

Model Archive Summary for Suspended-Sediment Concentration at Station 05374900; Zumbro River at Kellogg, Minnesota

This model archive summary (MAS) documents the suspended-sediment concentration (SSC) model developed to compute 15-minute SSC from turbidity readings. This is the first model developed for the site.

SITE AND MODEL INFORMATION

Site number: 05374900

Site name: Zumbro River at Kellogg, Minnesota (MN), Wabasha County

Location: Latitude N 44°18'43", Longitude W 92°00'17", referenced to NAD27

Hydrologic Unit: 07040004

Drainage area: 1,400 square miles

Date rating model was created: 1/3/2017

Model calibration data period: 8/3/2010–9/23/2016

Model application date: 4/1/2017

Computed by: Joel Grotten (jgrotten@usgs.gov), Hydrologist, Minnesota Water Science Center

Reviewed by: Chris Ellison (cellison@usgs.gov), Supervisory Hydrologist, Wyoming-Montana Water Science Center

Reviewed by: Jeffrey Ziegeweid (jrziege@usgs.gov), Hydrologist, Minnesota Water Science Center

Approved by: James Stark (stark@usgs.gov), Center Director, Minnesota Water Science Center

Additional Information

Type	Scheme	Key
doi	http://dx.doi.org	doi:10.5066/F75B00Q1
IPDS	https://ipds.usgs.gov	IP-085867

PHYSICAL SAMPLING EQUIPMENT AND SAMPLING DETAILS

Samples were collected 7–10 times per year during the open-water season (April through September) throughout the range of continuously observed hydrologic conditions. No samples were collected during the winter months because sediment transport is low (Tornes, 1986) in Minnesota when streamflow (Q) is generally contained under ice and receives little sediment input from the surrounding landscape. Water samples were collected using isokinetic samplers and equal-width-increment (EWI) and depth-integrating techniques, following procedures by Edwards and Glysson (1999). Most samples were collected using a D-74 rigid bottle sampler suspended from the downstream side of the U.S. Highway 61 Bridge. The total stream width was divided into 10 equal-width increments, and individual depth-integrated samples were collected at the centroid of each increment. Following collection, samples were transported to the USGS Sediment Laboratory in Iowa City, Iowa, where they were composited into a single sample and analyzed for suspended-sediment concentration (SSC) and particle-size fractions less than 0.0625 millimeters (fines). Analyses results were stored in the National Water Information System (NWIS) database (U.S. Geological Survey, 2017) and can be found at <http://mn.water.usgs.gov>.

SURROGATE EQUIPMENT AND SETUP DETAILS

A Forest Technology Systems DTS-12 digital turbidity sensor is installed at the site. The turbidity sensor is suspended from the downstream side of the U.S. Highway 61 Bridge and is positioned to collect turbidity readings in the

thalweg. The depth of the turbidity sensor in the water column may be adjusted by adjusting the chain length to keep the bottom of the sensor a few feet under water. The battery and datalogger are located in an enclosure on the upper part of the right bank on the downstream side of the bridge. The streamgage is maintained by the Minnesota Department of Natural Resources (DNR).

Turbidity Sensor Manufactured characteristics and configuration	
Make	Forest Technology Systems (FTS)
Model	DTS-12 Digital Turbidity Sensor
Serial number	039763 (installed in 2010) 037177 (installed in 2015 after 039763 cable broke)
Sensor Type	Optical nephelometer (sidescatter)
Range	0 to 1,600 FNU (nominal)
Accuracy (@ 25°C)	± 2% of reading + 0.2 FNU (0–399 FNU) ± 4% of reading (400–1,600 FNU)
Resolution	0.01 FNU
Operating Temperature	+32°F to 104°F
Measurement interval	900 sec
Measurement returned	Mean from 100 instantaneous samples at a sample rate of 20 Hz

MODEL-CALIBRATION DATASET

All turbidity and SSC data are stored in the National Water Information System (NWIS) database (U.S. Geological Survey, 2017). The complete water-quality record can be found at <http://mn.water.usgs.gov>. Streamflow data is stored in the DNR/Minnesota Pollution Control Agency Cooperate Stream Gaging website at <http://www.dnr.state.mn.us/waters/csg/index.html> (Minnesota Department of Natural Resouces, 2017). The regression model dataset considered 47 concurrent measurements of SSC and turbidity (TURB) data collected from 8/3/2010 through 9/23/2016. Out of the 47 samples collected during the period while the turbidity sensor was deployed, only 2 SSC values were not considered for data analysis because samples contained too low of a percentage of suspended-sediment smaller than 0.0625 millimeters (fines). These 2 SSC values were considered outliers (only eight percent of the mass of from samples collected on 7/12/2013 and 7/15/2014 consisted of particles less than 0.0625 millimeters in diameter) because of high concentrations of sands compared to fines. Outliers most likely resulted from inadvertently sampling the bottom of the channel by not reversing the sampler quickly enough and inadvertently contaminating the sample.

The model was initially calibrated using 45 SSC values. This analysis indicated no relation between turbidity and SSC when turbidity values were less than 11.5 FNU. Nine samples with values less than 11.5 FNU were removed from the dataset. This resulted in 36 paired SSC and turbidity values.

Because a sampling event usually takes longer than the 15-minute interval between turbidity measurements, the turbidity values used for model development were an average of 5 turbidity values: the turbidity value closest to when the SSC was collected (start time), 15-minutes after, 30-minutes after, 45-minutes after, and 60-minutes after.

MODEL DEVELOPMENT

An ordinary linear least squares regression analysis was carried out in the R open source environment (R Development Core Team, 2011), using different combinations of untransformed (Appendix 1) and \log_{10} -transformed data. SSC concentrations were evaluated for normal distribution of the data and potential outliers. The outlier test criteria flagged potential outliers and were further investigated. The only w outliers (7/12/2013 and 7/15/2014) removed were due to the high concentrations of sand. The distribution of residuals were examined for normality, and plots of residuals (the difference between the measured and predicted values) as compared to predicted SSC were examined for

homoscedasticity (meaning that their departures from zero did not change substantially over the range of predicted values). This comparison indicated that the data were not normally distributed and led to the conclusion that the most appropriate and reliable model would be one that estimated $\log_{10}(\text{SSC})$. An ordinary linear least squares regression analysis with \log_{10} -transformed data was performed. $\log_{10}(\text{TURB})$ and $\log_{10}(Q)$ were selected as the best predictors of $\log_{10}(\text{SSC})$ based on residual plots, relatively high adjusted coefficient of determination (adjusted R^2), and relatively low model standard percentage error (MSPE). Values of the aforementioned statistics and metrics were computed and are included below, along with all relevant sample data and more in-depth statistical information. The final model was chosen because at the highest measured SSC values, the predicted SSCs were closer to the measured than just using $\log_{10}(\text{TURB})$ (Appendix 2).

MODEL SUMMARY

Summary of final regression analysis for suspended-sediment concentration at site number 05374900. In the figures and tables below, the “log” in the R outputs refers to “ \log_{10} ”. Suspended-sediment concentration-based model:
 $\log_{10}(\text{SSC}) = [(0.709)\log_{10}(\text{TURB})] + [(0.138)\log_{10}(Q)] + 0.592$,

where

SSC = suspended-sediment concentration, in milligrams per liter (mg/L);

TURB = Turbidity, in formazin nephelometric units (FNU); and,

Q = Streamflow, in cubic feet per second (cfs).

