

## **Appendix 1.3. Model Archive Summary for Hardness Concentration at U.S. Geological Survey site 07143672; Little Arkansas River at Highway 50 near Halstead, Kansas, during May 1998 through December 2019**

This model archive summary summarizes the hardness model developed to compute hourly or daily hardness. Model development methods follow U.S. Geological Survey (USGS) guidance from Office of Surface Water/Office of Water Quality Technical Memoranda and USGS Techniques and Methods, book 3, chap. C4 (Rasmussen and others, 2009).

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### **Site and Model Information**

Site Number: 07143672

Site Name: Little Arkansas River at Highway 50 near Halstead, Kansas

Location: Latitude 38°01'43", longitude 97°32'25" referenced to North American Datum of 1927, in NW 1/4 NE 1/4 NE 1/4 sec.28, T.23 S., R.2 W., Harvey County, Kansas, hydrologic unit 11030012.

Equipment: A Sutron Satlink II High Data Rate Collection Platform and a Design Analysis Water Log H350/355 nonsubmersible pressure transducer transfers real-time stage and water-quality data via satellite. The primary reference gage is a Type-A wire-weight gage located on the downstream bridge guardrail. Check-bar elevation is 33.396 feet. The orifice tube is enclosed in 1.25-inch steel conduit trenched into the ground down to the edge of water, where the orifice emerges from the bank and culminates in a 2-inch open-end orifice tethered to a steel fencepost near the left edge of water. Gage height was measured during May 1998 through December 2019. A YSI 6600 water-quality monitor equipped with water temperature, specific conductance, pH, dissolved oxygen, and turbidity (a YSI Model 6026 [December 1998 through December 2006] and YSI Model 6136 [July 2004 through December 2017]) sensors collected data during May 1998 through December 2017. A YSI EXO2 water-quality monitor equipped with water temperature, specific conductance, pH, dissolved oxygen, turbidity, and fluorescent dissolved organic matter sensors collected data during January 2017 through December 2019. A Hach Nitratex monitor collected nitrate data during February 2017 through December 2019.

Date model was developed: June 1, 2020

Model calibration data period: May 12, 1998 through December 10, 2019

### **Model Data**

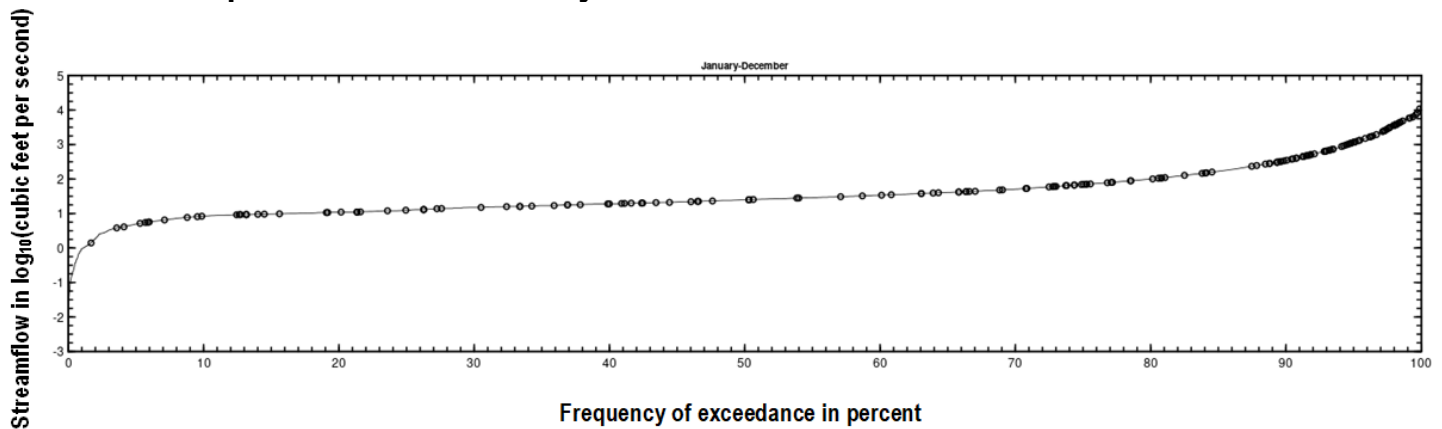
All data were collected using USGS protocols (U.S. Geological Survey, variously dated; Wagner and others, 2006; Sauer and Turnipseed, 2010; Turnipseed and Sauer, 2010) and are stored in the National Water Information System (NWIS) database (U.S. Geological Survey, 2021). Explanatory variables were evaluated individually and in combination. Potential explanatory variables included streamflow, water temperature, specific conductance, pH, dissolved oxygen, YSI EXO2 turbidity, nitrate, and fluorescent dissolved organic matter. Seasonal components (sine and cosine variables) also were evaluated as explanatory variables.

The regression model is based on 191 concomitant values of discretely collected hardness and continuously measured specific conductance during May 1998 through December 2019. Discrete samples were collected over a range of streamflow and specific conductance conditions. No samples had concentrations that were below laboratory detection limits. Summary statistics and the complete model-calibration dataset are provided below. Outliers and influential points were identified using studentized residuals, DFITS, Cook's D (Cook, 1977), and leverage. Outliers in previously published versions of this model (Christensen and others, 2003; Rasmussen and others, 2016) were examined and retained in the dataset if there were no clear issues, explanations, or conditions that would cause a result to be invalid for model calibration. All samples were retained in the dataset.

