Analysis of Water Quality Trends at Barton Springs and surrounding springs in Austin, TX (1995-2015) and an Alternative Framework for Future Analysis

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Abstract

Barton Springs is one of the most valuable and unique resources in Austin, Texas. For this reason, close monitoring of conditions at Barton Springs and at surrounding springs, and attention to changing water quality is an essential function of the Watershed Protection Department. Periodically, the available water quality record is re-examined for parameters of interest. In this latest update, trends in water quality were computed by using a two stage regression to account for flow in time. The results from this regression identified calcium, chloride, specific conductivity, sodium, and sulfate as increasing trends under recharge conditions for at least 4 or 5 of the sites analyzed. An alternative approach was also proposed to allow for more frequent analysis of trends using confidence intervals of the median curve relating the water quality parameter to flow. Future measurements consistently exceeding these intervals may alert policy makers to degrading water quality at Barton Springs earlier and allow a more timely response.

Introduction

The City of Austin (COA) regularly monitors water quality of karst springs in the Barton Creek watershed, which include Barton Springs, Eliza Springs, Old Mill Springs, Upper Barton Springs, Backdoor Springs, and Cold Springs. Past analyses (Turner 2000, Herrington et al, 2005, Herrington and Hiers, 2010) have pointed to a degradation of water quality over time. This affects not just COA natural resources, such as the endangered Barton Springs salamander (*Eurycea sosorum*) and the Austin Blind salamander (*Eurycea* *waterlooensis*), but also impacts a revenue source from annual visitors to Barton Springs Pool which have neared 800,000 visitations in recent years[1].

This report updates these analyses for data collected since the last report (Herrington and Hiers, 2010) and provides a straightforward framework for future analysis to be performed on a more frequent (i.e., annual) basis. This increased frequency can be used to inform City management of changing water quality conditions earlier while still using historical data as a solid frame of reference. Early warning based on quantitative data could make City responses more targeted and effective as well as supportable scientifically. The methods used in this report build upon those developed in the previous COA reports and unite them with some new concepts discussed herein.

Technical Background

The question of how to determine whether a temporal trend is present in water quality data is not a trivial one. This determination may consist of whether flow conditions have changed, to what extent, and whether there exists different flow regimes during the time period in question (Helsel and Hirsch, 2002). To address these questions, Turner (2000) first suggested partitioning the data into three flow regimes at Barton Springs. The first regime would consist of flow that was impacted by stormwater runoff conditions and was defined as occurring when fecal coliform bacteria count was greater than 100 colonies per 100 mL or when the total suspended solids concentration was greater than 10 mg/L. The second regime would consist of water quality data taken at Barton Springs during times with no recharge and excluding storm flow. No recharge conditions were defined to be when there was no flow at United States Geological Survey (USGS) gage 08155300 (Barton Creek at Loop 360). The third regime consisted of times of recharge events defined to be during times of positive flow at USGS gage 08155500 (Barton Springs at Austin) excluding storm flow conditions.

The Turner (2000) report is notable because, in addition to defining flow regimes at Barton Springs, it also utilized a two stage single linear regression technique for water quality data, rather than using a multiple linear regression in one stage. That is, it adjusts the analyte concentrations in a linear fashion based on its regression with flow. After normalizing the sample concentration for flow, a parametric linear regression model was used with time as the covariate to determine whether a temporal trend existed for 5 water quality parameters. This method is significant because it incorporated two separate regression analyses into one analysis. The first analysis regressed the water quality concentrations to flow and denoted this as a normalized concentration. Then, this normalized concentration was then regressed to time. Furthermore, the first stage of the analysis (i.e. normalizing the flow) applied both parametric and non-parametric methods for completeness. Of particular importance for this report is that for non-parametric methods, Turner calculated medians for every 5-year period from 1975 to 1999.

This method was continued in the update by Herrington et al. (2005) and Herrington and Hiers (2010), but expanded to include Upper Barton Springs, Old Mill Springs, Eliza Springs, Cold Springs, and Backdoor Springs, and about 20 water quality parameters. The 2010 report also excluded analyses of storm influenced samples keeping the remaining two data sets (recharge conditions and non-recharge conditions) for analysis.

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[1] Source: https://austintexas.gov/department/barton-springs-pool

In Porras (2014), we implemented this method with updated dissolved oxygen concentrations at Barton Springs, Eliza Springs, and Old Mill Springs. However, recognizing that the relationship between flow and dissolved oxygen was non-linear, we did not normalize dissolved oxygen for flow, and instead utilized a non-parametric linear regression of the dissolved oxygen in time. Following on the work of Turner (2007), we proceeded to show the non-linearity of the flow-dissolved oxygen relationship by fitting a family of non-linear equations regressing dissolved oxygen to spring discharge flow rates at USGS gage 08155500 (Barton Springs at Austin). Nevertheless, this approach suffered from essentially discarding information by using non-parametric models of dissolved oxygen versus time.

Methods

For this report, we utilize the same partitioning of the data into three categories: storm flow, non-recharge conditions, and recharge conditions. And, like the Herrington and Hiers (2010) report, we exclude data categorized as storm flow from the analysis. However, for this analysis, we limit the number of analyses to five springs (Barton Springs, Old Mill Springs, Eliza Springs, Upper Barton Springs, and Cold Springs) and fifteen water quality parameters. This provides a representative sample of the six springs initially sampled by Herrington and Hiers (2010) to test an alternative framework and at the same time limits the number of comparisons to 150 (5 springs x 15 water quality parameters x 2 flow regimes) rather than 240 (6 springs X 20 water quality parameters x 2 flow regimes). This effectively limits the number of false positives in the analysis. The current analysis excluded E. coli data from the analysis (as this parameter was utilized to screen data for stormwater runoff influence) as well as hardness, non-carbonate hardness, barium, and potassium (due to the limited number of samples available after 2010), leaving fifteen water quality parameters.

In all of the statistical methods utilized in examining water quality trends at Barton Springs thus far, there has been recognition that flow is an important covariate in explaining water quality. However, there exists different methods to account for the variability in water quality that arises from the variability in flow. Previous COA reports transform water quality to a normalized water quality value, and then, regress this normalized water quality value against time. For this update of water quality trends at the five springs analyzed, we follow the two stage regression method discussed above, but use residuals[2] instead of a normalized water quality value. We then incorporate these residuals into in a linear model of water quality versus time. This framework is a small deviation from the above method and is consistent with Helsel and Hirsch (2002). From this analysis, current and future analyses can be developed.

Helsel and Hirsch (2002) proposed the following two stage method to determine temporal trends in water quality. First, a regression model is constructed for water quality and flow. From the residuals of this regression model, a second model is constructed fitting the residuals against time. This method is similar to the method developed by Turner (2000) with the exception being the use of residuals rather than normalized flow. The advantage of residuals are that residuals are more likely to be normally distributed given an appropriate regression model for water quality and flow[3]. Thus, the key is to choose an appropriate regression to model water quality over flow.

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[2] Residuals are merely the difference between the model estimate and the data.

[3] An appropriate model is one that accurately, but not necessarily precisely, estimates the mean water quality concentration for each value of flow.

Two general options are available for choosing an appropriate model. First, one could continue using parametric techniques, which includes formulating either a linear parametric relationship (as in the 2000, 2005 and 2010 reports) or a non-linear parametric relationship. However, utilizing a linear function endangers oversimplifying the relation between the two variables and risks either underestimating or overestimating the magnitude of the residuals locally[4]. On the other hand, with a non-linear parametric relationship there exists the possibility of choosing from a number of curve families, each equally valid, and each requiring potentially cumbersome analytic techniques. The second option, which we use here, is a *non-parametric* relation between water quality and flow. From this option, Helsel and Hirsch (2002) recommend using a LOESS curve.

LOESS (or sometimes LOWESS, for Locally Weighted Scatterplot Smoothing) is a non-parametric technique that fits an estimate of the median value at each regressed value using data from local or the nearest neighboring data (Helsel and Hirsch, 2002). This results in a curve that does not require parameters for a global function (either a linear or non-linear function), but fits segments of the data in a continuous manner. Note that this is similar to the approach taken by Turner (2000) in finding the median in 5 year periods, however, LOESS uses smaller time periods and weights nearest neighbors more effectively. Furthermore, a LOESS approximation can effectively characterize both linear and non-linear relations.