The use of turbidity as an explanatory variable is appropriate physically and statistically. Turbidity makes sense physically because suspended sediment is composed of particles that scatter light in water. Streamflow makes sense physically because higher volumes of water tend to dilute these particles. The relation between turbidity and SSC can vary given varying concentrations of organic suspended particles that increase turbidity, but analysis of organic suspended particles was not included in the SSC analysis. The log-transformed model may be retransformed to the original units so that SSC 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 1.03. The retransformed model, accounting for BCF is:

$$\text{SSC} = 3.91 \times \text{TURB}^{0.709} \times Q^{0.138} \times 1.03.$$

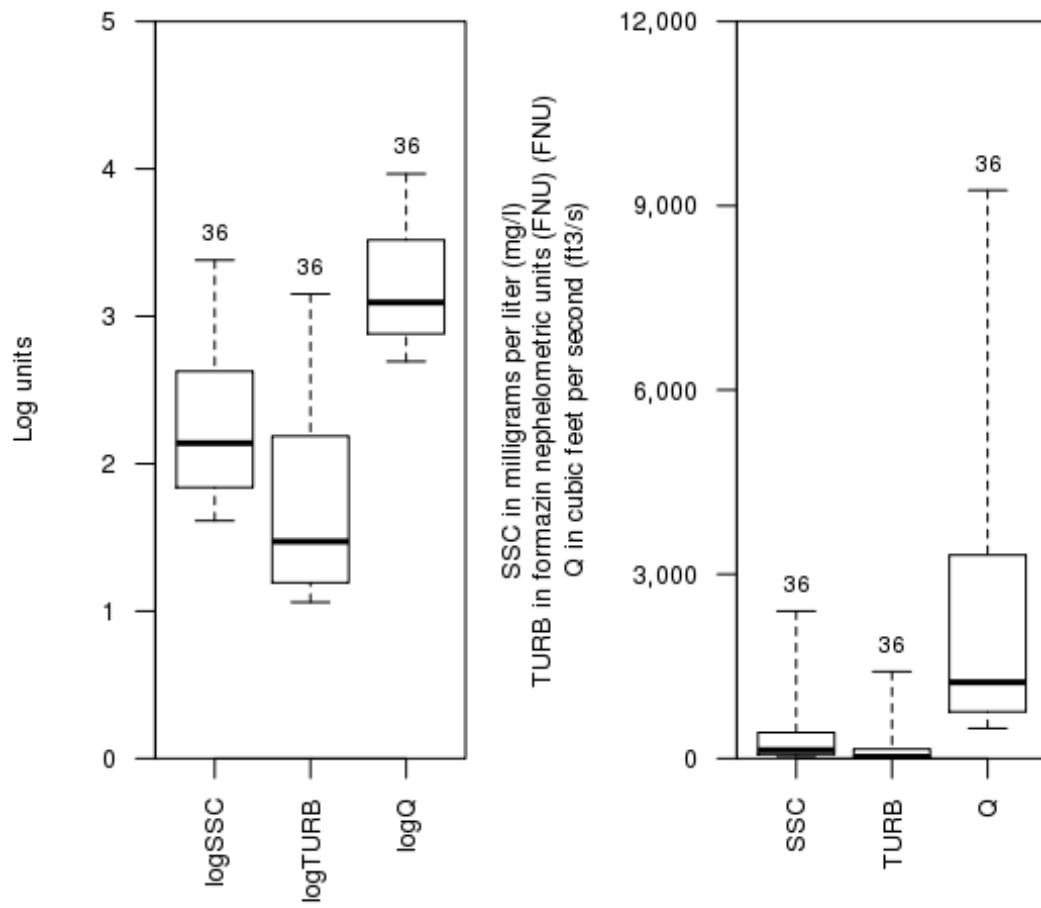
Model Statistics, Data, and Plots (In the figures and tables below, the “log” in the R outputs refers to “ \log_{10} ”)

Model

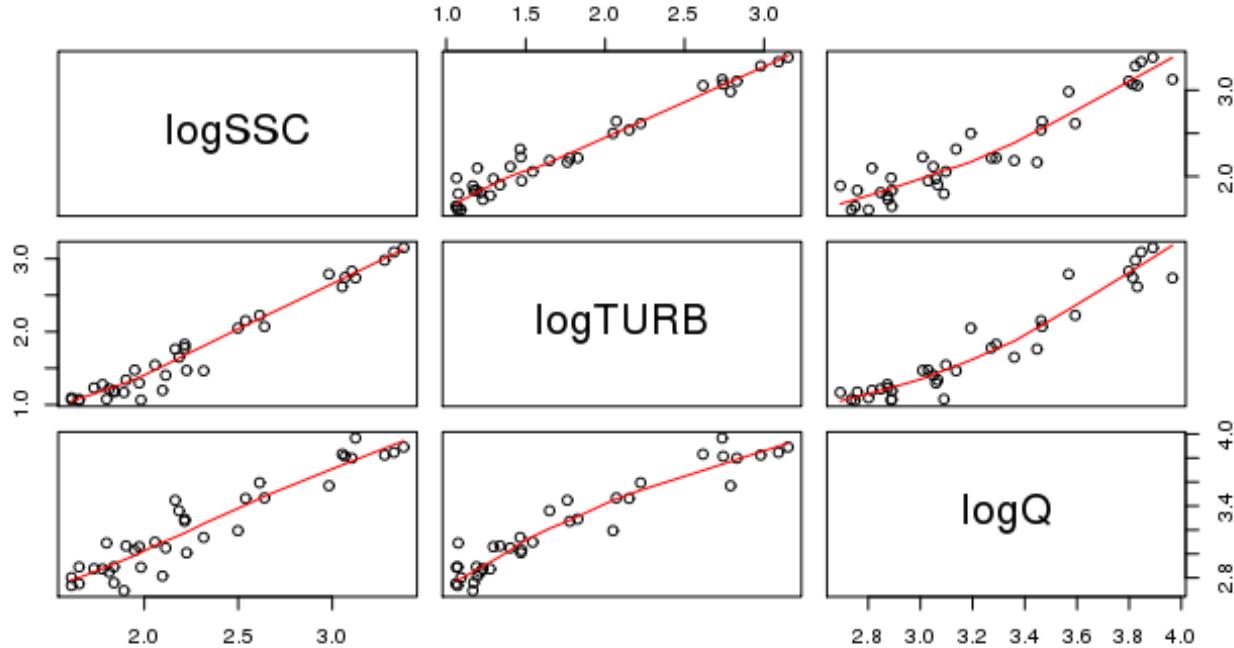
$\log_{10}(\text{SSC}) = [(0.709)\log_{10}(\text{TURB})] + [(0.138)\log_{10}(Q)] + 0.592$

	logSSC	SSC	logTURB	logQ	TURB	Q
Minimum	1.61	41	1.06	2.69	11.5	493
1st Quartile	1.84	69	1.19	2.88	15.6	761
Median	2.14	138	1.47	3.09	29.6	1240
Mean	2.28	449	1.76	3.22	210.0	2540
3rd Quartile	2.63	423	2.19	3.52	154.0	3310
Maximum	3.38	2400	3.15	3.97	1420.0	9250

Box Plots



Exploratory Plots



Basic Model Statistics

Number of Observations	36
Standard error (RMSE)	0.114
Average Model standard percentage error (MSPE)	26.5
Coefficient of determination (R^2)	0.96
Adjusted Coefficient of Determination (Adj. R^2)	0.957
Bias Correction Factor (BCF)	1.03

Variance Inflation Factors (VIF)

logTURB	logQ
11.3	11.3

Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t)
(Intercept)	0.592	0.3720	1.590	1.21e-01
logTURB	0.709	0.0945	7.510	1.23e-08
logQ	0.138	0.1640	0.844	4.05e-01

Correlation Matrix

	Intercept	logTURB	logQ
Intercept	1.000	0.906	-0.990
logTURB	0.906	1.000	-0.955
logQ	-0.990	-0.955	1.000