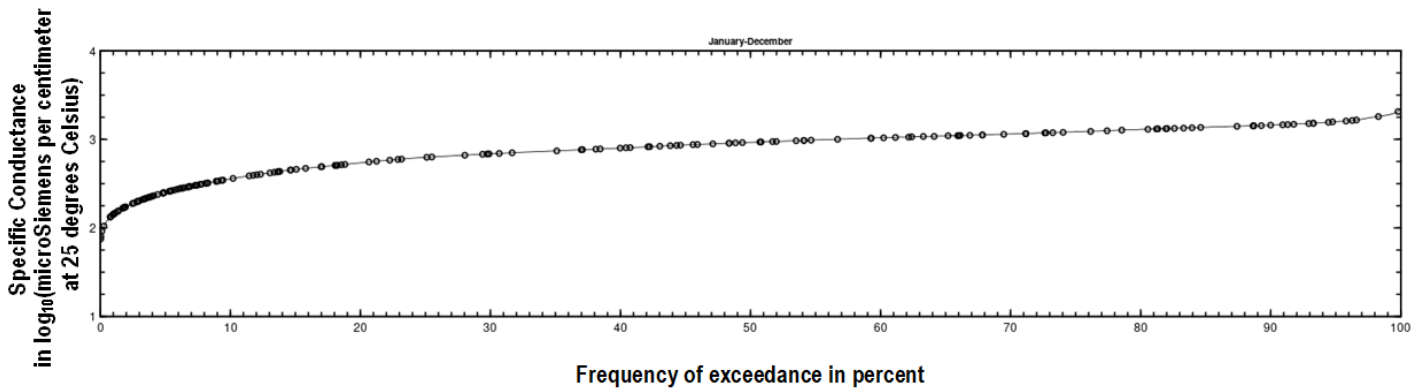
## Hardness

Discrete samples were collected from the downstream side of the bridge or instream within 50 feet of the bridge using equal-width-increment, multi-vertical, single vertical or grab-dip methods following U.S. Geological Survey (variously dated) and Rasmussen and others (2014). Discrete samples were collected on a semifixed to event-based schedule ranging from 4 to 13 samples per year with a FISP US DH-95 or D-95 with a Teflon bottle, cap, and nozzle depth-integrating sampler, a DH-81 with a Teflon bottle, cap, and nozzle hand sampler or a grab sample with a Teflon bottle depending on sample location. Samples were analyzed for hardness by the Wichita Municipal Water and Wastewater Laboratory in Wichita, Kansas, or the USGS National Water Quality Laboratory according to standard methods (American Public Health Association and others, 1995).

## Hardness Samples Plotted on January Streamflow Duration Curve



## Hardness Samples Plotted on Specific Conductance Duration Curve



## Continuous Data

Concomitant specific conductance values were time interpolated. If no concomitant continuous data were available within 2 hours of sample collection, the sample was not included in the dataset.

## Model Development

Ordinary least squares regression analysis was done using R (version 4.0.0) programming language (R Core Team, 2020) to relate discretely collected hardness to specific conductance and other continuously measured data. The distribution of residuals was examined for normality and plots of residuals (the difference between the measured and model-calculated values) compared to model-computed hardness were examined for homoscedasticity (departures from zero did not change substantially over the range of model-calculated values). Previously published explanatory variables were also strongly considered for continuity; however, the best explanatory variable(s) were ultimately selected.

Specific conductance was selected as the best predictor of hardness based on residual plots, high coefficient of determination ( $R^2$ ), and low model standard percentage error (MSPE) Specific conductance was positively related to hardness because it measures water's capacity to conduct an electrical current and is related to the concentration of ionized substances in water (Hem, 1992).

## Model Summary

Summary of final hardness regression analysis at USGS site number 07143672:

Hardness-based model:

$$\log_{10}(HD) = 1.01 \times \log_{10}(SC) - 0.554$$

where,

$\log_{10}$  = logarithm base 10;

$HD$  = hardness, in milligrams per liter as calcium carbonate (mg/L CaCO<sub>3</sub>); and

$SC$  = specific conductance, in microsiemens per centimeter at 25 degrees Celsius ( $\mu\text{S}/\text{cm}$ )

The log-transformed model may be retransformed to original units so that HD can be calculated directly. The retransformation introduces a bias in the calculated constituent. This bias may be corrected using Duan's bias correction factor (BCF; Duan, 1983). For this model, the calculated BCF is 1.01. The retransformed model, accounting for BCF is:

