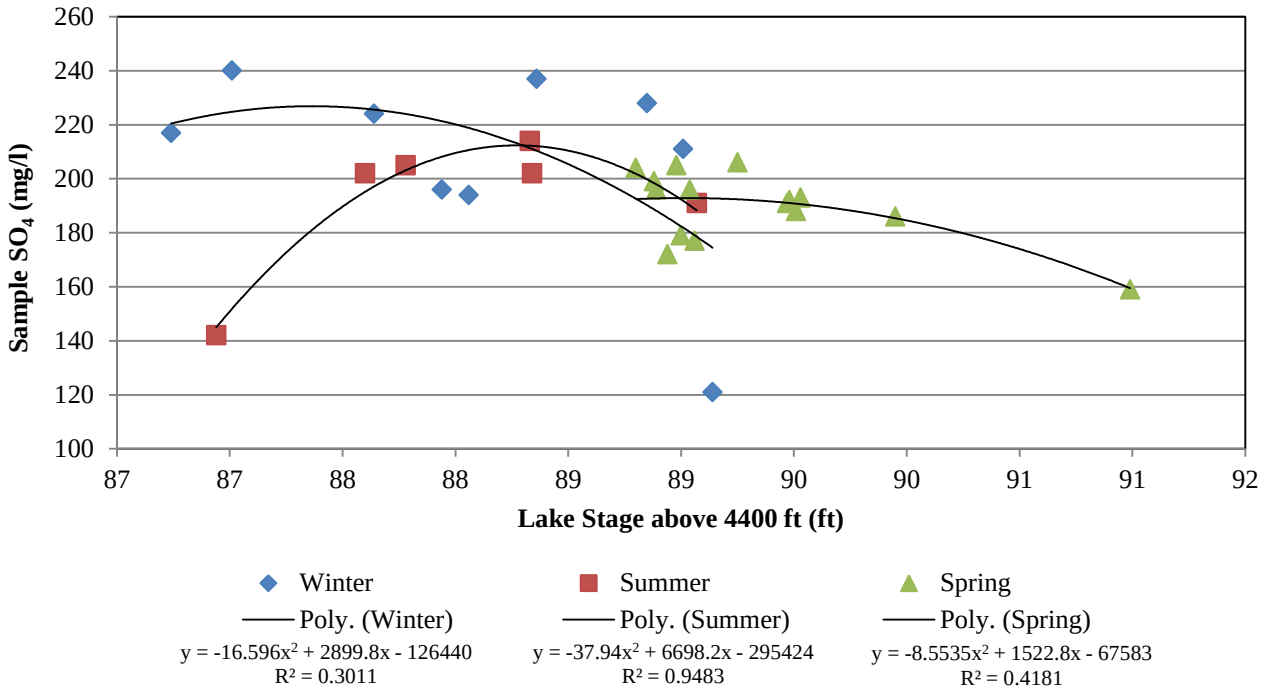

Figure 3-183: UT 53 Trendlines and Equations for SO_4

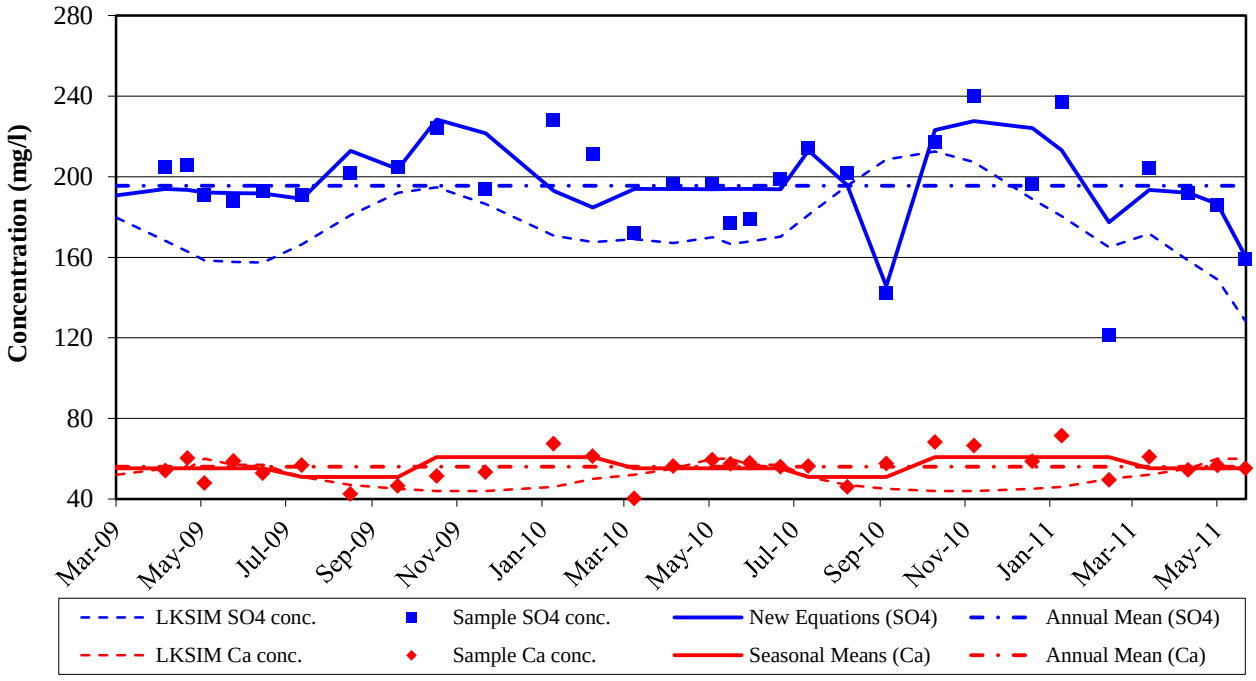

Figure 3-184: UT 53 Measured and Predicted Concentrations for SO_4 and Ca

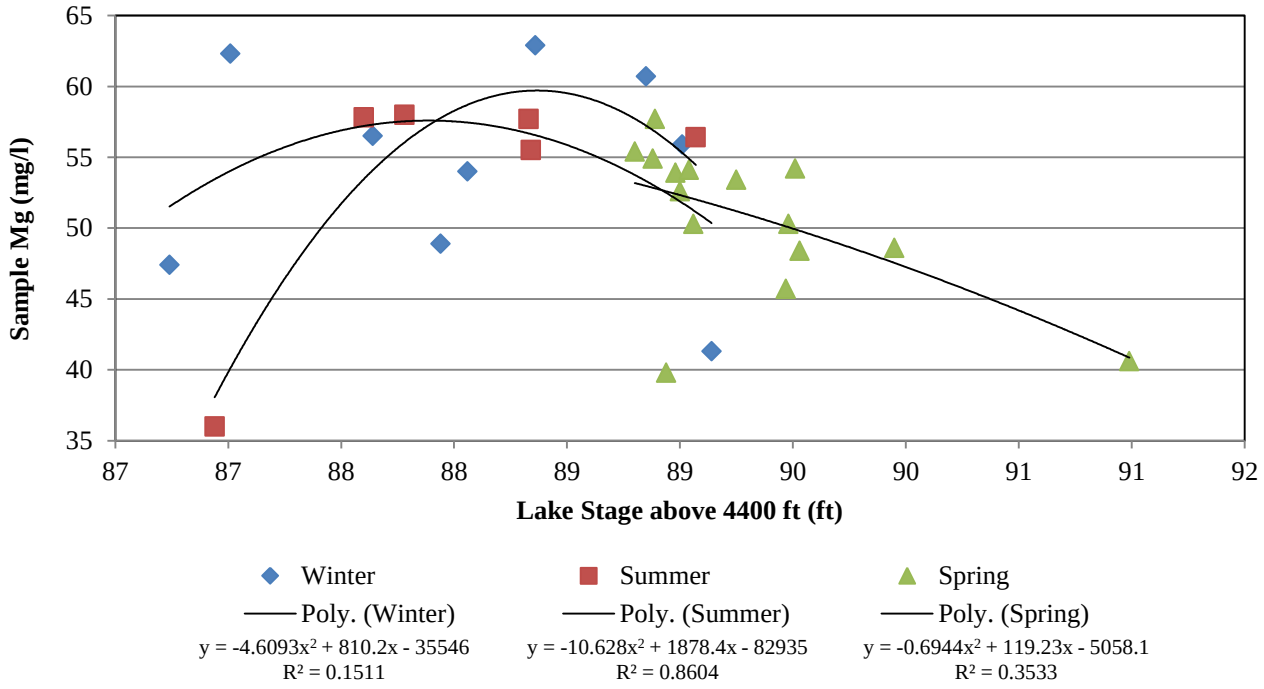

Figure 3-185: UT 53 Trendlines and Equations for Mg

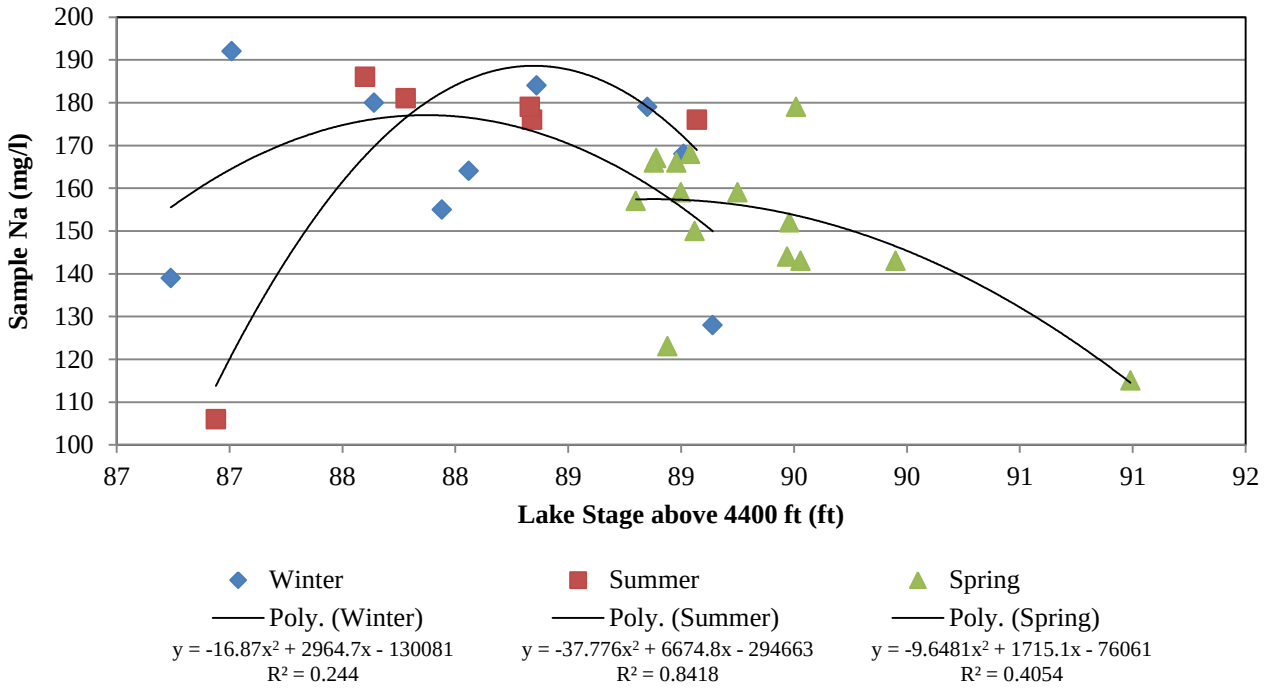