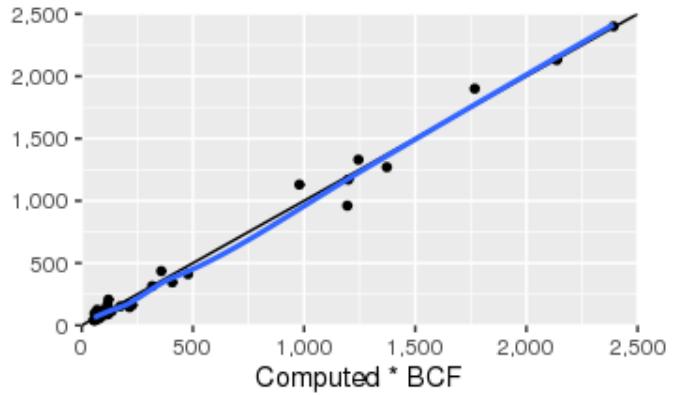
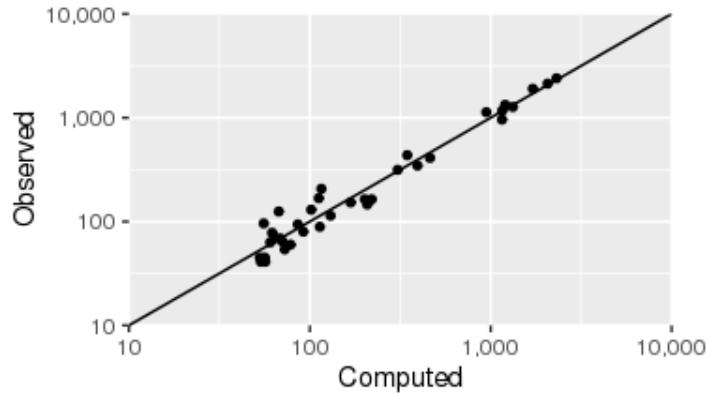
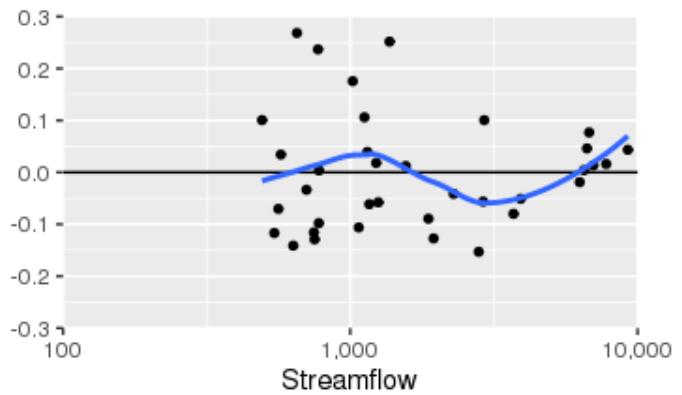
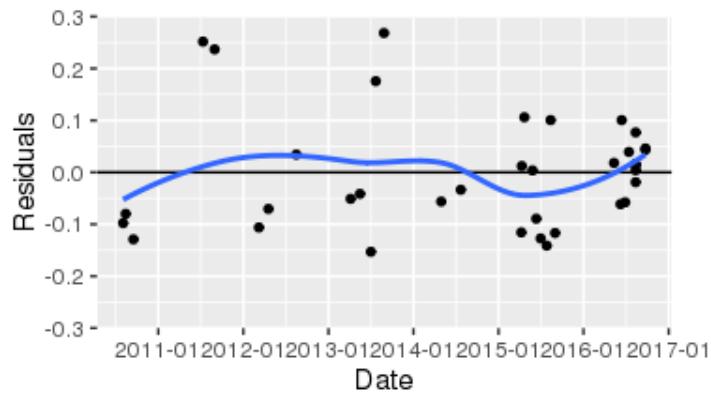
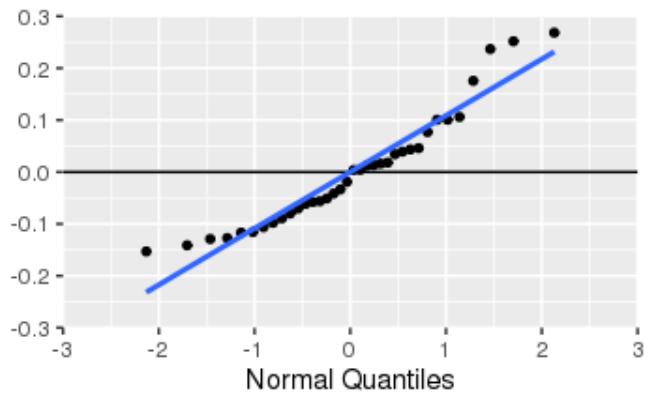
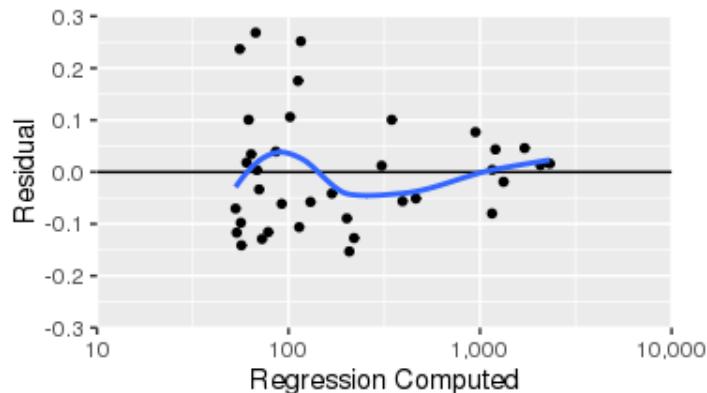
Outlier Test Criteria

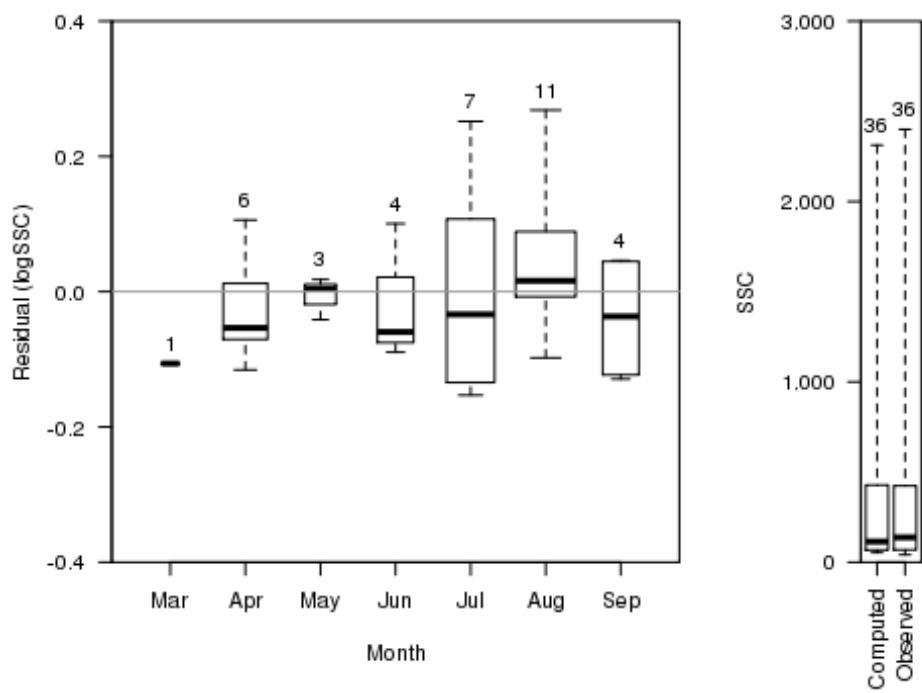
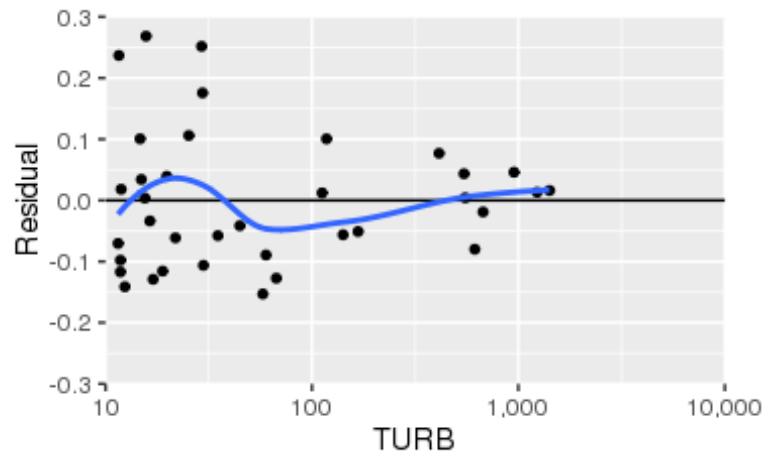
Leverage	Cook's D	DFFITS
0.167	0.194	0.471