$$HD = 0.2820 \times SC^{1.01}$$

## Model Statistics, Data, and Plots

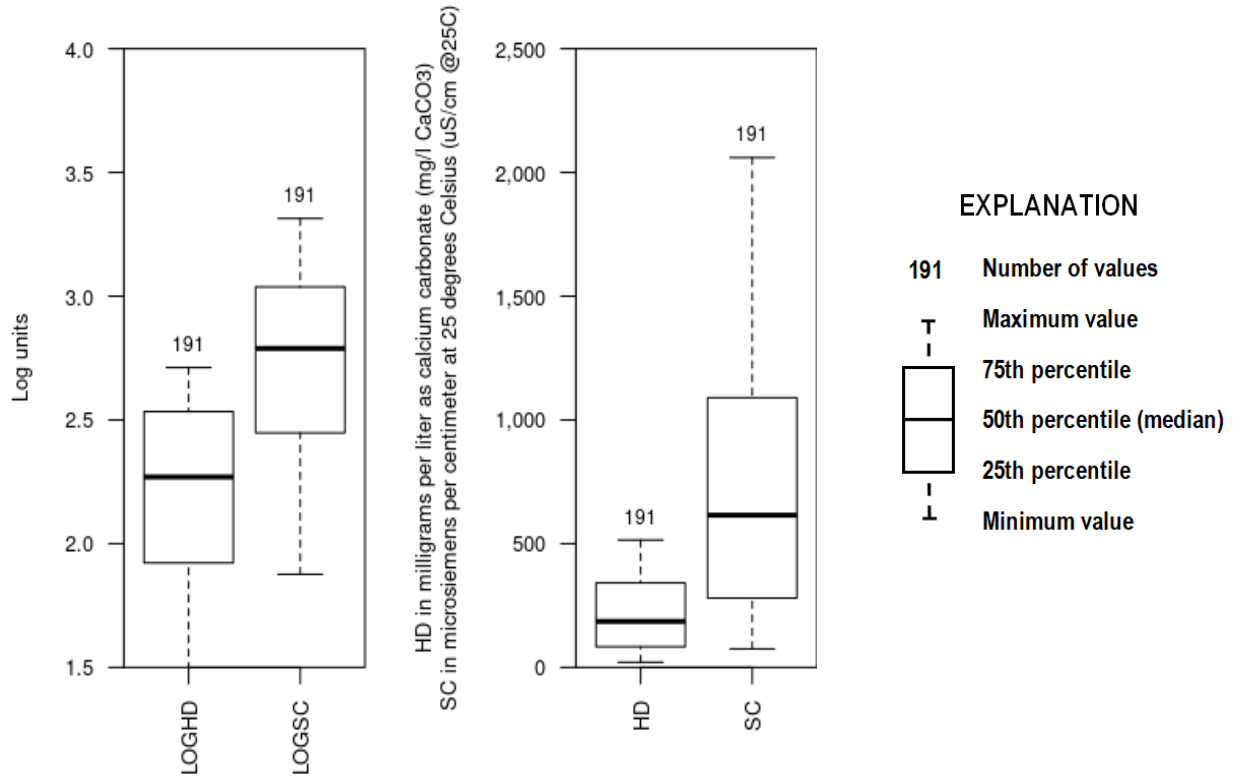
### Model

$$\text{LOGHD} = + 1.01 * \text{LOGSC} - 0.554$$

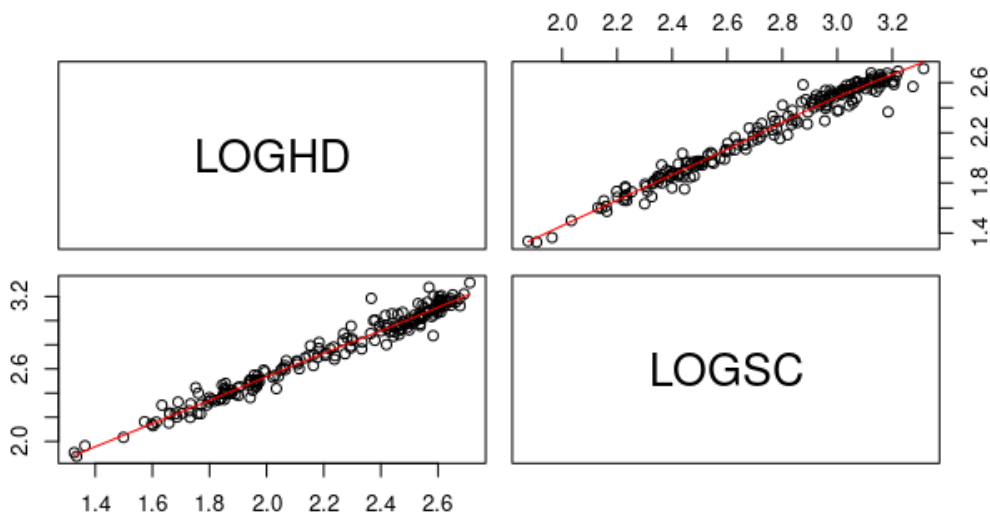
### Variable Summary Statistics

	LOGHD	HD	LOGSC	SC
Minimum	1.33	21.2	1.88	75.2
1st Quartile	1.91	80.7	2.45	279.0
Median	2.27	186.0	2.79	615.0
Mean	2.21	212.0	2.74	711.0
3rd Quartile	2.53	342.0	3.04	1100.0
Maximum	2.71	515.0	3.31	2060.0

## Box Plots



## Exploratory Plots



## Basic Model Statistics

Number of Observations	191
Standard error (RMSE)	0.0616
Average Model standard percentage error (MSPE)	14.2
Coefficient of determination (R <sup>2</sup> )	0.968
Adjusted Coefficient of Determination (Adj. R <sup>2</sup> )	0.968
Bias Correction Factor (BCF)	1.01

## Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t )
(Intercept)	-0.554	0.0366	-15.1	1.93e-34
LOGSC	1.010	0.0133	76.0	1.15e-143

## Correlation Matrix

	Intercept	E.vars
Intercept	1.000	-0.992
E.vars	-0.992	1.000

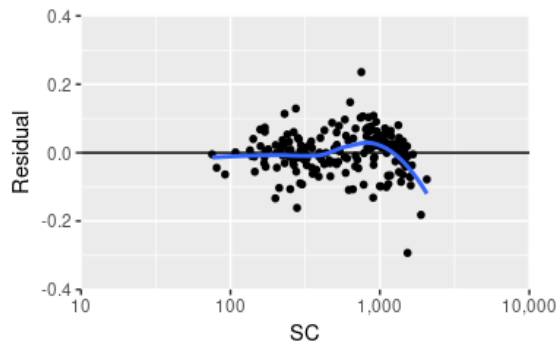
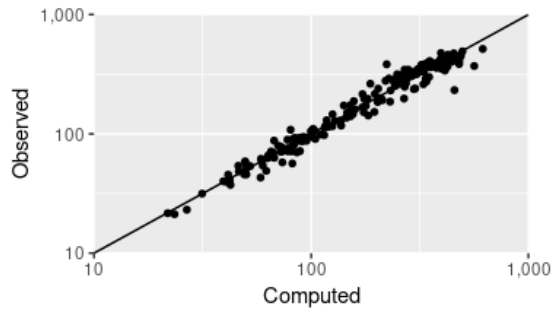
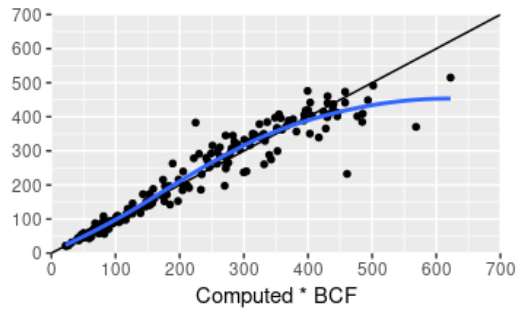
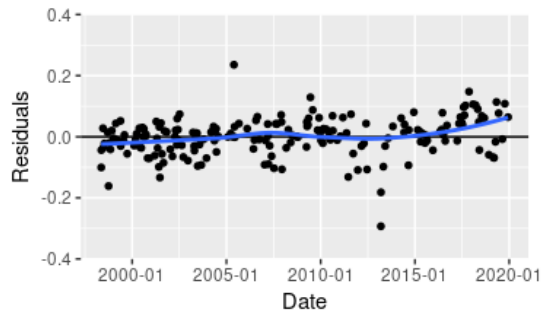
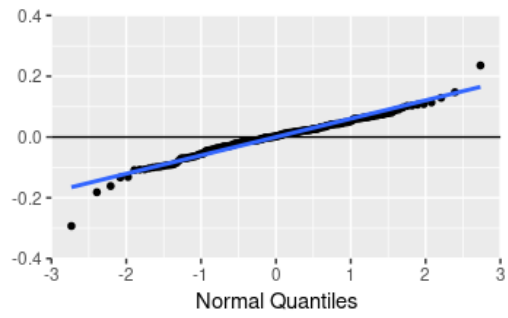
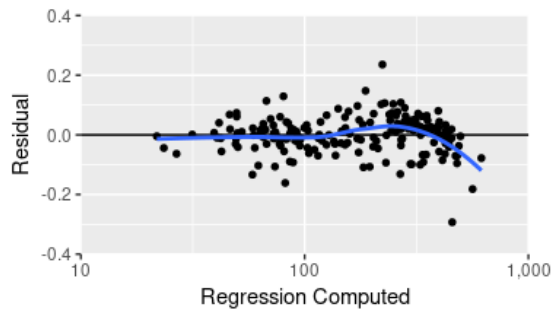
## Outlier Test Criteria