Figure 3-186: UT 53 Trendlines and Equations for Na

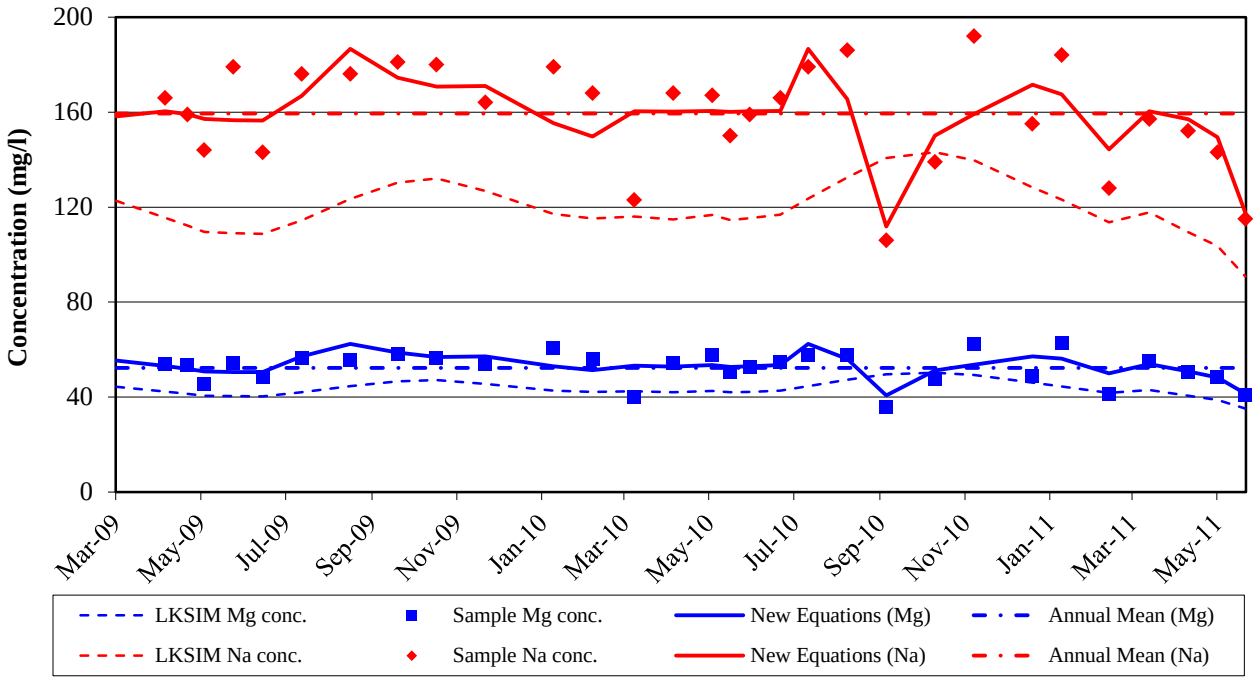

Figure 3-187: UT 53 Measured and Predicted Concentrations for Mg and Na

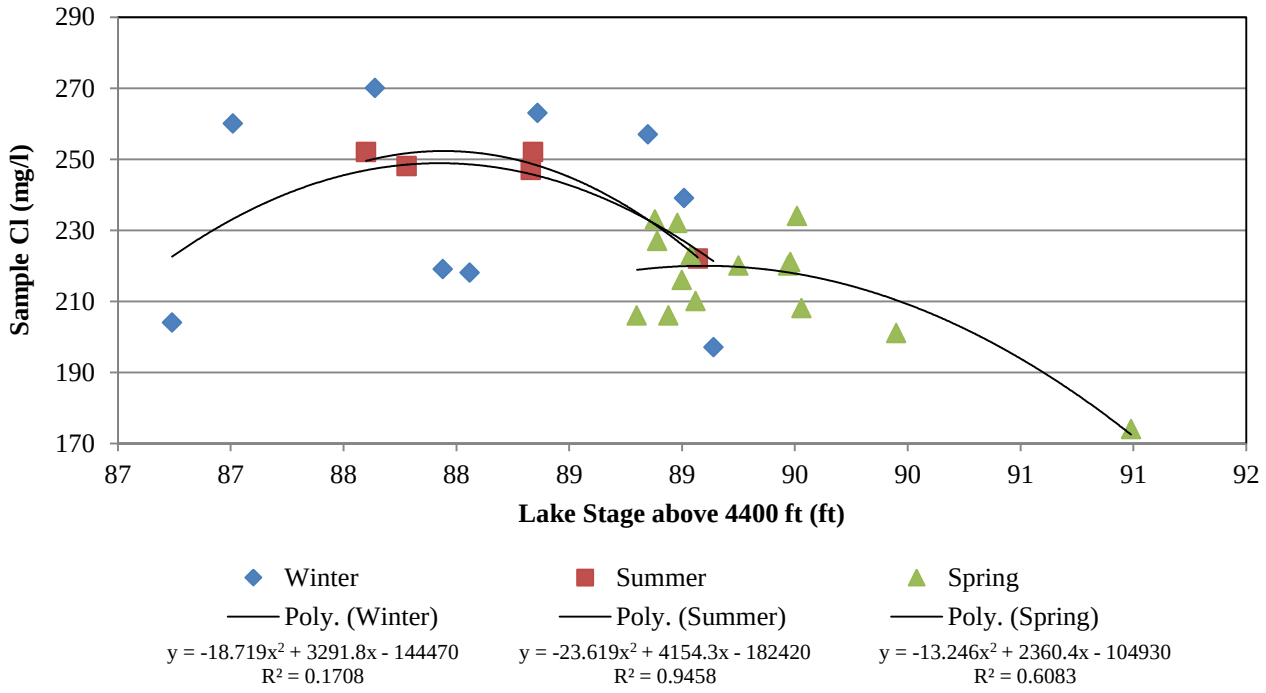

Figure 3-188: UT 53 Trendlines and Equations for Cl

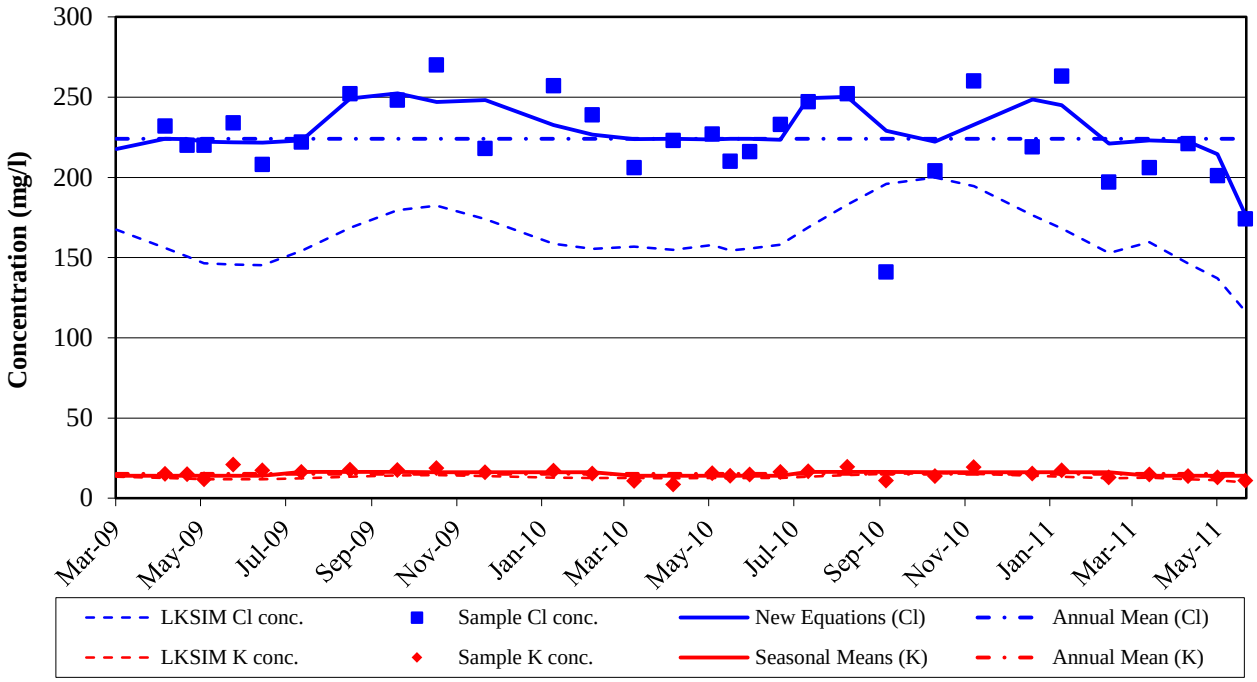

Figure 3-189: UT 53 Measured and Predicted Concentrations for Cl and K

Table 3-21: UT 53 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	1502	638	886	919	856	836	153	-
HCO_3	304	196	240	253	230	236	24.9	-
SO_4	240	121	196	208	193	190	25.0	0.51
Ca	71.4	40.2	56.0	60.8	50.9	55.2	7.21	-
Mg	62.9	36.0	52.4	54.4	53.6	50.7	6.66	0.45
Na	192	106	159	165	167	153	21.8	0.54
Cl	270	141	224	236	244	215	27.2	0.55
K	20.8	8.59	15.2	16.2	16.4	14.1	2.84	-