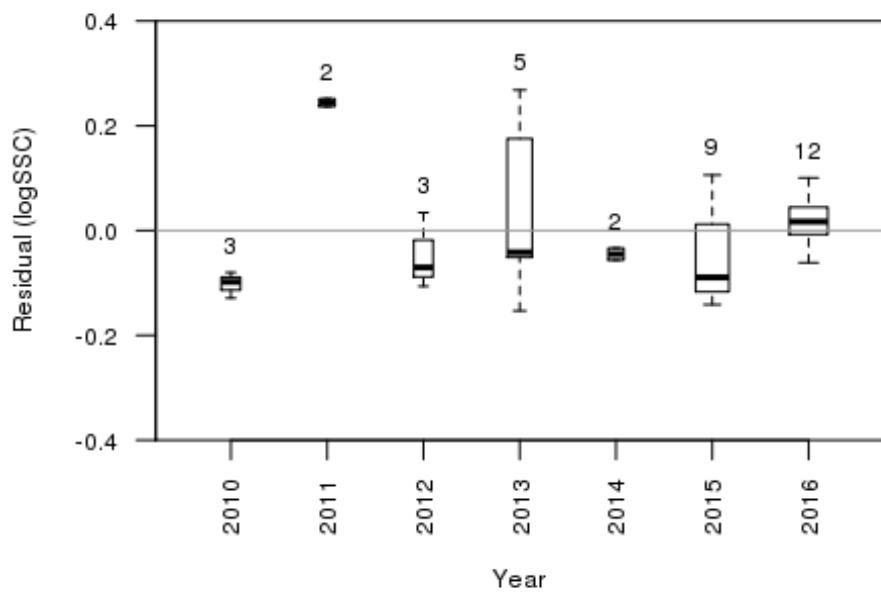
Flagged Observations

	logSSC	Estimate	Residual	Standard Residual	Studentized Residual	Leverage	Cook's D	DFFITS
8/14/2010 12:15	2.98	3.06	-0.0799	-0.782	-0.778	0.1940	0.04900	-0.3810
7/12/2011 14:00	2.32	2.06	0.2520	2.270	2.430	0.0453	0.08110	0.5290
8/31/2011 12:00	1.98	1.75	0.2370	2.150	2.280	0.0621	0.10200	0.5880
7/1/2013 19:45	2.16	2.32	-0.1530	-1.440	-1.470	0.1310	0.10500	-0.5710
8/27/2013 13:30	2.10	1.83	0.2680	2.440	2.660	0.0665	0.14200	0.7090
5/11/2016 17:15	1.80	1.78	0.0181	0.176	0.173	0.1810	0.00228	0.0815
9/23/2016 12:00	3.12	3.08	0.0435	0.421	0.415	0.1730	0.01240	0.1900

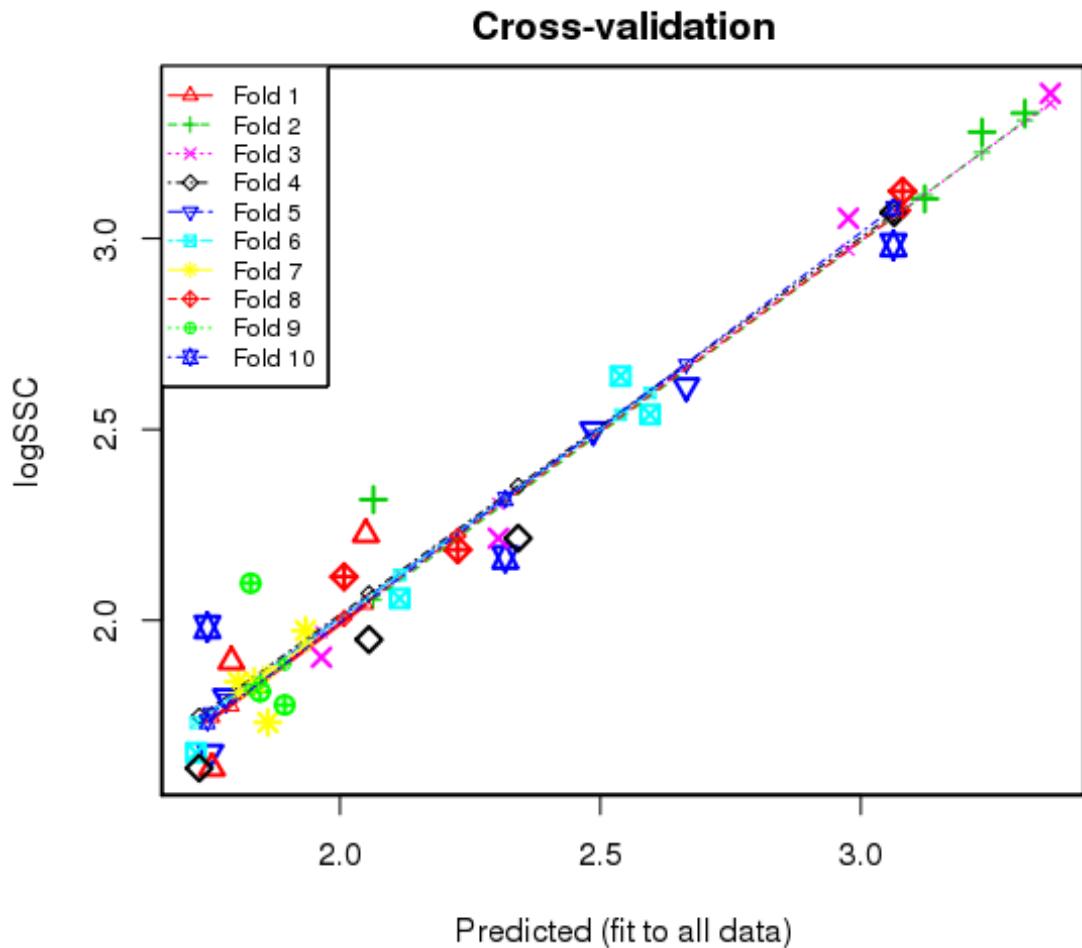
Statistical Plots







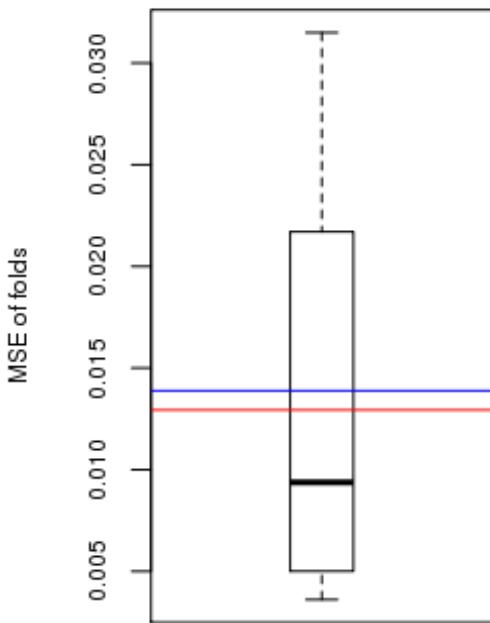
Cross-Validation



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Minimum MSE of folds: 0.00361
Mean MSE of folds: 0.01390
Median MSE of folds: 0.00938
Maximum MSE of folds: 0.03150
(Mean MSE of folds) / (Model MSE): 1.07000