In general, given these two stages, each with the choice of two regression models (parametric and non-parametric models) to fit, one can see the possibility of four choices in determining whether a temporal trend exists accounting for flow (Figure 1). One can regress the water quality parameters for flow using either parametric or non-parametric (LOESS) methods, and from this, determine the residuals. The difference between the first stage and the second stage is that at the second stage, the regression model, either a parametric or non-parametric (Mann Kendall), uses the residuals from the first stage versus time.

The structure of the data collected and the assumptions (or lack of assumptions) being made inform the selection of these choices. If the assumptions of normality fit the data, then a parametric model can be implemented for that data. Otherwise, a non-parametric method may be required.

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[4] This can be seen by looking ahead at Figure 3

	Non-parametric Method for Trend	Parametric Method for Trend
Parametric Method on flow	Mann-Kendall trend test on residuals from parametric regression of flow	Parametric trend test on residuals from parametric regression of flow
Non-Parametric Method on flow	Mann-Kendall trend test on residuals from LOESS regression of flow	Parametric trend test on residuals from LOESS regression of flow

Figure 1: A Graphical Representation of Four Methods in Determining Temporal Trends in Water Quality. The method with typically the most statistical power applies to the top right corner, but requires the most rigid assumptions. The method with the least statistical power is the lower left corner. This report will use the method on the lower right, which would have intermediate statistical power. That is, there will be no assumptions in the regression of flow to water quality, but residuals from the regressed water quality/flow curve will be assumed to be normally distributed about the median.

Examples from the results

A visualization of the method is useful in understanding the analysis. First, recognize that data points falling below the water quality/flow curve are negative residuals and that points falling above the curve are positive residuals. If more of the negative residuals occurred early in the data set and more positive residuals occurred later in the data set that might indicate a trend. This can be seen with the following examples from the results.

A LOESS regression model was fit to the concentration of nitrate/nitrite at Barton Springs versus Barton Springs discharge (Figure 2) represented by the dark line. This curve was offset equally in both directions to quantify the extent of difference from the median. The data was partitioned into four categories of five year (non-overlapping) increments. Earlier data (1995 to 2000) is represented by the yellow circles and the later data (2010 to 2015) is represented by the blue diamonds. If there is a trend in the data, then most of the earlier data will fall below the nitrate/flow curve and most of the later data will fall above the nitrate/flow curve. Data in between these two categories would fall around the curve and in between the offset lines.

In the nitrate example, data that falls below the lower offset line comes from the earlier data, while all of the data that falls above the upper offset line is associated with the later data. Intuitively, this indicates an increasing trend in nitrate/nitrite over time.

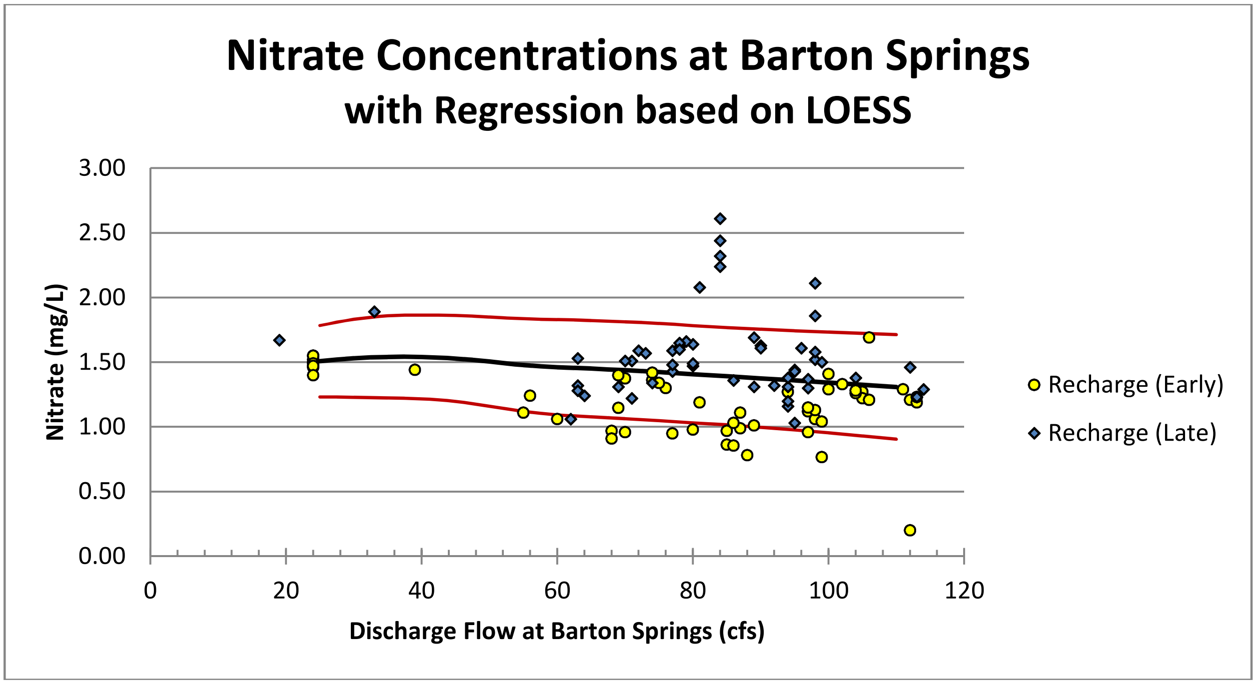

Figure 2: Nitrate Concentrations (mg/L) at Barton Springs under Recharge Conditions with LOESS regression (black line) and its offsets to quantify the extent of the difference from the median (red lines) based on LOESS. Early data are measurements from 1995 to 2000. Late data are measurements from 2010 to 2015.

A second example is provided in the regression of chloride at Barton Springs with Barton Springs discharge under recharge conditions (Figure 3). In this case, the regression curve is more non-linear than the nitrite/nitrate regression curve.

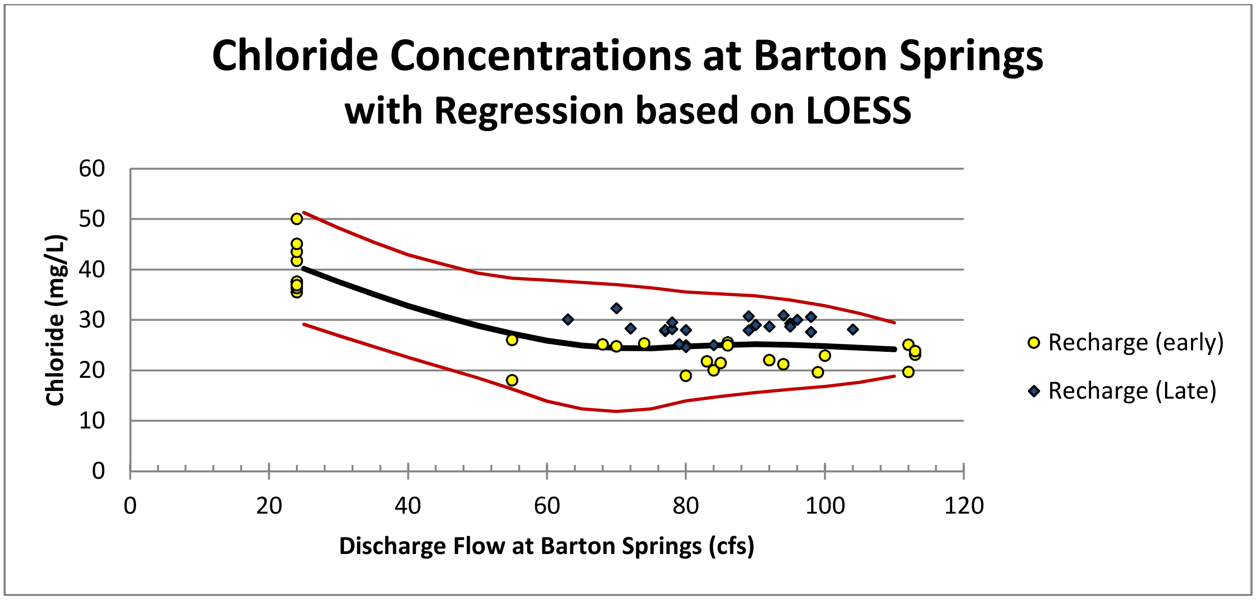

Figure 3: Chloride Concentrations (mg/L) at Barton Springs under Recharge Conditions with LOESS regression (black line) and its offsets (red lines) based on LOESS. Early data are measurements from 1995 to 2000. Late data are measurements from 2010 to 2015.