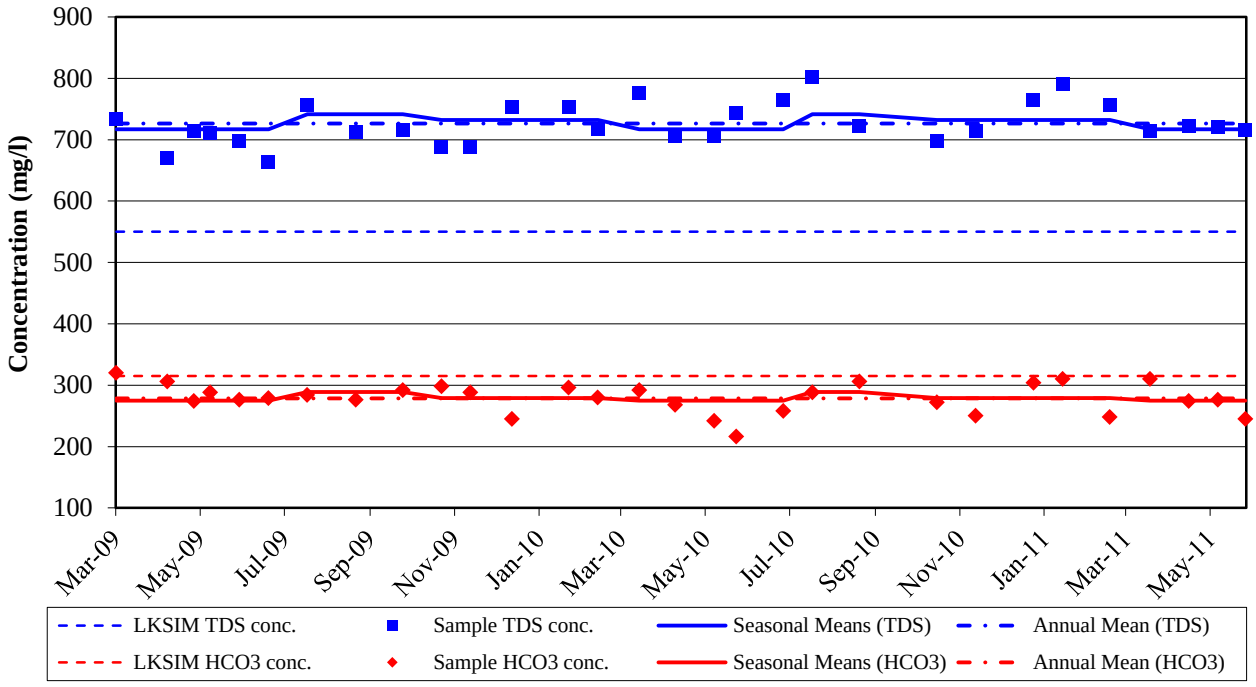

Figure 3-190: UT 71 Measured and Predicted Concentrations for TDS and HCO_3

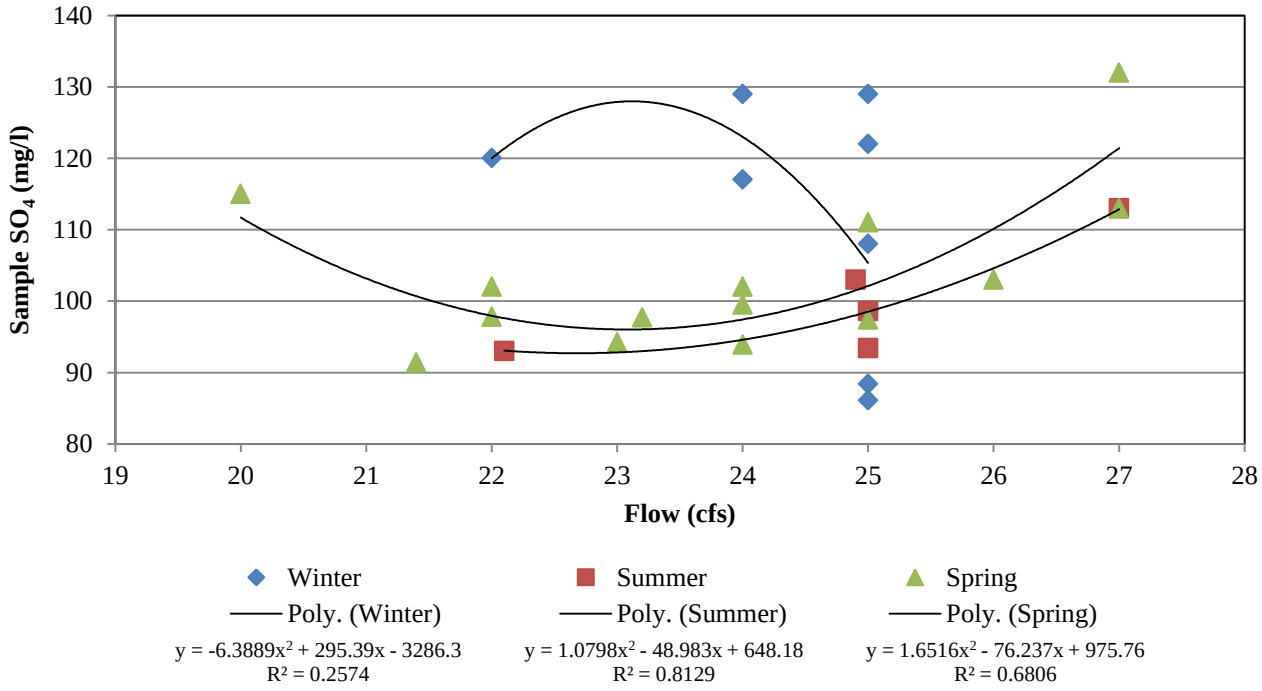

Figure 3-191: UT 71 Trendlines and Equations for SO_4

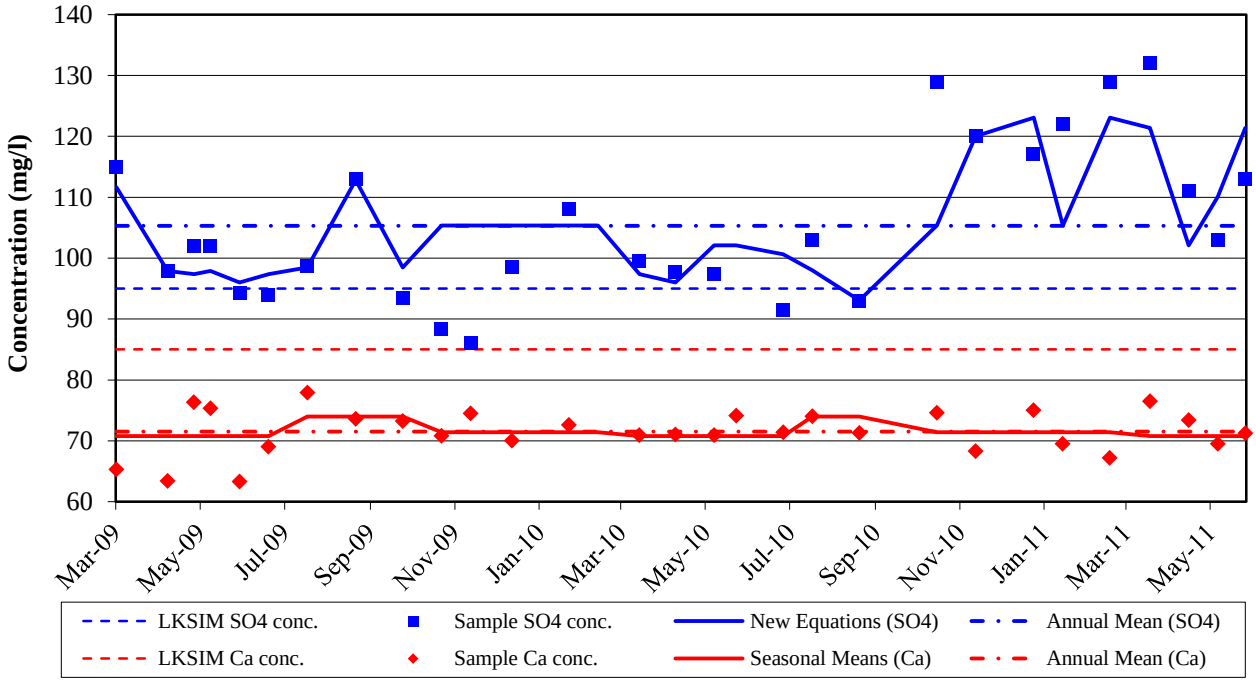

Figure 3-192: UT 71 Measured and Predicted Concentrations for SO_4 and Ca