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Red line - Model MSE

Blue line - Mean MSE of folds

Model-Calibration Data Set

0	Date	logSSC	logTURB	logQ	SSC	TURB	Q	Computed logSSC	Computed SSC	Residual	Normal Quantiles
1	8/3/2010	1.65	1.07	2.89	45	11.8	777	1.75	58.3	-0.0978	-0.807
2	8/14/2010	2.98	2.79	3.57	961	615	3700	3.06	1190	-0.0799	-0.627
3	9/16/2010	1.73	1.23	2.88	54	17	751	1.86	75.2	-0.129	-1.46
4	7/12/2011	2.32	1.47	3.14	207	29.2	1370	2.06	120	0.252	1.7
5	8/31/2011	1.98	1.06	2.89	96	11.6	772	1.75	57.5	0.237	1.46
6	3/8/2012	1.95	1.47	3.03	89	29.8	1070	2.06	118	-0.106	-0.907
7	4/18/2012	1.65	1.06	2.75	45	11.5	562	1.72	54.7	-0.0705	-0.545

8	8/16/2012	1.84	1.17	2.76	69	14.9	573	1.8	66	0.0342	0.466
9	4/6/2013	2.61	2.22	3.59	411	167	3920	2.66	478	-0.051	-0.245
10	5/16/2013	2.18	1.65	3.36	153	44.7	2290	2.23	174	-0.0415	-0.174
11	7/2/2013	2.16	1.76	3.45	146	57.8	2800	2.32	215	-0.153	-2.13
12	7/23/2013	2.23	1.47	3.01	168	29.5	1020	2.05	116	0.176	1.28
13	8/27/2013	2.1	1.2	2.81	125	15.7	652	1.83	69.7	0.268	2.13
14	4/30/2014	2.54	2.15	3.46	346	142	2900	2.6	407	-0.0563	-0.317
15	7/23/2014	1.81	1.21	2.85	65	16.4	704	1.85	72.6	-0.0336	-0.104
16	4/9/2015	1.78	1.28	2.87	60	18.9	747	1.89	81	-0.116	-1.02
17	4/11/2015	2.5	2.05	3.19	315	112	1560	2.49	317	0.0122	0.174
18	4/22/2015	2.11	1.4	3.05	130	25.3	1120	2.01	105	0.106	1.14
19	5/27/2015	1.84	1.19	2.89	69	15.5	778	1.84	70.8	0.00371	0.0346
20	6/12/2015	2.21	1.78	3.27	164	59.9	1870	2.3	208	-0.0894	-0.714
21	7/1/2015	2.21	1.83	3.29	164	67.2	1950	2.34	227	-0.127	-1.28
22	7/27/2015	1.61	1.09	2.8	41	12.4	633	1.75	58.7	-0.141	-1.7
23	8/13/2015	1.89	1.17	2.69	78	14.7	493	1.79	64	0.101	1.02
24	9/1/2015	1.61	1.07	2.74	41	11.8	544	1.73	55.5	-0.117	-1.14
25	5/11/2016	1.8	1.08	3.09	63	11.9	1230	1.78	62.5	0.0181	0.391
26	6/8/2016	1.9	1.34	3.07	80	21.8	1160	1.96	95.3	-0.0613	-0.466
27	6/13/2016	2.64	2.07	3.47	436	118	2930	2.54	358	0.101	0.907
28	6/28/2016	2.06	1.54	3.1	114	35	1250	2.11	135	-0.0577	-0.391
29	7/14/2016	1.97	1.3	3.06	94	19.8	1150	1.93	88.8	0.0393	0.545
30	8/11/2016	3.38	3.15	3.89	2400	1420	7780	3.36	2390	0.0161	0.317
31	8/12/2016	3.33	3.09	3.85	2130	1230	7020	3.32	2140	0.0133	0.245
32	8/12/2016	3.1	2.83	3.8	1270	674	6290	3.12	1370	-0.019	-0.0346
33	8/12/2016	3.07	2.74	3.81	1170	553	6510	3.06	1200	0.00416	0.104
34	8/12/2016	3.05	2.62	3.83	1130	413	6780	2.98	979	0.0769	0.807
35	9/23/2016	3.28	2.98	3.82	1900	953	6670	3.23	1770	0.046	0.714
36	9/23/2016	3.12	2.74	3.97	1330	545	9250	3.08	1240	0.0435	0.627

Definitions

SSC: Suspended sediment concentration (SSC) in mg/l (80154)

TURB: Turbidity in FNU (63680)

Q: Stream flow, mean. daily in ft³/s (00060)

App Version 1.0

References

- Minnesota Department of Natural Resources, 2017, MNDNR/MPCA cooperative stream gaging: accessed March 3, 2017, at <http://www.dnr.state.mn.us/waters/csg/index.htm>
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- Edwards, T.K., and Glysson, G.D., 1999, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C2, 89 p. [Also available at <http://pubs.usgs.gov/twri/twri3-c2/>.]
- R Development Core Team, 2011, R installation and administration, Version 2.14.1, 2011-12-22: 73 p. [Also available at <http://streaming.stat.iastate.edu/CRAN/doc/manuals/Radmin.pdf>.]
- Tornes, L.H., 1986, Suspended sediment in Minnesota streams: U.S. Geological Survey Water-Resources Investigations Report 85-4312, 33 p. [Also available at <http://pubs.er.usgs.gov/publication/wri854312>.]
- U.S. Geological Survey, 2017, National Water Information System (NWISWeb)—USGS surface-water data for Minnesota: U.S. Geological Survey database, accessed January, 2017, at <http://waterdata.usgs.gov/mn/nwis/sw/>. [Also available at <http://dx.doi.org/10.5066/F7P55KJN>.]