The difference between the nitrate/nitrite and chloride examples highlights the difference in the approaches taken in the earlier reports. The nitrite/nitrate regression can be easily approximated with a linear function while the chloride regression would not fit into a linear regression. Thus, each would require different analytic methods. LOESS provides a unifying method for regressing water quality with flow for any constituent.

Results

A LOESS regression curve was constructed for each of the fifteen water quality parameters collected at each of the five springs assessed in this report. Non-storm influenced data was partitioned into two sets, data collected during recharge events and data collected during non-recharge events, as defined by Herrington et al. (2005). From each of these 150 curves, residuals were calculated for each data point and a parametric linear regression model was fit to the residuals versus time to determine whether or not a temporal trend existed (Table 1). This determination was made by computing the 99% confidence intervals of the mean slope over time. If the 99% confidence intervals included zero, then it was inferred that there was no trend.

Table 1: Presence of Water Quality Temporal Trends at each of the five springs for fifteen water quality parameters. The "-" indicates that not enough data was collected to make an inference of trends. Light blue highlighting indicates parameters where four or more sites had an increasing trend. Light green highlighting refers to the remaining trending parameter/site pairs that are not correlated across four or more sites.

Water Quality Parameter	Flow Condition	Barton Springs	Cold Springs	Eliza Springs	Old Mill Springs	Upper Barton
DO	Recharge	No	No	No	No	No
	No Recharge	No	No	No	No	No
Alkalinity	Recharge	No	No	No	No	No
	No Recharge	No	No	No	No	No
Calcium	Recharge	Increase	Increase	Increase	Increase	Increase
	No Recharge	No	Increase	Increase	Increase	Increase
Chloride	Recharge	Increase	Increase	Increase	Increase	Increase
	No Recharge	No	Increase	No	No	No
Conductivity	Recharge	Increase	Increase	No	Increase	Increase
	No Recharge	Increase	Increase	No	No	No
Fluoride	Recharge	No	No	No	No	No
	No Recharge	Increase	No	No	No	No
Magnesium	Recharge	Increase	Increase	No	No	No
	No Recharge	No	No	Increase	No	Increase
Nitrate/nitrite	Recharge	Increase	No	Increase	Increase	No
	No Recharge	No	No	No	No	No
pH	Recharge	Decrease	No	No	No	No
	No Recharge	No	No	No	Increase	No
Silica	Recharge	No	-	No	No	-
	No Recharge	No	-	No	No	-

Table 1 (continued)

Water Quality Parameter	Flow Condition	Barton Springs	Cold Springs	Eliza Springs	Old Mill Springs	Upper Barton
Sodium	Recharge	Increase	Increase	No	Increase	Increase
	No Recharge	Decrease	Increase	No	No	Increase
Strontium	Recharge	No	-	No	No	No
	No Recharge	No	No	No	No	No
Sulfate	Recharge	Increase	Increase	Increase	Increase	No
	No Recharge	No	Increase	No	No	Increase
TKN	Recharge	No	No	No	No	No
	No Recharge	No	No	No	No	No
Temperature	Recharge	No	No	No	No	No
	No Recharge	No	No	No	No	No

During the period of assessment (1995-2015), chloride, conductivity, sodium, and sulfate had positive (increasing) temporal trends for at least four of the five sites under recharge conditions and calcium showed positive trends at four sites under both recharge and non-recharge conditions. These constituents are highlighted in the table in light blue. Other constituents with increasing trends at less than four sites are highlighted in light green. Nitrate/nitrite had increasing trends for three of the five sites under recharge conditions, and magnesium and conductivity were increasing at two sites each under recharge and non-recharge conditions, respectively.

To see the extent of the inferred increase, the constituents that showed positive trends under recharge conditions across more than two sites are annotated into the table below and are expressed in terms of mg/L increase per year (Table 2). Thus, for example, given that this trend continues past 2015, one would expect calcium at Barton Springs to increase at a rate between 0.30 mg/L and 0.92 mg/L every year.

Table 2: Confidence Intervals of the Mean Trends in Water Quality (mg/L per year) under Recharge Conditions. Increasing trends displayed as 99% confidence intervals of the yearly mean increase. The lower confidence interval and the upper confidence interval are marked as LCI and UCI.

Water Quality Parameter	Barton Springs		Cold Springs		Eliza Springs		Old Mill Springs	
	LCI	UCI	LCI	UCI	LCI	UCI	LCI	UCI
Calcium	0.30	0.92	0.40	1.50	0.20	0.88	0.27	0.84
Chloride	0.15	0.52	0.28	0.83	0.15	0.58	0.43	0.84
Conductivity	2.07	4.34	1.94	7.74	-	-	1.18	5.70
Nitrate	0.012	0.028	-	-	0.001	0.02	0.008	0.04
Sodium	0.03	0.31	0.18	0.47	-	-	0.001	0.37
Sulfate	0.28	1.03	0.29	1.31	0.36	1.13	0.66	1.17

Discussion

Calcium, chloride, and sulfate all share positive temporal trends in four sites under recharge conditions. This may indicate a dependence or correlation between the sites during recharge. An analysis of the correlation coefficients between Barton Springs and the other sites assessed in this report reveals this link (Table 3).

Table 3: Pairwise correlations between water quality at Barton Springs and three of the springs assessed in this report.

Water Quality Parameter	Cold Springs	Eliza Springs	Old Mill Springs
Calcium	0.77	0.84	0.74
Chloride	0.47	0.44	0.39
Sulfate	0.77	0.77	0.74

Correlation coefficients range from -1 to 1, where a -1 indicates perfect negative correlation, 0 indicates no correlation and 1 indicates perfect positive correlation. Thus, for example, the correlation coefficient for calcium between Barton Springs and Cold Springs is 0.77. This indicates that if calcium is high at Barton Springs, then it will likely be high at Cold Springs. Note that these correlations are pairwise between Barton Springs and one of the other three springs. A more accurate representation of the correlation occurring would include three-way and four-way correlations between the sites as well as even higher dimensional correlations between the constituents. This higher dimensional matrix would be difficult to graph or place in a table. Nevertheless, this higher dimensional correlation may point to the need for and inform future deterministic modeling of the aquifer and surface water interaction.

The methods and the results presented provided a synthesis uniting the contribution of flow to temporal trends in environmental data. A key component of this analysis required assumptions regarding the structure of the residuals against time (the 2nd stage). Figure 4 below shows this graph for calcium at Barton Springs. Assuming for the moment that normality and homoscedacity are present among the residuals, one may ask whether this linear parametric model is a good fit.