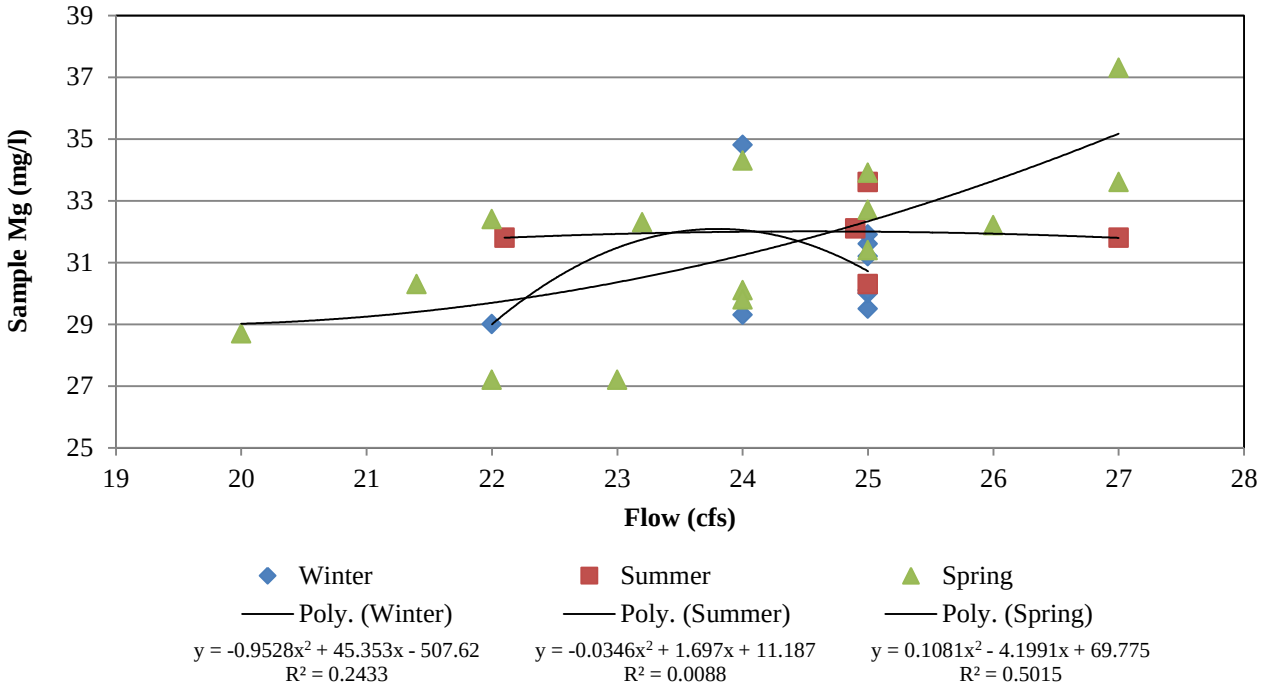

Figure 3-193: UT 71 Trendlines and Equations for Mg

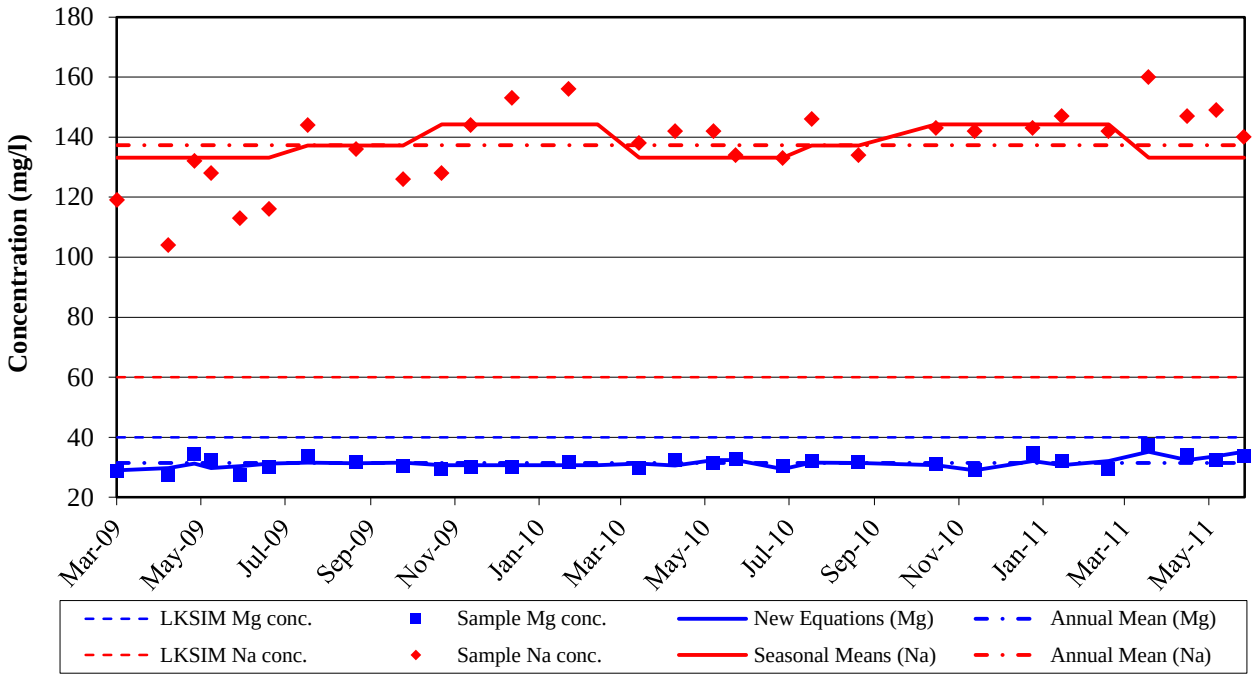

Figure 3-194: UT 71 Measured and Predicted Concentrations for Mg and Na

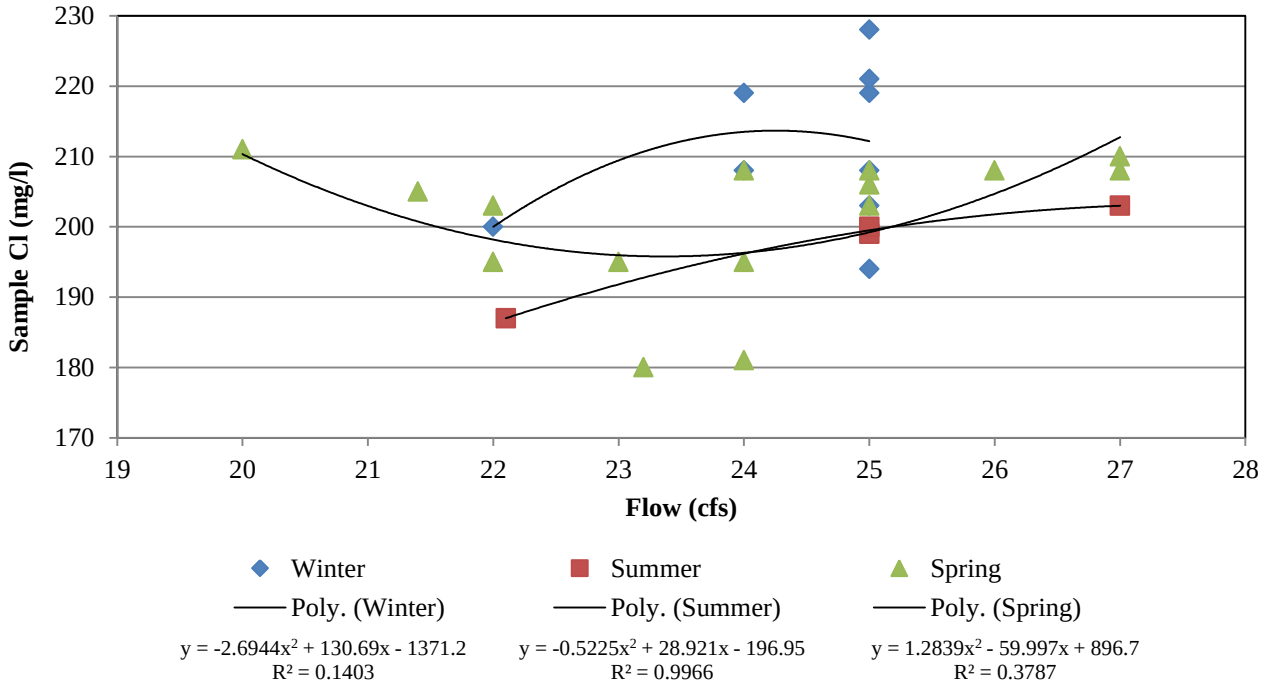

Figure 3-195: UT 71 Trendlines and Equations for Cl