Appendix 1

Model Statistics, Data, and Plots

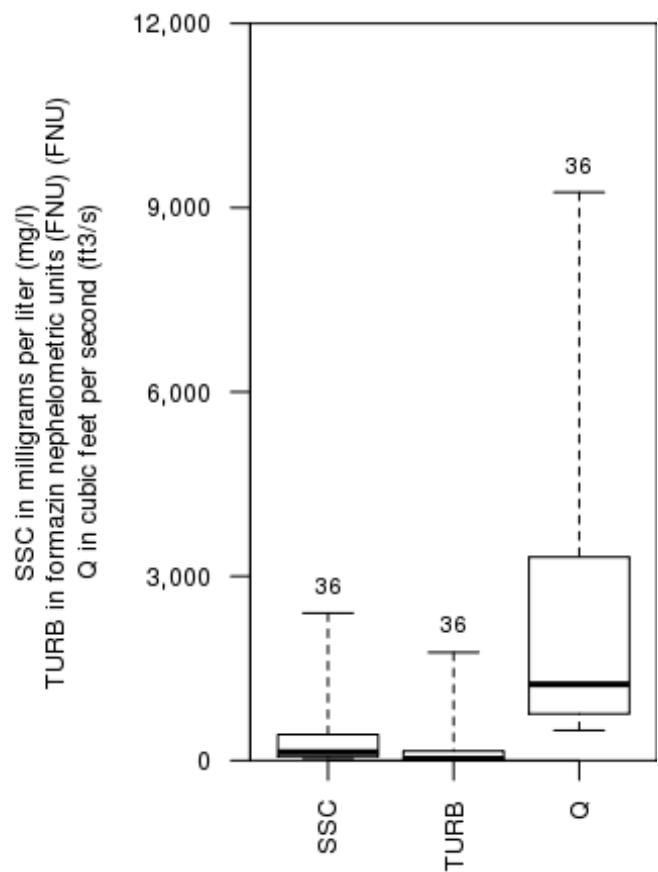
Model

$$SSC = + 0.977 * TURB + 0.0979 * Q - 25.4$$

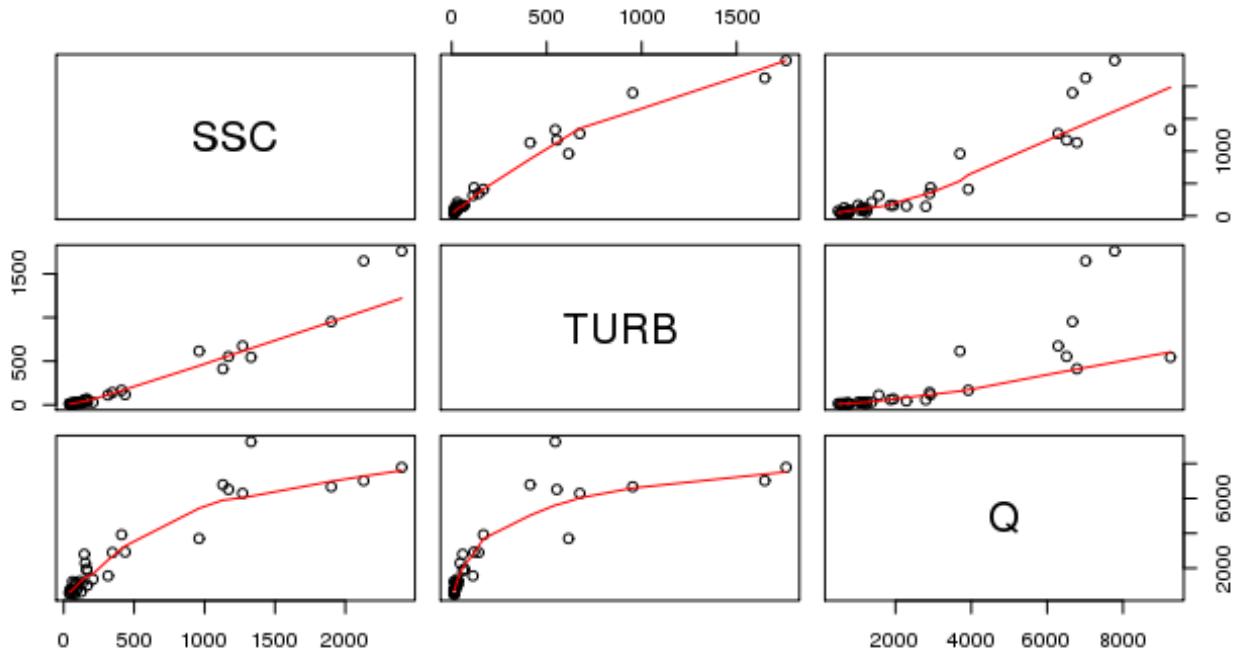
Variable Summary Statistics

	SSC	TURB	Q
Minimum	41	11.5	493
1st Quartile	69	15.6	762
Median	138	29.6	1240
Mean	449	231.0	2540
3rd Quartile	424	154.0	3310
Maximum	2400	1760.0	9250

Box Plots



Exploratory Plots



Basic Model Statistics

Number of Observations	36
Standard error (RMSE)	85.8
Average Model standard percentage error (MSPE)	19.1
Coefficient of determination (R^2)	0.983
Adjusted Coefficient of Determination (Adj. R^2)	0.982

Variance Inflation Factors (VIF)
 TURB Q
 2.99 2.99

Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t)
(Intercept)	-25.4000	21.8000	-1.17	2.52e-01
TURB	0.9770	0.0582	16.80	1.02e-17
Q	0.0979	0.0100	9.78	2.84e-11

Correlation Matrix

	Intercept	TURB	Q
Intercept	1.000	0.337	-0.665
TURB	0.337	1.000	-0.816
Q	-0.665	-0.816	1.000

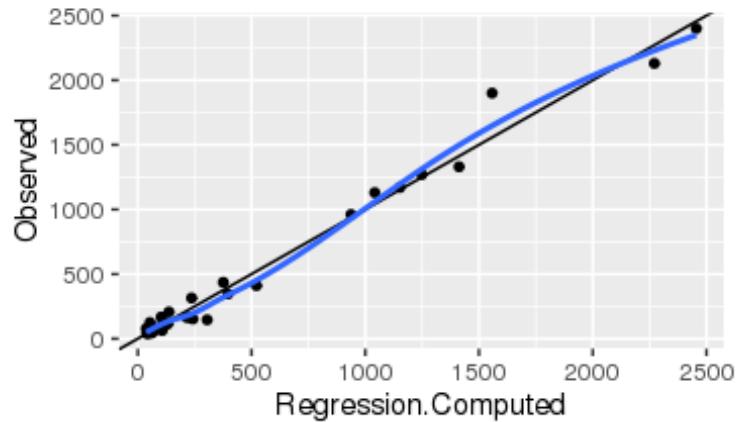
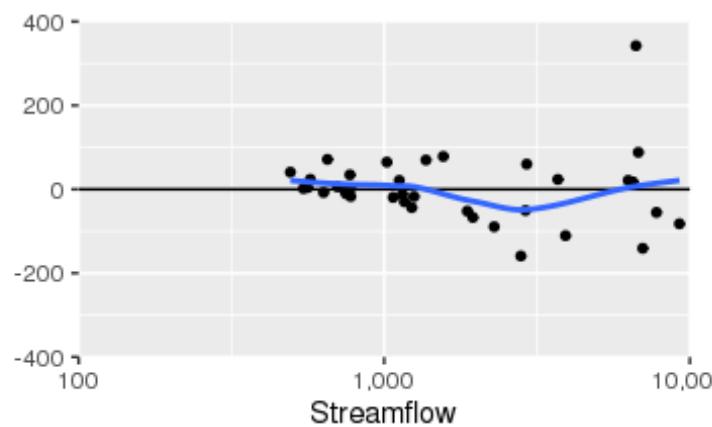
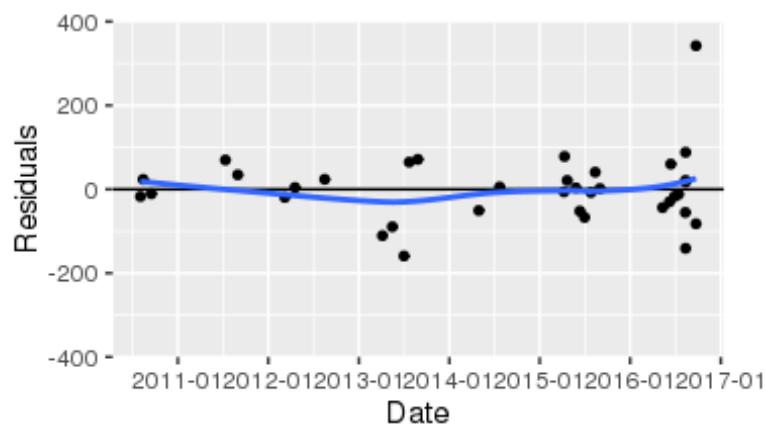
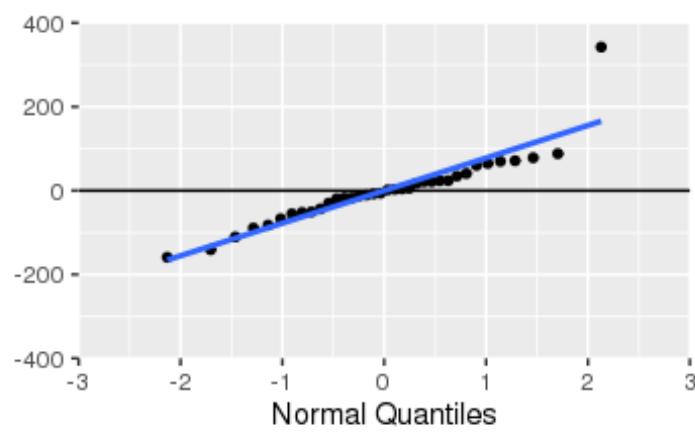
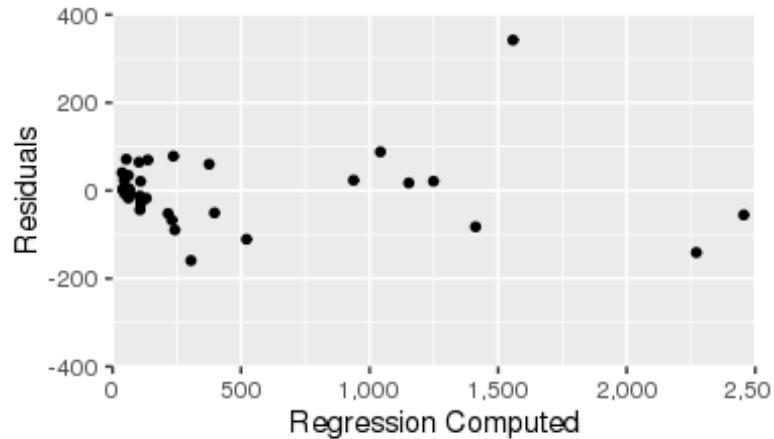
Outlier Test Criteria