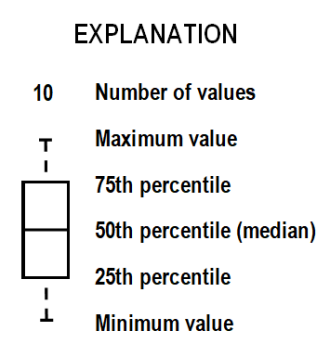
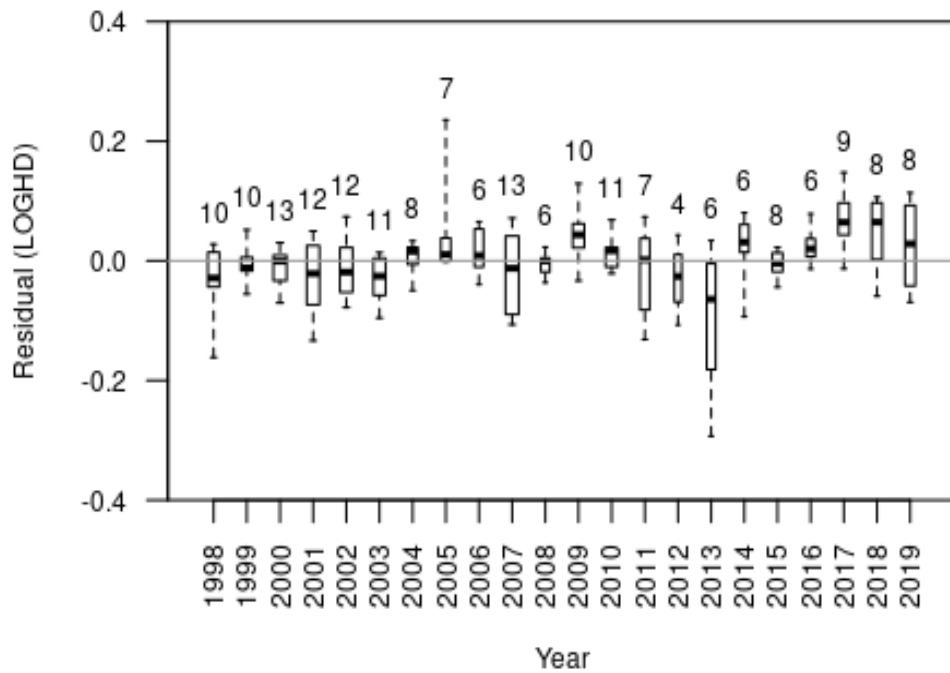
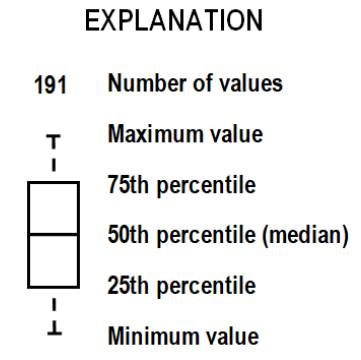
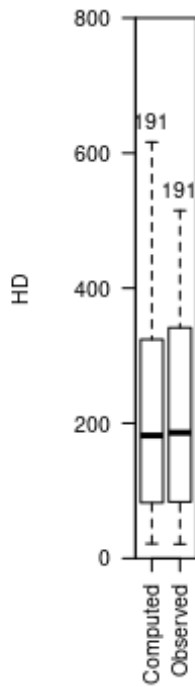
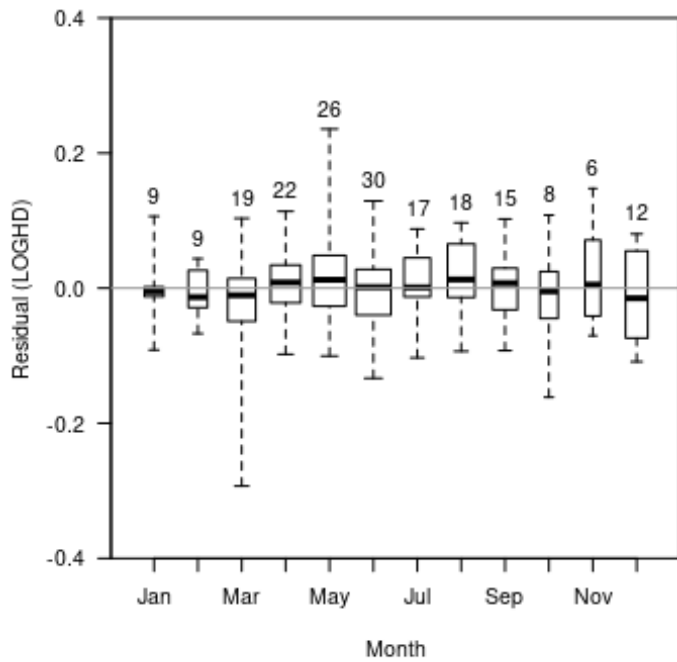
Leverage	Cook's D	DFFITS
0.0314	0.1946	0.2047