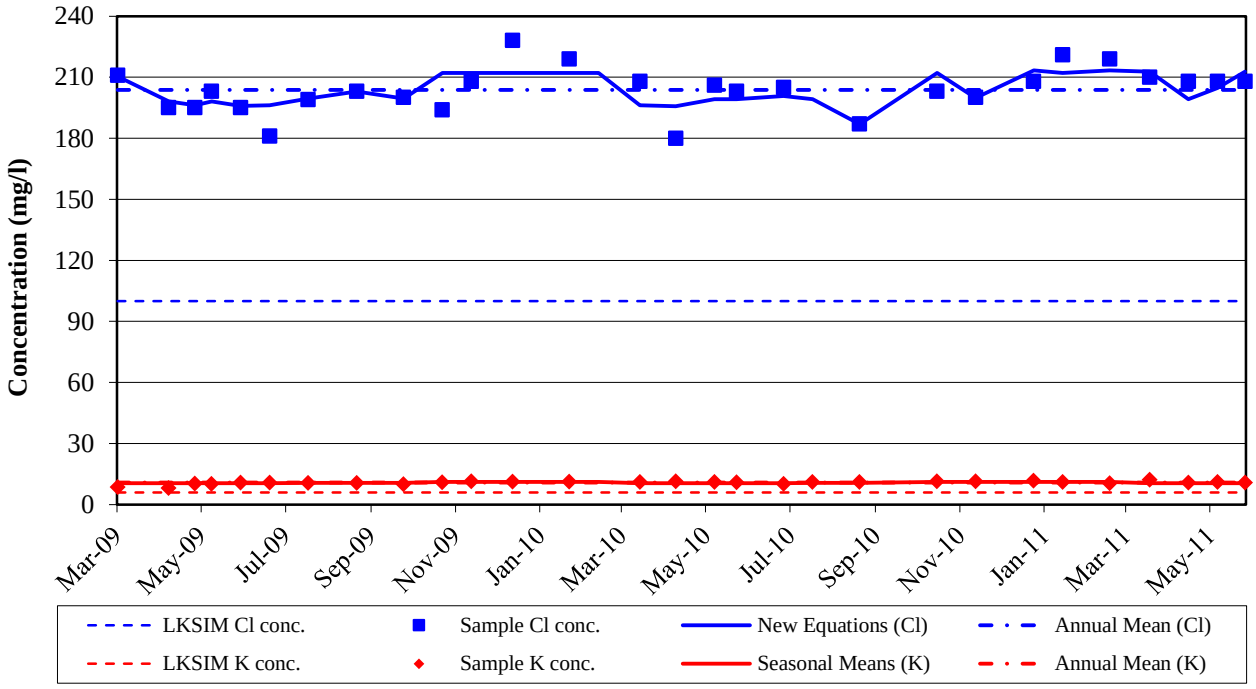

Figure 3-196: UT 71 Measured and Predicted Concentrations for Cl and K

Table 3-22: UT 71 Statistical Values for the Parameters of Interest

	Maximum (mg/l)	Minimum (mg/l)	Overall Mean (mg/l)	Winter Mean (mg/l)	Summer Mean (mg/l)	Spring Mean (mg/l)	Std. Deviation (mg/l)	Correlation, r^2
TDS	802	664	726	732	742	717	33.5	-
HCO_3	320	216	279	279	289	275	24.3	-
SO_4	132	86.1	105	111	100	104	12.8	0.51
Ca	77.9	63.3	71.5	71.4	74.0	70.8	3.67	-
Mg	37.3	27.2	31.4	30.8	31.9	31.6	2.26	0.44
Na	160	104	137	144	137	133	12.8	-
Cl	228	180	204	211	197	201	11.1	0.48
K	12.2	8.09	10.7	11.2	10.6	10.5	0.829	-