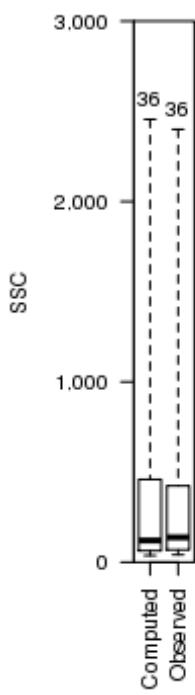
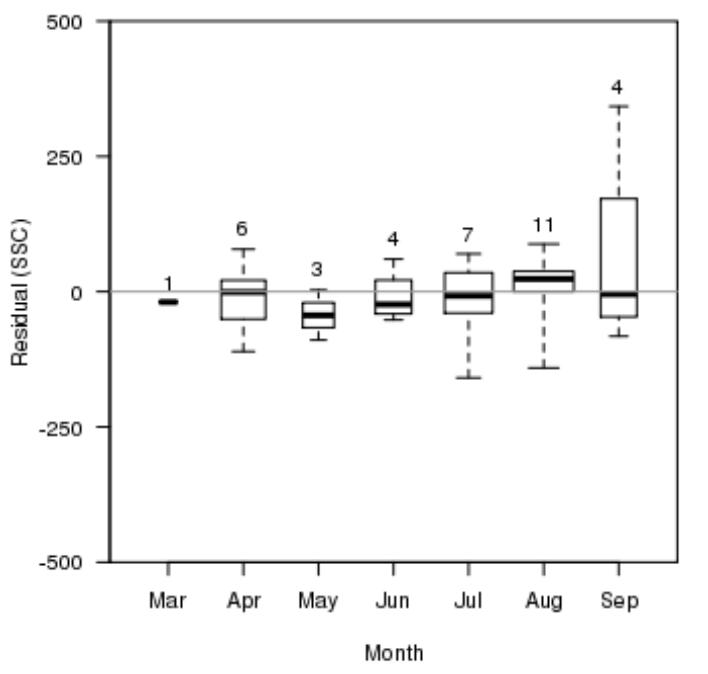
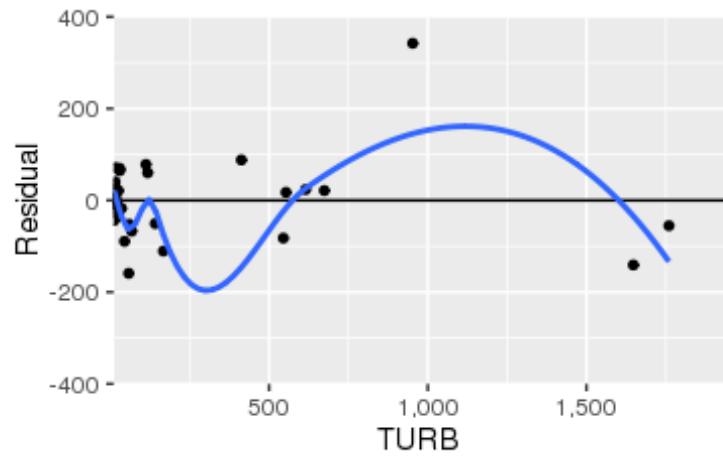
Leverage	Cook's D	DFFITS
0.167	0.194	0.471

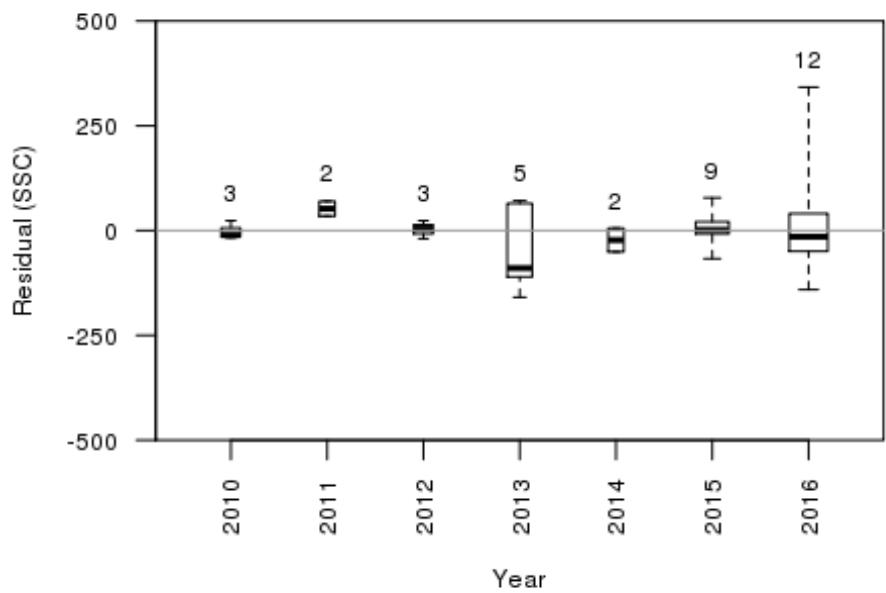
Flagged Observations

		SSC	Estimate	Residual	Standard Residual	Studentized Residual	Residual	Leverage	Cook's D	DFFITS
8/11/2016	18:45	2400	2460	-55.3	-0.863		-0.859	0.443	0.197	-0.766
8/11/2016	20:30	2130	2270	-141.0	-2.130		-2.260	0.406	1.030	-1.860
8/12/2016	14:15	1130	1040	88.1	1.140		1.140	0.188	0.100	0.550
9/22/2016	20:15	1900	1560	342.0	4.240		6.180	0.114	0.774	2.220
9/23/2016	12:00	1330	1410	-82.3	-1.250		-1.260	0.413	0.367	-1.060