## Flagged Observations

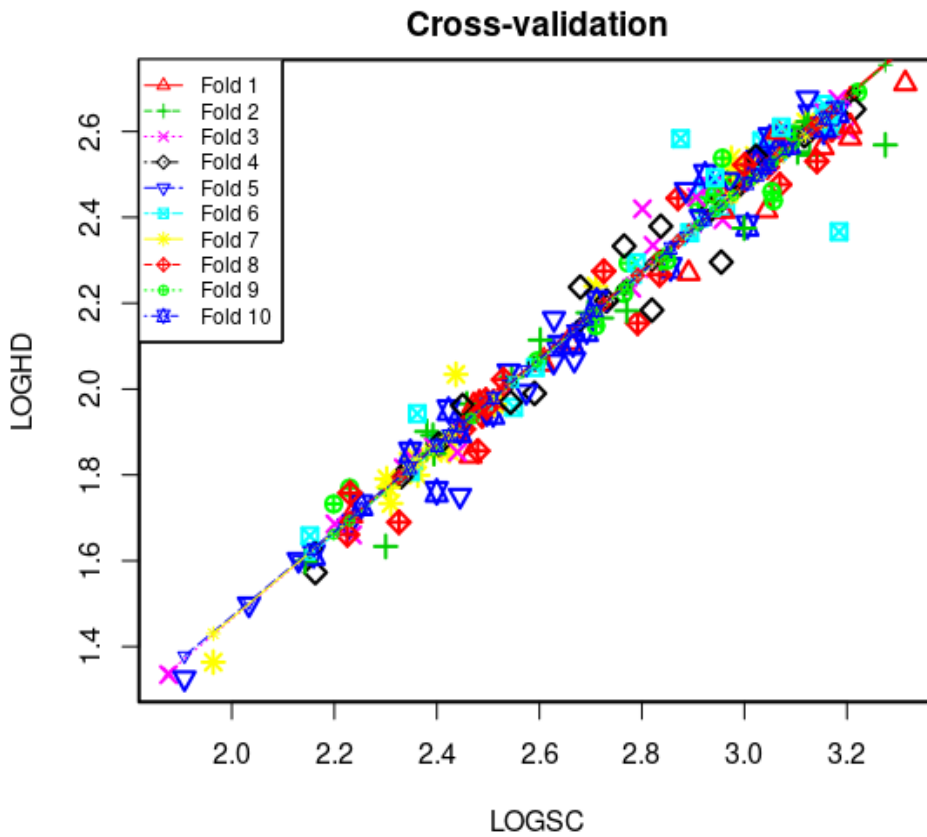
	LOGHD	Estimate	Residual	Standard Residual	Studentized Residual	Leverage	Cook's D	DFFITS
10/1/1998 11:20	1.75	1.91	-0.16100	-2.6300	-2.6700	0.00921	0.032100	-0.2580
6/22/2001 10:35	1.63	1.77	-0.13300	-2.1800	-2.2000	0.01410	0.034000	-0.2630
5/26/2005 12:00	2.58	2.35	0.23600	3.8400	3.9800	0.00612	0.045300	0.3120
5/25/2007 10:20	1.36	1.43	-0.06360	-1.0500	-1.0500	0.03300	0.018800	-0.1940
6/16/2009 10:20	2.03	1.91	0.12900	2.1000	2.1200	0.00942	0.021100	0.2070
3/12/2013 9:30	2.37	2.66	-0.29300	-4.7900	-5.0900	0.01450	0.169000	-0.6180
3/13/2013 11:50	2.57	2.75	-0.18200	-2.9800	-3.0400	0.01860	0.084000	-0.4190
7/30/2013 10:15	1.33	1.34	-0.00463	-0.0766	-0.0764	0.03960	0.000121	-0.0155
12/14/2015 10:35	1.33	1.37	-0.04410	-0.7290	-0.7280	0.03720	0.010300	-0.1430

# Statistical Plots

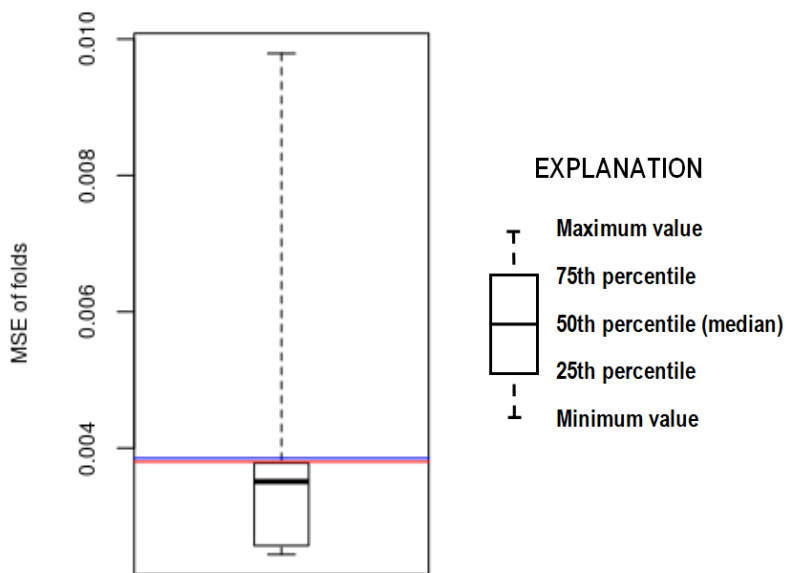




# Cross Validation



Minimum MSE of folds: 0.00244  
Mean MSE of folds: 0.00385  
Median MSE of folds: 0.00351  
Maximum MSE of folds: 0.00979  
(Mean MSE of folds) / (Model MSE): 1.01000