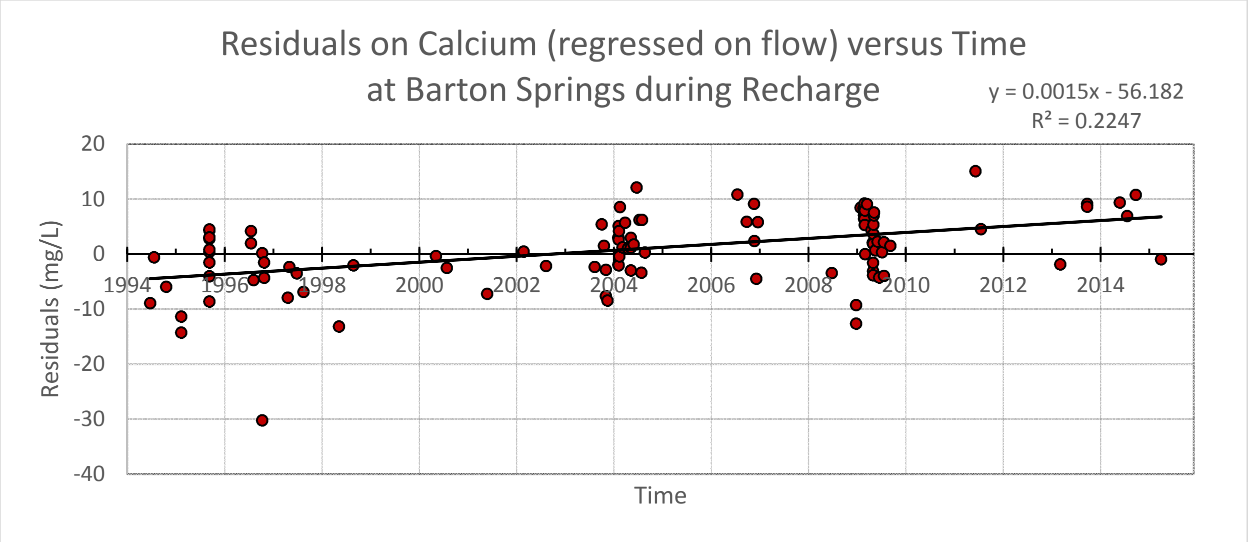

Figure 4: Plot of the residuals versus time for Calcium at Barton Springs during Recharge Conditions

The regression of calcium over time at Barton Springs has an R^2 value, a measure of the amount of variability explained by the regression with time, of 22%. This value typically indicates poor to fair fit to time and presumes an additional source of the remaining 78% of variability. This R^2 value is not uncommon among the regression models of time assessed in this report. Potential sources of variability in the data can be explained by measurement error or other temporally changing environmental factors, such as climatic conditions and land use.

Some of this variability can be mitigated with continued water quality sampling of the springs. As sampling continues, it becomes easier to distinguish which signals in the data are false and those that are not false. An alternative analytic framework is presented to make decisions on whether a temporal trend is present using contemporaneous data at each spring without relying on the linear parametric model above.

An Alternative Approach

As discussed in the Introduction of this paper, reports are regularly written updating the status of water quality trends at Barton Springs. However, the frequency of these updates ranges from 5 to 7 years. Furthermore, the methods used to analyze the data differ from report to report. Thus, a consistent course of exploring and analyzing the data on a yearly (or more frequent) basis can provide meaning on a regular basis to the standard sampling of the springs and reliability to the decisions being made. The course described in this section builds on the analysis of this report and outlines a plan using this analysis to implement a more consistent future analysis of temporal trends in water quality.

The approach presented herein is based on 99% confidence intervals of the LOESS curves for each water quality parameter at each site under recharge and non-recharge conditions. The second stage of the regression (residuals vs. time) is excluded from this approach because of the high variability mentioned in the previous section. The LOESS curves along with their confidence intervals can be seen in tabular form in Appendix A. An example is shown for dissolved oxygen at Barton Springs under recharge conditions (Table 4). The lower and upper confidence intervals of the median dissolved oxygen concentration (the 2nd and 3rd rows, respectively) at Barton Springs is shown for various Barton Springs discharge rates (the top row). Thus, if the discharge rate at Barton Springs is 55 ft^3/s, then the expected lower and upper confidence intervals of the median dissolved oxygen concentrations are 4.3 mg/L and 8.2 mg/L, respectively. Measurements either above or below these values for a given discharge rate indicate a significant anomaly and something to be investigated.

Table 4: Upper and Lower Confidence Intervals (mg/L) for Dissolved Oxygen at Barton Springs

	Discharge Flow at Barton Springs (ft^3/s)																	
	25	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**	**105**	**110**
LCI	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.6	4.9	5.0	5.0	5.1	5.1	5.1	5.0	5.0	5.1	5.3
UCI	6.7	7.0	7.4	7.6	7.8	8.0	8.2	8.3	8.3	8.4	8.5	8.6	8.5	8.4	8.5	8.6	8.7	8.7

Future measurements (or the mean of the measurements if several measurements are made on the same day) taken from these springs can now be compared to the limits given in the tables. These confidence intervals are derived from the median data at every 5 ft^3/s increments and do not assume a temporal trend. Thus, measurements taken outside of the confidence intervals provide further indication of a temporal trend. Yearly reports of the number times measurements are exceeded can inform whether action or further investigation is needed. If there are no measurements taken outside of the confidence intervals, then those measurements can be included into the data set for future analyses and would result in an updating of the confidence intervals.

Conclusion

An update of temporal trends at the Barton Springs, Eliza Springs, Old Mill Springs, and Cold Springs was conducted for selected water quality parameters. Water quality parameters indicating a positive trend for at least four of the five springs included calcium, chloride, conductivity, sodium, and sulfate under recharge conditions. However, the model fit using the second stage of the regression techniques was fair to poor indicating other sources of variability may be present and have not been accounted.   Thus, an alternative approach to examining the data for trends was proposed. Confidence intervals of the LOESS curve were calculated for each of the 15 constituents under recharge and non-recharge conditions. Future measurements could be compared against these intervals at any time. Several measurements falling outside the intervals taken over the course of a year may indicate a continuing trend in the water quality for that year and point toward further investigation or action.

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Appendix A

Confidence Intervals of the LOESS curve for each water quality parameter under recharge and non-recharge flow conditions

Barton Springs		Discharge Flow (cfs) at Barton Springs (USGS Gage 0815500)																	
		25	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**	**105**	**110**
DO	**Recharge**	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.6	4.9	5.0	5.0	5.1	5.1	5.1	5.0	5.0	5.1	5.3
		6.7	7.0	7.4	7.6	7.8	8.0	8.2	8.3	8.3	8.4	8.5	8.6	8.5	8.4	8.5	8.6	8.7	8.7
	No Recharge	3.5	3.6	3.7	4.0	4.4	4.7	4.9	5.2	5.3	5.3	5.2	5.1	4.9	4.8	4.6	4.4	4.2	3.9
		6.1	6.5	6.7	6.9	6.9	7.0	7.1	7.2	7.3	7.6	7.8	8.1	8.3	8.5	8.7	8.9	9.1	9.3
Alkalinity	**Recharge**	238	242	246	249	249	246	244	241	233	222	213	204	204	208	212	215	217	217
		270	267	264	262	262	265	265	265	270	279	288	298	305	311	314	317	321	325
	No Recharge	232	230	230	231	233	238	243	244	239	234	231	229	228	229	231	237	251	265
		284	287	291	295	299	299	298	298	303	306	308	309	309	307	304	298	284	270
Calcium	**Recharge**	71	71	71	72	72	73	75	77	77	76	76	75	77	80	79	77	73	69
		96	101	105	108	109	111	109	106	103	101	101	103	105	106	108	111	114	118
	No Recharge	49	47	47	49	54	61	67	69	70	71	72	74	76	79	82	86	89	93
		126	129	129	124	116	107	101	100	102	103	104	104	104	103	101	99	96	94
Chloride	**Recharge**	29.1	26.9	24.7	22.6	20.5	18.5	16.3	13.9	12.4	11.9	12.4	13.9	14.9	15.6	16.2	16.8	17.7	18.9
		51.3	48.2	45.5	42.9	41.0	39.3	38.3	37.9	37.5	37.0	36.4	35.6	35.2	34.8	34.0	32.8	31.3	29.5
	No Recharge	25.2	22.7	20.7	19.1	18.1	17.4	16.9	16.7	15.8	14.7	13.9	13.3	13.1	13.3	13.9	15.8	18.2	20.6
		54.1	50.6	47.2	44.1	41.2	38.7	36.9	35.5	35.7	36.0	36.2	36.0	35.3	34.1	32.4	29.3	25.6	21.8
Conduct-	**Recharge**	608	591	576	561	549	537	525	514	504	499	499	507	521	530	537	551	567	580
		763	767	769	769	768	767	764	758	752	747	748	750	752	745	733	722	713	708
	No Recharge	606	590	577	566	556	547	540	537	538	540	542	545	548	552	556	560	564	568
		778	772	765	759	753	747	741	735	728	721	715	709	705	702	702	703	705	710
Fluoride	**Recharge**	0.05	0.05	0.06	0.07	0.08	0.08	0.08	0.07	0.05	0.04	0.03	0.03	0.06	0.08	0.08	0.06	0.03	<DL
		0.43	0.41	0.40	0.39	0.38	0.36	0.35	0.34	0.34	0.34	0.33	0.31	0.30	0.28	0.28	0.29	0.31	0.33
	No Recharge	0.14	0.10	0.08	0.08	0.07	0.06	0.06	0.06	0.07	0.09	0.10	0.11	0.12	0.14	0.15	0.15	0.16	0.17
		0.50	0.51	0.51	0.49	0.46	0.40	0.35	0.31	0.29	0.28	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.26
Magnesium	**Recharge**	22.6	20.8	19.0	17.2	15.8	14.3	12.4	10.5	9.1	8.3	9.0	11.2	13.2	14.9	16.2	17.0	17.6	18.3
		24.9	25.6	26.3	26.9	27.3	27.6	28.2	28.7	28.9	28.5	27.2	24.9	23.8	23.7	23.7	23.6	23.4	22.9
	No Recharge	14.2	12.9	12.2	12.2	12.9	13.7	14.0	13.6	13.2	13.3	13.6	14.3	15.2	16.3	17.8	19.4	20.8	22.1
		34.9	35.0	34.6	33.1	31.0	28.8	27.5	27.3	27.3	27.3	27.2	27.0	26.6	26.0	25.1	24.1	23.3	22.6