3.3 Discussion of Results

Table 3.3-1 displays the r^2 values and averages for each site along with the maximum, minimum, and average values for each concentration. For every station, the new data proved its value to the LKSIM program. Great improvements have been made with this data by either generating better trendline equations or by providing more accurate mean values. Among the equations that were generated, the site with the best r^2 values, with an average of 0.80, was Hobble Creek (UT 44). This is a comparatively high correlation, and these mathematical equations should be post audited in the future to verify their accuracy.

Among the 21 sites that were analyzed in this study, new equations were found for approximately 67 percent of the TDS and ion concentrations on the whole. However, the data from the seven WWTPs generated fewer equations, overall, than the 13 Utah Lake tributaries and the Jordan River. Only 55 percent of the TDS and ion concentration values for the WWTPs could be simulated with an acceptable equation. Conversely, 75 percent of the TDS and ion concentrations for the Utah Lake tributaries and the Jordan River could be simulated with an acceptable equation.

Table 3-23: Coefficients of Determination among the Various Sites

Site Code	TDS	HCO_3	Ca	Cl	Mg	K	Na	SO_4	Average r^2 Values
UT 9	0.44	0.73	0.55	0.42	-	0.46	-	-	0.52
UT 13	0.79	0.68	0.72	0.76	0.85	0.66	0.77	0.60	0.73
UT 18	0.68	0.84	0.79	0.65	0.79	0.63	0.55	0.62	0.69
UT 20	0.85	0.67	0.65	0.71	0.74	0.74	0.83	0.77	0.74
UT 27	0.41	0.59	-	-	-	-	-	-	0.50
UT 29	0.58	0.72	0.54	-	0.64	-	0.40	-	0.58

Table 3-23: Continued

UT 38	0.58	0.56	0.61	0.47	0.48	0.59	0.58	0.49	0.54
UT 42	-	0.47	-	0.47	0.40	0.47	0.51	-	0.46
UT 43	0.46	0.41	-	-	-	0.61	-	0.56	0.51
UT 44	0.84	0.83	0.85	0.58	0.88	0.76	0.88	0.76	0.80
UT 47	-	0.44	0.77	-	0.43	0.46	0.43	0.50	0.50
UT 48	0.52	0.42	-	-	-	-	0.57	0.61	0.53
UT 51	0.48	0.62	0.60	0.41	0.55	-	0.46	0.47	0.51
UT 53	-	-	-	0.55	0.45	-	0.54	0.51	0.51
UT 71	-	-	-	0.48	0.44	-	-	0.51	0.48
UT 27A	-	0.58	0.65	-	0.53	0.46	-	-	0.55
UT 38A	0.54	0.49	0.78	-	0.75	0.46	0.62	0.43	0.58
UT 43A	-	0.45	0.43	0.82	0.54	0.43	0.58	0.64	0.55
UT 47A	-	-	0.57	0.51	0.45	-	-	0.55	0.52
UT 51A	-	-	0.54	0.49	0.50	0.57	0.58	-	0.54
UT 51C	-	-	-	-	-	-	-	-	-
Average	0.60	0.59	0.65	0.56	0.59	0.56	0.59	0.57	0.59
Maximum	0.85	0.84	0.85	0.82	0.88	0.76	0.88	0.77	0.80
Minimum	0.41	0.41	0.43	0.41	0.40	0.43	0.40	0.43	0.46

The poor percentage of acceptable equations for the various WWTPs may have occurred because there was a comparatively low variation among the flow rates. For example, the Salem WWTP (UT 51C) had a relatively constant flow of 0.8 cfs. Thus, no acceptable, trendline equations were produced in correlating the flow with the TDS and ion concentrations. Nevertheless, in this case, the seasonal mean values that were used instead seem to be sufficient in predicting TDS and ion concentrations.

Of the various trendline equations that were used to describe the correlation of TDS and ion concentrations with flow rates, about 64 percent were polynomial equations. Although the data points that had polynomial trends were best described by this type of equation, flow rates beyond the limits of these sampled data sets may show the behavior of the concentrations to be of a different trend.

As mentioned earlier, this study focused on 13 of the main tributaries of Utah Lake, seven WWTPs, and the Jordan River Outlet. Although great improvements have been made with the data that was collected, it would be beneficial to this study if additional water quality samples were collected from the sites of this study in the future in order to gauge the accuracy of the trendline equations that were generated. Further, it may be beneficial to collect samples from the other tributaries to find their effect on the water quality of the lake. Also, if a greater amount of sample points were created, more reliable trendlines could be produced.

4 CONCLUSION

The water quality of Utah Lake is of great importance to agriculture, recreation, and wildlife. The purpose of LKSIM is to accurately simulate the changes in water quality of Utah Lake. After comparing the predicted values of LKSIM with the recently collected data over a 26 month period, it has been established that an update of LKSIM is necessary. With the new equations and mean values that were presented in this study, LKSIM should be able to more accurately simulate the water quality of Utah Lake according to the flow rates of the tributaries and the time of the year. Additionally, future water samples from the sites of this study can gauge the accuracy of the equations and mean values found in this report.

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