Red line - Model MSE

Blue line - Mean MSE of folds



## Model-Calibration Dataset

	Date	LOGHD	LOGSC	HD	SC	Computed LOGHD	Computed HD	Residual	Normal Quantiles
1	5/12/1998	2.42	3.04	261	1100	2.52	332	-0.1	-1.64
2	5/14/1998	1.73	2.31	54.1	204	1.78	60.4	-0.0436	-0.892
3	6/15/1998	2.54	3.04	350	1100	2.52	331	0.0279	0.551
4	6/25/1998	2.39	2.96	248	907	2.43	272	-0.0356	-0.745
5	7/13/1998	2.11	2.66	128	458	2.13	136	-0.022	-0.551
6	9/14/1998	2.5	3.01	317	1030	2.49	310	0.0145	0.211
7	10/1/1998	1.75	2.45	56.4	279	1.91	82.7	-0.161	-2.21
8	10/22/1998	2.06	2.61	114	406	2.08	121	-0.0198	-0.491
9	11/6/1998	1.66	2.24	45.7	172	1.7	50.8	-0.0413	-0.854
10	12/3/1998	2.48	2.99	305	978	2.46	294	0.0202	0.362
11	1/6/1999	2.69	3.22	491	1660	2.7	502	-0.00483	-0.171
12	2/1/1999	1.88	2.42	75.6	266	1.89	78.7	-0.0133	-0.404
13	2/19/1999	2.65	3.13	442	1340	2.6	403	0.0437	0.854
14	3/11/1999	2.63	3.16	424	1460	2.64	439	-0.0108	-0.279
15	4/7/1999	2.23	2.78	172	603	2.25	180	-0.0166	-0.462
16	5/20/1999	2.54	3.02	350	1040	2.49	314	0.0519	0.994
17	5/24/1999	1.8	2.36	63	231	1.83	68.3	-0.0305	-0.678
18	7/19/1999	1.68	2.23	48	169	1.69	49.9	-0.0129	-0.376
19	8/4/1999	1.7	2.23	50.7	171	1.7	50.5	0.0059	0.0525
20	9/28/1999	1.57	2.16	37.4	145	1.63	42.9	-0.0556	-0.994
21	2/8/2000	2.6	3.15	399	1430	2.63	430	-0.0288	-0.613
22	3/6/2000	1.85	2.39	70.9	247	1.86	73.3	-0.0105	-0.265
23	3/27/2000	1.88	2.4	75.6	252	1.87	74.7	0.00945	0.0919
24	5/19/2000	2.62	3.12	419	1320	2.59	396	0.0279	0.566
25	5/30/2000	2.06	2.63	116	424	2.1	126	-0.0333	-0.728
26	6/26/2000	1.94	2.51	87.5	323	1.98	96.1	-0.0365	-0.78
27	7/19/2000	2.51	3.01	327	1030	2.48	308	0.0302	0.582
28	7/27/2000	2.07	2.6	116	394	2.07	117	0.000388	-0.0393
29	8/15/2000	2.53	3.03	341	1080	2.51	324	0.0259	0.491
30	9/7/2000	2.52	3.04	329	1110	2.52	333	-0.000607	-0.0787
31	9/25/2000	2.56	3.08	362	1200	2.55	360	0.00747	0.0787
32	10/27/2000	1.99	2.59	97.7	389	2.06	116	-0.0699	-1.24
33	11/30/2000	2.6	3.2	402	1580	2.67	477	-0.0703	-1.27
34	3/13/2001	1.96	2.55	90.6	355	2.02	105	-0.0617	-1.06
35	4/12/2001	2.29	2.77	197	593	2.24	177	0.0497	0.973
36	4/26/2001	2.62	3.15	415	1410	2.62	424	-0.00534	-0.185
37	5/9/2001	2.65	3.21	449	1640	2.69	493	-0.0371	-0.798
38	6/1/2001	2.38	3.01	240	1010	2.48	304	-0.0985	-1.59
39	6/11/2001	1.89	2.39	78	247	1.86	73.1	0.0321	0.597
40	6/22/2001	1.63	2.3	43	200	1.77	59	-0.133	-2.08
41	7/12/2001	2.5	2.99	319	968	2.46	290	0.0449	0.873
42	8/1/2001	2.54	3.13	350	1340	2.6	403	-0.0563	-1.02
43	8/30/2001	2.53	3.14	339	1380	2.62	417	-0.0852	-1.33
44	9/18/2001	1.69	2.2	48.5	159	1.67	46.9	0.019	0.32
45	10/30/2001	2.53	3.05	342	1110	2.52	333	0.0155	0.238
46	1/9/2002	2.6	3.17	402	1480	2.64	446	-0.041	-0.835
47	2/20/2002	2.56	3.15	365	1420	2.63	428	-0.0641	-1.11
48	4/10/2002	2.6	3.13	403	1350	2.6	406	0.000341	-0.0525
49	4/22/2002	1.83	2.34	67.9	221	1.81	65.3	0.0211	0.376
50	5/14/2002	2.17	2.72	146	526	2.19	157	-0.0266	-0.582
51	5/23/2002	2.24	2.71	174	513	2.18	153	0.0593	1.04
52	6/6/2002	2.57	3.07	367	1170	2.54	352	0.0234	0.447
53	6/17/2002	1.61	2.16	41.1	144	1.63	42.6	-0.0115	-0.306