		25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
Nitrate	**Recharge**	1.23	1.23	1.22	1.22	1.20	1.16	1.12	1.09	1.08	1.06	1.05	1.03	1.01	1.00	0.98	0.95	0.93	0.90
		1.78	1.83	1.86	1.86	1.86	1.85	1.84	1.83	1.82	1.81	1.80	1.78	1.77	1.75	1.74	1.73	1.72	1.71
	No Recharge	1.20	1.12	1.03	0.95	0.86	0.78	0.70	0.59	0.49	0.40	0.34	0.31	0.30	0.32	0.50	0.66	0.74	0.76
		1.93	1.93	1.94	1.95	1.97	1.99	2.02	2.07	2.13	2.18	2.34	2.48	2.48	2.37	2.07	1.84	1.70	1.66
pH	**Recharge**	6.9	6.8	6.7	6.7	6.7	6.6	6.6	6.6	6.6	6.6	6.5	6.5	6.5	6.6	6.6	6.6	6.5	6.4
		7.3	7.4	7.4	7.4	7.4	7.5	7.5	7.5	7.6	7.7	7.7	7.7	7.7	7.6	7.5	7.5	7.5	7.6
	No Recharge	6.5	6.6	6.6	6.7	6.7	6.6	6.6	6.6	6.6	6.5	6.5	6.5	6.5	6.5	6.5	6.4	6.4	6.4
		7.6	7.5	7.4	7.4	7.4	7.4	7.5	7.6	7.6	7.7	7.7	7.7	7.7	7.6	7.6	7.5	7.5	7.4
Silica	**Recharge**		11.32	10.75	10.17	9.60	9.07	8.82	8.70	8.59	8.52	8.55	8.83	9.04	9.16	9.35	9.58	9.85	10.16
			11.60	11.49	11.46	11.74	12.05	12.57	13.20	13.82	13.58	12.49	11.37	11.58	12.54	13.16	13.61	13.69	13.60
	No Recharge	9.65	9.55	9.54	9.63	9.76	9.87	9.92	9.98	10.08	10.11	10.27	10.47	10.63	10.69	10.66	10.45	10.17	9.88
		12.37	12.53	12.79	13.10	13.40	13.60	13.60	13.58	13.44	13.17	13.08	13.11	13.26	13.45	13.63	13.74	13.81	13.89
Sodium	**Recharge**	20.5	16.8	13.5	10.5	8.3	6.2	4.5	3.0	2.3	2.7	5.1	13.0	13.4	12.0	11.3	11.3	11.1	10.8
		29.3	28.8	28.2	27.6	26.9	26.2	25.7	25.4	25.0	24.0	21.1	13.0	13.4	16.4	17.8	18.0	18.2	18.4
	No Recharge	1.0	<DL	<DL	<DL	<DL	2.7	6.6	8.7	9.1	9.6	9.9	10.3	10.8	11.3	11.8	12.2	12.4	12.7
		53.0	52.3	50.0	45.4	38.9	31.6	25.3	21.9	20.9	19.7	18.9	18.0	17.0	16.1	15.1	14.3	13.6	12.9
Strontium	**Recharge**	0.57	0.33	0.13	<DL	<DL	<DL	0.04	0.21	0.38	0.41	0.50	0.58	0.48	0.46	0.44	0.47	0.50	0.53
		5.36	4.71	4.09	3.48	2.94	2.39	1.70	1.43	1.17	1.11	0.88	0.69	0.77	0.79	0.83	0.82	0.80	0.77
	No Recharge	1.77	1.36	1.03	0.80	0.67	0.62	0.64	0.65	0.68	0.74	0.81	0.85	0.77	0.71	0.66	0.47	0.30	0.12
		3.63	3.51	3.35	3.16	2.93	2.66	2.37	2.08	1.79	1.48	1.18	0.95	0.87	0.81	0.76	0.89	1.05	1.20
Sulfate	**Recharge**	31.4	29.0	27.7	26.5	25.4	24.1	21.4	17.8	14.7	12.0	13.1	16.8	18.8	20.2	20.7	20.6	20.4	20.0
		44.2	52.5	58.5	63.8	66.3	68.5	68.3	66.7	64.7	62.3	61.4	61.1	59.2	56.1	52.7	48.9	45.5	42.7
	No Recharge	28.9	26.4	24.5	23.3	22.7	22.5	21.8	20.9	18.7	16.8	15.3	14.4	14.1	14.3	14.9	17.6	21.3	25.0
		47.9	47.1	45.7	43.5	40.8	38.4	37.4	37.7	39.9	42.1	44.1	45.2	45.3	44.4	42.7	38.3	32.6	26.9
TKN	**Recharge**	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
		0.44	0.39	0.35	0.30	0.28	0.28	0.30	0.33	0.38	0.46	0.60	0.71	0.83	0.85	0.71	0.59	0.48	0.40
	No Recharge	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
		0.39	0.38	0.37	0.35	0.31	0.31	0.39	0.47	0.49	0.49	0.48	0.48	0.48	0.47	0.47	0.48	0.48	0.49

Temperature	**Recharge**	21.4	21.0	20.4	19.9	19.5	19.1	18.7	18.1	17.5	17.1	16.7	16.5	16.8	17.6	18.3	18.7	19.0	19.0
		21.5	21.8	22.3	22.6	22.9	23.1	23.2	23.4	23.6	23.7	23.6	23.4	23.2	23.0	22.9	22.8	22.6	22.3
	No Recharge	20.6	20.5	20.4	20.2	20.2	20.2	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.4	20.5	20.6
		22.3	22.4	22.4	22.5	22.6	22.5	22.5	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.3	22.3	22.2	22.1