54	7/9/2002	2.47	2.92	292	830	2.39	249	0.0739	1.43
55	8/20/2002	2.13	2.69	136	493	2.16	147	-0.0278	-0.597
56	9/18/2002	2.48	3.07	300	1170	2.54	352	-0.0664	-1.13
57	12/17/2002	2.71	3.31	515	2060	2.79	622	-0.0779	-1.3
58	3/24/2003	2.03	2.55	107	351	2.01	104	0.0139	0.171
59	4/16/2003	2.61	3.17	412	1480	2.64	446	-0.0305	-0.661
60	4/22/2003	2.28	2.86	191	718	2.33	215	-0.0455	-0.932
61	5/15/2003	1.96	2.5	92.2	315	1.97	93.5	-0.00221	-0.145
62	5/28/2003	2.18	2.7	151	496	2.17	148	0.0125	0.158
63	6/10/2003	2.42	2.94	262	862	2.41	258	0.011	0.131
64	6/24/2003	2.59	3.21	385	1610	2.68	484	-0.0956	-1.51
65	7/30/2003	2.55	3.1	357	1270	2.58	382	-0.0255	-0.566
66	9/2/2003	1.86	2.48	71.8	302	1.95	89.6	-0.0924	-1.43
67	10/15/2003	1.81	2.35	64.2	223	1.82	66.1	-0.00821	-0.211
68	12/11/2003	2.61	3.21	409	1610	2.68	485	-0.0699	-1.21
69	3/9/2004	1.82	2.33	65.5	216	1.8	63.9	0.0148	0.225
70	3/29/2004	2.56	3.07	362	1170	2.54	352	0.0167	0.265
71	4/26/2004	2.66	3.16	460	1430	2.63	431	0.0332	0.629
72	5/13/2004	2.22	2.76	167	581	2.24	174	-0.0127	-0.362
73	5/26/2004	2.45	2.96	282	907	2.43	272	0.0193	0.334
74	6/16/2004	2.47	2.97	293	928	2.44	278	0.0262	0.506
75	6/21/2004	1.99	2.57	98.6	375	2.04	112	-0.0496	-0.952
76	7/26/2004	1.5	2.03	31.5	108	1.5	31.8	0.0011	-0.0131
77	1/28/2005	2.11	2.64	128	435	2.11	130	-0.000483	-0.0656
78	3/25/2005	1.97	2.5	94.3	313	1.96	92.9	0.0107	0.118
79	5/11/2005	2.59	3.12	389	1310	2.59	394	-0.000732	-0.0919
80	5/26/2005	2.58	2.88	383	751	2.35	225	0.236	2.73
81	6/7/2005	2.04	2.54	110	347	2.01	103	0.033	0.613
82	6/14/2005	1.8	2.33	62.5	214	1.8	63.3	-0.0013	-0.131
83	8/31/2005	2.11	2.6	130	400	2.07	119	0.0432	0.816
84	2/7/2006	2.54	3.04	348	1100	2.51	330	0.0265	0.536
85	6/8/2006	2.27	2.83	185	683	2.31	204	-0.0397	-0.816
86	6/26/2006	1.97	2.51	93	324	1.98	96.2	-0.0104	-0.252
87	7/28/2006	1.9	2.38	79.6	240	1.85	71.1	0.0534	1.02
88	8/23/2006	2.16	2.63	146	425	2.1	127	0.0656	1.24
89	9/27/2006	2.3	2.84	199	686	2.31	205	-0.00899	-0.225
90	1/10/2007	2.44	3.06	275	1140	2.53	343	-0.0914	-1.39
91	1/30/2007	2.42	2.96	265	920	2.44	276	-0.0125	-0.348
92	3/12/2007	2.33	2.82	216	663	2.29	198	0.0416	0.763
93	3/21/2007	2.21	2.73	161	538	2.2	161	0.0038	0.0131
94	3/27/2007	1.84	2.47	69.9	292	1.93	86.7	-0.0895	-1.36
95	4/18/2007	1.86	2.42	72.2	263	1.89	78	-0.0293	-0.629
96	5/25/2007	1.36	1.96	23.1	92	1.43	27	-0.0636	-1.08
97	7/11/2007	1.69	2.33	49	212	1.79	62.7	-0.103	-1.7
98	8/13/2007	2.49	2.98	312	952	2.45	286	0.0424	0.78
99	9/5/2007	2.53	3.02	343	1050	2.49	314	0.0414	0.745
100	11/27/2007	2.58	3.03	379	1080	2.51	324	0.0713	1.36
101	12/4/2007	2.6	3.08	396	1190	2.55	358	0.0483	0.932
102	12/12/2007	1.76	2.4	57.6	251	1.87	74.4	-0.106	-1.75
103	3/4/2008	1.86	2.42	71.7	266	1.89	78.8	-0.0364	-0.763
104	4/14/2008	2.21	2.71	160	515	2.18	154	0.023	0.433
105	5/29/2008	1.94	2.49	86.6	308	1.96	91.3	-0.0187	-0.476
106	6/30/2008	1.94	2.47	86.9	293	1.93	86.8	0.0044	0.0393
107	9/16/2008	1.87	2.4	74.5	253	1.87	75.1	0.000887	-0.0262
108	10/17/2008	1.77	2.31	59	202	1.77	59.7	-0.00118	-0.105
109	4/1/2009	2.15	2.71	140	513	2.18	153	-0.0333	-0.711