Eliza Springs		Discharge Flow (cfs) at Barton Springs (USGS Gage 0815500)																	
		25	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**	**105**	**110**
DO	**Recharge**	4.1	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8	5.0	5.2	5.3	5.0	4.8	4.7	4.8
		5.0	5.7	6.2	6.7	7.1	7.4	7.6	7.9	8.0	8.1	8.2	8.1	8.0	7.9	7.9	8.0	8.4	8.6
	No Recharge	3.8	4.1	4.1	4.1	4.2	4.4	4.5	4.7	4.8	5.0	5.1	5.2	5.2	5.3	5.3	5.3		
		5.5	5.8	6.4	6.9	7.3	7.5	7.6	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6		
Alkalinity	**Recharge**	238	242	246	249	249	246	244	241	233	222	213	204	204	208	212	215	217	217
		270	267	264	262	262	265	265	265	270	279	288	298	305	311	314	317	321	325
	No Recharge	237	227	218	209	202	199	204	210	217	222	225	227	228	228	226	223	220	
		291	299	305	310	312	310	303	296	289	286	286	287	288	289	291	293	295	
Calcium	**Recharge**							79.3	79.8	79.8	79.6	78.9	78.1	78.6	79.7	80.0	80.5	80.4	81.4
								92.9	93.8	95.7	98.1	101.7	105.7	108.9	111.1	110.8	109.0	108.1	108.2
	No Recharge	73.8	73.2	73.0	73.2	73.6	74.5	75.3	76.1	76.0	76.2	76.8	77.6	78.5	79.8	81.6			
		96.5	98.6	100.1	101.3	102.5	103.8	104.9	106.0	106.3	106.3	106.1	105.7	104.9	103.7	102.1			
Chloride	**Recharge**							25.3	19.9	15.3	11.3	8.4	6.0	8.1	12.7	16.4	18.7	21.1	24.7
								38.7	33.0	30.2	29.2	31.7	35.3	37.2	37.4	35.1	31.4	28.3	24.7
	No Recharge	31.9	28.9	26.5	24.7	23.3	22.5	21.9	21.4	20.7	20.0	19.3	18.8	18.4	18.2	18.2			
		53.0	49.5	46.3	43.5	41.5	40.4	39.6	38.9	37.8	36.3	35.0	33.5	31.8	29.9	27.8			
Conductivity	**Recharge**							566	525	502	493	504	520	538	544	538	541	548	555
								719	686	665	652	657	671	704	733	734	733	727	723
	No Recharge	643	642	637	629	621	611	598	586	573	563	553	545	538	532	528			
		760	744	732	724	719	716	715	715	713	710	708	707	706	705	705			
Fluoride	**Recharge**							0.12	0.03	<DL	<DL	<DL	<DL	<DL	0.08	0.11	0.03	0.01	0.04
								0.25	0.38	0.41	0.41	0.37	0.32	0.26	0.23	0.26	0.33	0.34	0.31
	No Recharge	0.17	0.12	0.09	0.06	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.11	0.11			
		0.50	0.52	0.52	0.51	0.49	0.46	0.42	0.39	0.35	0.33	0.31	0.30	0.30	0.30	0.30			
Magnesium	**Recharge**							16.6	16.4	16.1	15.9	15.8	15.8	14.6	14.1	15.1	18.0	20.8	20.9
								23.7	23.1	22.6	22.0	21.2	20.4	22.5	24.6	24.9	22.8	20.8	20.9

		25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
Magnesium	**No Recharge**	21.4	20.9	20.5	20.1	19.8	19.6	19.3	19.1	18.5	18.0	17.9	17.9	18.0	18.4	19.0			
		27.8	27.3	26.8	26.5	26.4	26.6	26.8	27.0	27.0	26.7	26.5	26.1	25.7	25.1	24.3			
Nitrate	**Recharge**							1.24	1.11	0.57	0.21	<DL	<DL	<DL	0.32	0.59	0.72	0.77	0.84
								1.24	1.11	1.56	2.00	2.60	3.24	3.13	2.59	1.93	1.60	1.55	1.49
	No Recharge	1.04	1.03	1.03	1.04	1.05	1.03	0.99	0.96	0.93	0.92	0.91	0.92	0.92	0.94	0.97			
		1.76	1.79	1.80	1.77	1.75	1.74	1.74	1.73	1.73	1.73	1.73	1.72	1.70	1.67	1.64			
pH	**Recharge**				6.88	6.81	6.74	6.69	6.65	6.64	6.66	6.64	6.60	6.58	6.61	6.67	6.72	6.74	6.75
					7.72	7.66	7.59	7.54	7.50	7.47	7.46	7.50	7.56	7.60	7.52	7.42	7.34	7.30	7.30
	No Recharge	6.67	6.66	6.65	6.64	6.63	6.62	6.62	6.62	6.61	6.59	6.58	6.57	6.55	6.55	6.54			
		7.58	7.56	7.53	7.50	7.50	7.58	7.70	7.80	7.83	7.81	7.79	7.74	7.67	7.59	7.50			
Silica	**Recharge**										11.6	11.4	11.3	11.1	11.0	11.2	11.5	11.8	12.0
											12.6	12.7	12.8	12.9	13.0	12.9	12.7	12.5	12.3
	No Recharge	10.9	11.1	11.2	11.2	11.3	11.3	11.4	11.4	11.5	11.7	11.6	11.5	11.4	11.6	11.9			
		12.1	12.4	12.5	12.4	12.4	12.3	12.2	12.2	12.1	12.1	12.1	12.2	12.4	12.8	13.3			
Sodium	**Recharge**							9.6	9.1	9.0	9.2	9.7	10.1	10.1	10.4	10.9	11.8	13.1	14.2
								22.4	19.9	17.8	16.0	15.3	14.9	16.8	18.8	19.1	18.2	17.0	16.4
	No Recharge	20.8	17.9	15.7	14.1	13.0	12.7	12.7	12.7	12.4	12.0	11.7	11.5	11.4	11.4	11.8			
		31.1	29.4	27.7	26.2	25.1	24.5	24.1	23.7	22.9	22.0	21.0	20.0	18.8	17.4	15.7			
Strontium	**Recharge**							0.56	0.53	0.50	0.49	0.52	0.51	0.49	0.45	0.48	0.56	0.64	0.72
								1.33	1.30	1.28	1.20	1.04	0.94	0.86	0.89	0.89	0.85	0.79	0.72
	No Recharge	2.42	2.19	2.04	1.91	1.74	1.58	1.37	1.17	1.03	0.89	0.73	0.61	0.54	0.55	0.63			
		3.43	2.89	2.45	2.03	1.74	1.63	1.68	1.73	1.70	1.62	1.51	1.39	1.26	1.10	0.89			
Sulfate	**Recharge**							49.5	38.9	24.5	15.0	9.9	6.3	9.0	14.1	18.3	19.8	21.8	24.7
								49.5	38.9	40.1	42.2	51.1	61.5	63.3	60.3	53.7	47.4	41.6	37.2
	No Recharge	33.1	31.1	29.3	27.6	25.8	23.9	22.2	20.6	19.4	18.7	18.3	18.3	18.7	19.6	21.2			
		48.0	46.7	45.6	44.7	44.0	43.6	43.1	42.7	41.9	41.2	40.7	40.0	39.1	38.1	36.7			

TKN	**Recharge**												0.23 0.32	0.12 0.12	0.00 0.23	<DL 0.40	<DL 0.52	<DL 0.37	0.11 0.28
	No Recharge	<DL 0.55	<DL 0.46	<DL 0.36	<DL 0.25	0.05 0.18	0.10 0.12	0.08 0.15	0.03 0.20	<DL 0.27	<DL 0.32	<DL 0.32	<DL 0.31	<DL 0.29	<DL 0.26	0.04 0.21			
Temp-erature	**Recharge**	20.7 21.6	20.4 22.0	20.1 22.4	19.8 22.7	19.5 23.0	19.3 23.2	19.1 23.4	18.9 23.6	18.6 23.8	18.3 23.9	18.2 23.7	18.4 23.1	18.8 22.2	19.1 21.8	18.2 23.4	17.6 24.5	17.4 24.8	17.3 24.6
	No Recharge	20.5 22.2	20.4 22.2	20.3 22.2	20.2 22.3	19.9 22.5	19.7 22.7	19.5 22.8	19.5 22.8	19.6 22.8	19.7 22.7	19.9 22.7	20.1 22.6	20.2 22.6	20.4 22.5	20.6 22.4	20.9 22.3		

Old Mill Springs		Discharge Flow (cfs) at Barton Springs (USGS Gage 0815500)																	
		25	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**	**105**	**110**
DO	**Recharge**					2.7	3.3	3.7	4.1	4.4	4.5	4.7	4.8	4.9	4.9	4.8	4.8	4.9	4.8
						7.2	7.4	7.6	7.7	7.8	7.8	7.7	7.7	7.6	7.5	7.5	7.6	7.7	8.0
	No Recharge	0.6	0.9	1.5	2.7	3.6	3.7	3.5	3.4	3.4	3.4	3.5	3.6	3.8	4.0	4.4	4.8		
		9.0	8.3	7.7	7.1	6.6	7.0	7.7	8.2	8.3	8.3	8.4	8.4	8.3	8.2	8.0	7.7		
Alkalinity	**Recharge**					215	225	230	234	230	224	214	203	194	196	202	210	219	228
						271	265	262	261	267	275	286	296	304	309	318	316	312	306
	No Recharge	214	225	230	231	232	234	236	235	231	227	224	222	223	227	235			
		294	292	293	294	296	298	299	302	304	307	310	312	312	310	305			
Calcium	**Recharge**							69.8	74.6	77.6	79.2	77.1	74.2	75.1	78.0	80.2	81.2	78.8	78.1
								91.4	94.9	97.5	99.5	101.0	102.4	103.4	103.8	103.2	103.2	105.9	108.7
	No Recharge	63.7	69.5	75.3	82.5	82.0	82.0	81.7	77.4	75.6	74.3	73.3	73.5	75.1	78.2	84.2			
		128.0	117.3	107.1	96.2	94.0	94.0	93.0	97.9	101.1	105.0	107.4	108.5	107.9	105.5	100.3			
Chloride	**Recharge**							33.5	32.8	31.2	28.8	22.9	16.3	19.4	27.2	33.9	35.2	37.0	38.8
								56.9	54.5	53.4	53.5	56.3	59.8	60.8	59.6	55.4	53.1	50.6	47.7
	No Recharge					47.0	47.0	45.9	42.9	42.2	41.7	40.8	39.5	38.3	36.9	35.5			
						56.0	56.0	56.6	57.2	55.2	53.5	53.0	53.0	53.3	53.9	54.6			
Conduct	**Recharge**							590	580	576	578	585	594	602	606	599	601	609	614
								785	773	762	752	751	756	774	791	796	799	797	794
	No Recharge	581	637	710	750	750	713	658	639	635	640	642	641	639	635	630			
		1370	1160	974	825	815	809	837	828	809	785	778	780	785	787	783			
Fluoride	**Recharge**							0.15	0.04	0.00	<DL	<DL	<DL	<DL	0.05	0.04	0.02	0.06	0.08
								0.29	0.41	0.43	0.43	0.41	0.38	0.34	0.32	0.35	0.36	0.34	0.36
	No Recharge	0.18	0.13	0.09	0.06	0.05	0.06	0.08	0.11	0.14	0.16	0.16	0.16	0.17	0.16	0.16			
		0.56	0.57	0.57	0.54	0.49	0.42	0.35	0.28	0.24	0.23	0.23	0.23	0.26	0.29	0.33			
Magnesium	**Recharge**							15.9	7.6	5.3	4.4	6.9	10.5	14.2	16.8	18.0	19.6	20.0	19.4
								25.3	32.8	34.5	35.0	32.5	29.0	26.6	25.7	26.0	25.3	25.6	26.0
	No Recharge	16.2	17.7	19.8	22.0	22.0	22.0	20.6	18.6	17.8	17.2	17.1	17.4	18.1	19.5	22.0			
		35.6	34.0	31.4	27.5	25.5	25.5	26.1	27.5	28.1	28.9	29.1	29.0	28.7	27.9	26.3			

Nitrate	**Recharge**						0.65	0.65	0.62	0.35	0.20	0.07	0.11	0.35	0.68	0.69	0.71	0.79
							1.20	1.20	1.61	2.03	2.50	2.99	3.02	2.37	1.69	1.68	1.68	1.60
	No Recharge	<DL	0.29	0.69	1.04	1.28	1.30	1.28	1.12	0.99	0.97	0.96	0.97	0.99	1.03	1.10			
		2.13	2.12	2.04	1.89	1.69	1.60	1.65	1.70	1.77	1.78	1.78	1.77	1.74	1.70	1.64			
pH	**Recharge**				6.85	6.80	6.75	6.71	6.68	6.69	6.71	6.67	6.63	6.62	6.70	6.75	6.79	6.77	6.72
					7.90	7.80	7.69	7.62	7.56	7.52	7.52	7.58	7.65	7.69	7.59	7.46	7.37	7.36	7.43
	No Recharge	6.46	6.50	6.55	6.61	6.66	6.70	6.70	6.69	6.66	6.64	6.60	6.57	6.55	6.55	6.58			
		8.06	7.85	7.66	7.51	7.40	7.35	7.38	7.48	7.58	7.66	7.66	7.61	7.55	7.50	7.50			
Silica	**Recharge**										11.61	11.46	11.32	11.18	11.04	11.02	11.23	11.48	11.72
											12.48	12.50	12.50	12.50	12.50	12.63	12.78	12.76	12.70
	No Recharge								12.08	6.60	9.53	11.85	12.05	12.12	12.29	12.39			
									12.56	16.35	14.12	11.95	11.95	12.02	12.49	12.96			
Sodium	**Recharge**							12.6	14.9	16.8	18.5	19.6	20.4	20.5	21.1	22.2	22.4	18.5	14.9
								29.2	31.1	32.1	32.4	30.9	29.0	30.3	32.4	32.7	32.3	34.8	35.5
	No Recharge				29.0	29.0	29.0	28.5	27.4	26.4	25.6	24.9	24.5	24.5	24.7	25.3			
					35.0	35.0	35.0	35.0	35.0	35.0	35.0	34.7	34.3	33.7	32.9	31.9			
Strontium	**Recharge**							0.63	0.62	0.62	0.62	0.66	0.72	0.72	0.64	0.63	0.68	0.72	0.73
								1.26	1.29	1.33	1.30	1.16	0.98	0.90	0.93	0.96	0.96	0.94	0.90
	No Recharge	1.22	1.34	1.41	1.48	1.45	1.40	1.33	1.15	1.01	0.88	0.77	0.69	0.67	0.69	0.75			
		3.04	2.69	2.37	2.04	1.73	1.60	1.54	1.53	1.51	1.48	1.43	1.35	1.24	1.12	1.00			
Sulfate	**Recharge**							51.5	45.6	38.9	32.8	28.2	24.4	25.7	29.0	31.7	32.7	34.4	37.0
								63.6	55.2	52.6	53.1	59.1	66.3	69.7	70.6	67.5	63.0	57.9	53.4
	No Recharge					43.0	43.0	41.0	38.1	35.8	33.9	32.3	31.6	31.7	32.6	34.3			
						52.0	52.0	52.5	53.9	54.2	55.0	56.4	57.1	56.9	56.0	54.4			
TKN	**Recharge**												0.20	<DL	<DL	<DL	<DL	0.03	0.15
													0.20	0.54	0.67	0.54	0.33	0.23	0.18
	No Recharge	<DL	<DL	0.07	0.07	0.07	0.03	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	0.09			
		0.66	0.40	0.13	0.16	0.19	0.31	0.43	0.51	0.51	0.50	0.44	0.39	0.33	0.24	0.12			
Temp	**Recharge**				19.9	19.9	19.8	19.7	19.5	19.3	18.9	18.7	18.6	18.6	18.6	18.2	17.7	17.6	17.7
					22.1	22.3	22.4	22.6	22.8	23.0	23.2	23.2	23.0	22.6	22.5	23.4	24.3	24.5	24.3

No Recharge	14.5	17.3	20.2	20.2	20.2	20.2	19.4	18.1	17.3	16.9	16.9	17.0	17.5	18.4	20.7	21.4
	28.9	25.3	22.1	22.1	22.1	22.1	23.1	24.3	25.0	25.4	25.5	25.3	25.0	24.2	22.0	21.4