110	4/6/2009	2.43	2.91	269	813	2.38	244	0.0481	0.912
111	4/13/2009	2.29	2.79	197	615	2.26	184	0.0343	0.661
112	4/30/2009	1.97	2.46	92.4	287	1.93	85.3	0.0388	0.711
113	5/12/2009	1.95	2.42	89.3	265	1.89	78.5	0.0603	1.06
114	6/16/2009	2.03	2.44	108	274	1.91	81.2	0.129	2.21
115	7/30/2009	2.24	2.68	173	478	2.15	143	0.0876	1.59
116	11/2/2009	1.96	2.47	91.5	296	1.94	87.9	0.0216	0.39
117	12/1/2009	2.58	3.05	384	1120	2.52	336	0.0621	1.13
118	12/17/2009	2.64	3.16	441	1430	2.63	431	0.0142	0.185
119	1/6/2010	2.64	3.18	442	1520	2.66	458	-0.0116	-0.32
120	1/19/2010	2.68	3.18	473	1520	2.66	458	0.0187	0.306
121	2/11/2010	2.61	3.16	407	1430	2.63	432	-0.0212	-0.521
122	2/23/2010	2.59	3.09	389	1230	2.56	370	0.0263	0.521
123	4/13/2010	2.62	3.12	420	1330	2.6	400	0.0248	0.476
124	6/1/2010	2.36	2.89	231	782	2.37	234	-0.00126	-0.118
125	6/15/2010	1.84	2.36	69.5	228	1.83	67.5	0.0169	0.279
126	7/7/2010	1.6	2.14	39.7	139	1.61	41	-0.00986	-0.238
127	8/19/2010	2.45	2.91	280	806	2.38	241	0.0684	1.3
128	8/25/2010	1.84	2.35	69	225	1.82	66.6	0.0199	0.348
129	11/16/2010	2.05	2.59	112	391	2.06	116	-0.0109	-0.293
130	1/19/2011	2.64	3.16	437	1460	2.64	440	0.00182	0
131	3/7/2011	2.51	2.98	327	951	2.45	285	0.063	1.16
132	5/16/2011	2.57	3.09	374	1220	2.56	367	0.0122	0.145
133	6/20/2011	2.3	2.95	198	901	2.43	270	-0.132	-1.98
134	8/11/2011	1.77	2.23	58.8	170	1.7	50.1	0.0736	1.39
135	9/22/2011	1.85	2.44	71.3	275	1.91	81.7	-0.0552	-0.973
136	12/21/2011	2.15	2.79	142	619	2.26	185	-0.109	-1.89
137	3/1/2012	1.66	2.23	45.8	168	1.69	49.6	-0.0306	-0.694
138	4/18/2012	1.94	2.5	88	315	1.97	93.4	-0.0216	-0.536
139	5/29/2012	2.49	2.97	307	936	2.44	281	0.0431	0.798
140	6/18/2012	2.18	2.82	153	660	2.29	197	-0.107	-1.82
141	3/12/2013	2.37	3.18	232	1530	2.66	461	-0.293	-2.73
142	3/13/2013	2.57	3.27	370	1880	2.75	568	-0.182	-2.39
143	4/29/2013	2.37	3	237	999	2.47	300	-0.0978	-1.55
144	6/3/2013	2.11	2.67	127	463	2.14	138	-0.0304	-0.645
145	7/30/2013	1.33	1.88	21.6	75.2	1.34	22.1	-0.00463	-0.158
146	10/30/2013	2.53	3.03	341	1060	2.5	318	0.0338	0.645
147	4/9/2014	2.6	3.06	397	1160	2.54	349	0.061	1.08
148	6/4/2014	2.4	2.91	252	822	2.39	246	0.0143	0.198
149	6/12/2014	1.66	2.15	45.5	142	1.62	41.9	0.0402	0.728
150	8/28/2014	2.27	2.89	186	778	2.36	233	-0.0934	-1.47
151	9/4/2014	1.79	2.3	61.8	201	1.77	59.3	0.0223	0.404
152	12/10/2014	2.68	3.12	476	1330	2.6	399	0.0803	1.55
153	2/25/2015	2.59	3.1	393	1250	2.57	377	0.0225	0.418
154	4/7/2015	2.61	3.12	405	1310	2.59	394	0.0165	0.252
155	4/20/2015	1.96	2.51	92.2	325	1.98	96.6	-0.0161	-0.433
156	5/28/2015	1.73	2.25	53.6	179	1.72	52.9	0.0103	0.105
157	7/14/2015	2.3	2.85	200	706	2.32	211	-0.0205	-0.506
158	8/6/2015	1.87	2.39	73.3	247	1.86	73.3	0.00428	0.0262
159	8/27/2015	1.85	2.39	70.7	248	1.86	73.5	-0.0122	-0.334
160	12/14/2015	1.33	1.91	21.2	80.8	1.37	23.7	-0.0441	-0.912
161	5/2/2016	1.97	2.48	92.9	304	1.95	90.2	0.0169	0.293
162	6/1/2016	2.02	2.53	105	339	2	101	0.0235	0.462
163	6/16/2016	2.27	2.73	188	532	2.2	159	0.0785	1.51
164	7/5/2016	1.6	2.13	40	135	1.6	39.8	0.00697	0.0656
165	8/10/2016	1.91	2.45	80.7	283	1.92	84	-0.0136	-0.418

166	9/12/2016	1.85	2.35	71.2	223	1.82	66	0.0371	0.678
167	3/30/2017	1.9	2.44	79.4	279	1.91	82.6	-0.0132	-0.39
168	5/3/2017	1.96	2.45	91.5	282	1.92	83.7	0.0432	0.835
169	5/30/2017	2.47	2.94	297	862	2.41	258	0.0644	1.21
170	6/27/2017	2.54	3.02	348	1050	2.5	316	0.0464	0.892
171	7/12/2017	2.45	2.94	283	876	2.41	262	0.0378	0.694
172	8/1/2017	2.33	2.77	215	583	2.24	174	0.0969	1.7
173	8/17/2017	2.38	2.84	239	687	2.31	205	0.0707	1.33
174	9/5/2017	2.44	2.87	278	742	2.34	222	0.102	1.75
175	11/14/2017	2.42	2.8	263	632	2.27	189	0.148	2.39
176	1/30/2018	2.46	2.89	291	769	2.36	230	0.106	1.89
177	3/21/2018	2.5	2.92	316	838	2.4	251	0.103	1.82
178	5/1/2018	2.54	2.97	345	943	2.45	283	0.0905	1.64
179	5/22/2018	2.52	3	333	1000	2.47	301	0.0485	0.952
180	6/2/2018	1.97	2.54	93.1	350	2.01	104	-0.0434	-0.873
181	7/18/2018	1.73	2.2	54	158	1.66	46.6	0.068	1.27
182	9/6/2018	1.76	2.23	57.2	170	1.7	50.2	0.0613	1.11
183	12/3/2018	2.18	2.77	152	589	2.24	176	-0.059	-1.04
184	2/26/2019	2.46	3.05	288	1130	2.53	340	-0.0671	-1.16
185	3/14/2019	2.07	2.67	117	466	2.14	139	-0.0691	-1.18
186	4/10/2019	2.41	2.96	260	909	2.43	273	-0.0166	-0.447
187	4/29/2019	1.94	2.36	87.7	230	1.83	68.1	0.114	2.08
188	6/11/2019	2.49	2.94	311	876	2.41	263	0.0772	1.47
189	8/21/2019	1.96	2.5	90.8	314	1.97	93.3	-0.00769	-0.198
190	10/8/2019	2.54	2.96	345	906	2.43	272	0.108	1.98
191	12/10/2019	2.61	3.07	407	1180	2.55	355	0.0643	1.18

## Definitions

HD: Total hardness -- SDWA NPDWR in mg/L CaCO<sub>3</sub> (00900)

SC: Specific conductance in  $\mu\text{S}/\text{cm}$  @25C (00095)

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