Cold Springs		Discharge Flow (cfs) at Barton Springs (USGS Gage 0815500)																	
		25	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**	**105**	**110**
DO	**Recharge**							5.4	4.9	4.6	4.7	5.5	6.2	7.0	6.4	5.1	4.6	4.1	5.3
								6.8	6.8	6.8	6.9	7.0	7.2	7.4	8.2	8.5	8.3	8.8	9.7
	No Recharge	4.2	4.4	4.8	5.2	5.6	5.4	5.1	4.7	4.4	4.4	4.4	4.4	4.5	4.5	4.6	4.7	4.8	
		8.3	8.1	7.8	7.5	7.3	7.6	8.0	8.4	8.7	8.7	8.7	8.7	8.8	9.0	9.4	10.1	10.9	
Alkalinity	**Recharge**							218	202	195	198	207	215	219	208	195	203	212	215
								228	230	232	232	239	245	257	278	299	296	282	264
	No Recharge	237	227	218	209	202	199	204	210	217	222	225	227	228	228	226	223	220	
		291	299	305	310	312	310	303	296	289	286	286	287	288	289	291	293	295	
Calcium	**Recharge**							74.6	76.7	76.9	76.2	76.0	75.3	77.1	79.8	79.2	76.5	73.1	69.3
								109.2	106.2	103.0	100.7	101.1	103.4	104.7	106.0	108.2	111.1	114.4	118.0
	No Recharge	68.9	66.7	65.7	66.1	66.6	65.5	63.6	61.7	60.6	61.2	63.1	65.8	69.8	74.8	82.6			
		98.8	100.7	101.1	100.0	98.9	100.4	103.4	106.5	108.9	109.9	109.9	109.5	108.4	106.9	103.1			
Chloride	**Recharge**	29.1	26.9	24.7	22.6	20.5	18.5	16.3	13.9	12.4	11.9	12.4	13.9	14.9	15.6	16.2	16.8	17.7	18.9
		51.3	48.2	45.5	42.9	41.0	39.3	38.3	37.9	37.5	37.0	36.4	35.6	35.2	34.8	34.0	32.8	31.3	29.5
	No Recharge	12.3	11.9	12.0	12.8	13.4	12.5	10.9	9.1	7.9	7.9	8.6	9.6	11.2	13.1	15.8	20.2	24.9	
		26.9	28.1	29.5	31.0	32.9	35.8	38.5	41.1	43.0	43.6	43.4	42.8	41.5	39.9	37.4	33.1	28.6	
Conductivity	**Recharge**							589	553	526	509	512	515	526	522	512	518	543	565
								738	720	713	719	745	771	805	825	780	728	693	668
	No Recharge	520	512	509	507	502	494	489	486	489	499	509	522	536	551	565	582	600	
		669	682	693	703	715	728	737	744	747	743	742	738	732	724	714	698	680	
Fluoride	**Recharge**	0.05	0.05	0.06	0.07	0.08	0.08	0.08	0.07	0.05	0.04	0.03	0.03	0.06	0.08	0.08	0.06	0.03	<DL
		0.43	0.41	0.40	0.39	0.38	0.36	0.35	0.34	0.34	0.34	0.33	0.31	0.30	0.28	0.28	0.29	0.31	0.33
	No Recharge	0.14	0.10	0.08	0.08	0.07	0.06	0.06	0.06	0.07	0.09	0.10	0.11	0.12	0.14	0.15	0.15	0.16	0.17
		0.50	0.51	0.51	0.49	0.46	0.40	0.35	0.31	0.29	0.28	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.26
Magnesium	**Recharge**	22.6	20.8	19.0	17.2	15.8	14.3	12.4	10.5	9.1	8.3	9.0	11.2	13.2	14.9	16.2	17.0	17.6	18.3
		24.9	25.6	26.3	26.9	27.3	27.6	28.2	28.7	28.9	28.5	27.2	24.9	23.8	23.7	23.7	23.6	23.4	22.9
	No Recharge	19.2	18.4	17.9	17.6	17.4	17.1	16.8	16.5	16.3	16.4	16.7	17.1	17.9	18.8	20.3			
		26.4	26.6	26.7	26.6	26.5	26.7	26.9	27.1	27.2	27.1	26.8	26.6	26.2	25.8	24.9			

Nitrate	**Recharge**							<DL 1.23	<DL 1.63	<DL 2.00	<DL 2.34	<DL 2.65	<DL 2.95	<DL 2.90	<DL 2.20	0.70 1.18	0.38 1.53	0.50 1.30	0.55 1.08
	No Recharge	1.32 2.02	1.11 2.14	0.75 2.31	0.32 2.45	0.05 2.50	0.04 2.43	0.17 2.31	0.33 2.19	0.48 2.08	0.65 2.00	0.80 1.91	0.88 1.86	0.90 1.84	0.88 1.84	0.80 1.88			
pH	**Recharge**							6.61 7.91	6.41 8.29	6.27 8.54	6.22 8.62	6.24 8.49	6.27 8.37	6.50 8.14	6.94 7.60	6.83 7.53	6.70 7.52	6.68 7.40	6.75 7.22
	No Recharge	6.76 7.58	6.80 7.56	6.82 7.50	6.82 7.44	6.81 7.43	6.78 7.46	6.75 7.50	6.72 7.53	6.69 7.55	6.67 7.56	6.65 7.57	6.63 7.59	6.62 7.60	6.62 7.62	6.63 7.64	6.66 7.66	6.69 7.68	
Silica	**Recharge**																		
	No Recharge																		
Sodium	**Recharge**							14.7 27.2	13.2 26.4	11.8 25.6	10.7 24.7	9.9 24.6	9.1 24.5	8.6 26.3	8.9 28.4	8.6 26.0	11.3 21.7	13.0 18.9	12.6 16.6
	No Recharge	6.5 15.8	4.8 17.4	3.0 19.1	1.1 20.9	-0.3 22.5	-0.2 23.2	0.8 23.3	1.9 23.4	2.9 23.4	3.8 23.3	4.5 23.1	5.2 23.0	6.0 22.7	6.7 22.5	7.5 22.2			
Strontium	**Recharge**							0.30 0.30	0.30 0.30	0.30 0.30	0.30 0.30	0.30 0.30	0.30 0.30	0.30 0.30	0.31 0.31	0.29 0.29	0.28 0.28		
	No Recharge	0.29 0.38	0.28 0.37	0.27 0.36	0.27 0.34	0.26 0.33	0.25 0.34	0.23 0.35	0.22 0.35	0.21 0.35	0.20 0.35	0.19 0.34	0.19 0.34	0.19 0.33	0.20 0.33	0.20 0.32			
Sulfate	**Recharge**	31.4 44.2	29.0 52.5	27.8 58.5	26.5 63.8	25.4 66.3	24.1 68.5	21.4 68.3	17.8 66.7	14.7 64.7	12.0 62.3	13.1 61.4	16.8 61.1	18.8 59.2	20.2 56.2	20.7 52.7	20.6 49.0	20.4 45.5	20.0 42.7
	No Recharge	17.4 33.5	17.8 35.2	18.7 37.1	20.4 39.0	21.3 41.8	19.4 46.9	16.3 51.8	13.3 56.6	11.3 60.2	11.2 61.6	12.4 61.6	14.3 61.0	17.0 59.5	20.3 57.6	25.1 54.3	31.9 49.1	38.8 43.8	
TKN	**Recharge**	<DL 0.27	<DL 0.20	<DL 0.12	<DL 0.13	<DL 0.21	<DL 0.29	<DL 0.39	<DL 0.50	<DL 0.61	<DL 0.67	<DL 0.65	<DL 0.59	<DL 0.50	<DL 0.37	<DL 0.15			
	No Recharge												<DL 0.21	<DL 0.44	<DL 0.65	<DL 0.64	<DL 0.30	<DL 0.23	0.19
Temperature	**Recharge**							19.2 22.1	21.0 22.1	22.0 22.0	21.9 21.9	19.5 21.8	17.2 21.8	14.4 23.4	12.8 26.7	12.9 28.3	14.1 26.2	14.8 25.4	14.7 26.7

No Recharge	20.5	19.8	19.0	18.2	17.5	16.8	16.3	15.9	15.5	15.5	15.8	16.3	17.0	17.8	19.0	20.4	21.8
	20.5	20.9	21.7	22.7	23.7	24.4	24.8	25.1	25.2	25.2	24.9	24.5	24.1	23.7	23.2	22.9	22.5