Statistical Plots

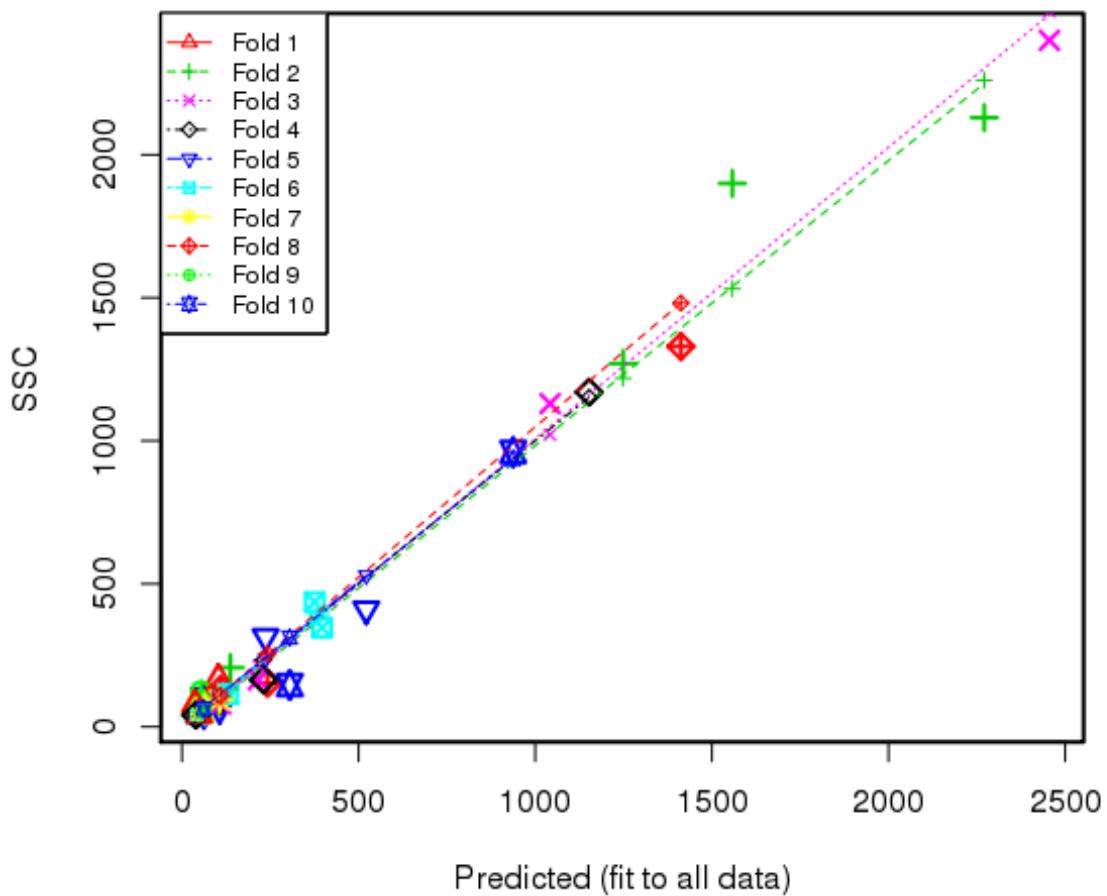






Cross Validation

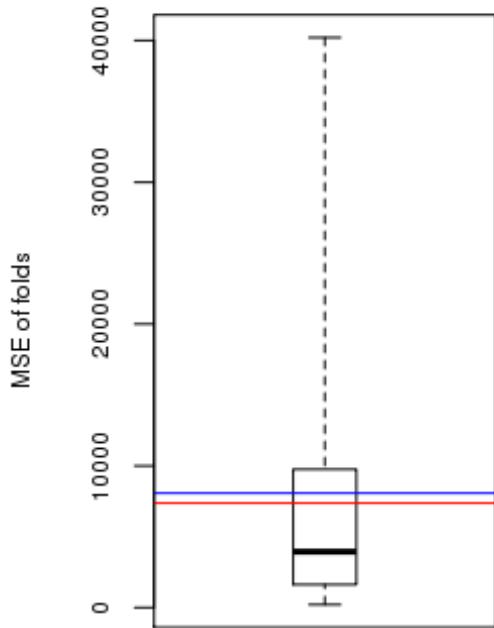
Cross-validation



```

Minimum MSE of folds:    211.0
Mean MSE of folds:     8070.0
Median MSE of folds:   3940.0
Maximum MSE of folds:  40200.0
(Mean MSE of folds) / (Model MSE):    1.1

```



Red line - Model MSE

Blue line - Mean MSE of folds

Model-Calibration Data Set

0	Date	SSC	TURB	Q	Computed	Residual	Normal	Censored
							Quantiles	Values
1	2010-08-03	45	11.8	777	62.2	-17.2	-0.317	--
2	2010-08-14	961	615	3700	937	23.5	0.545	--
3	2010-09-16	54	17	751	64.7	-10.7	-0.174	--
4	2011-07-12	207	29.2	1370	137	69.8	1.14	--
5	2011-08-31	96	11.6	772	61.5	34.5	0.714	--
6	2012-03-08	89	29.8	1070	108	-19.4	-0.466	--
7	2012-04-18	45	11.5	562	40.8	4.17	0.174	--

8	2012-08-16	69	14.9	573	45.2	23.8	0.627	--
9	2013-04-06	411	167	3920	522	-111	-1.46	--
10	2013-05-16	153	44.7	2290	242	-89.4	-1.28	--
11	2013-07-02	146	57.8	2800	305	-159	-2.13	--
12	2013-07-23	168	29.5	1020	103	64.8	1.02	--
13	2013-08-27	125	15.7	652	53.7	71.3	1.28	--
14	2014-04-30	346	142	2900	397	-50.6	-0.714	--
15	2014-07-23	65	16.4	704	59.5	5.49	0.245	--
16	2015-04-09	60	18.9	747	66.2	-6.16	-0.0346	--
17	2015-04-11	315	112	1560	237	78.3	1.46	--
18	2015-04-22	130	25.3	1120	109	21.1	0.391	--
19	2015-05-27	69	15.5	778	65.9	3.13	0.104	--
20	2015-06-12	164	59.9	1870	216	-52.1	-0.807	--
21	2015-07-01	164	67.2	1950	231	-67.1	-1.02	--
22	2015-07-27	41	12.4	633	48.7	-7.65	-0.104	--
23	2015-08-13	78	14.7	493	37.2	40.8	0.807	--
24	2015-09-01	41	11.8	544	39.4	1.64	0.0346	--
25	2016-05-11	63	11.9	1230	107	-43.7	-0.627	--
26	2016-06-08	80	21.8	1160	110	-29.9	-0.545	--
27	2016-06-13	436	118	2930	376	60.1	0.907	--
28	2016-06-28	114	35	1250	131	-17.3	-0.391	--
29	2016-07-14	94	19.8	1150	106	-12.2	-0.245	--
30	2016-08-11	2400	1760	7780	2460	-55.3	-0.907	--
31	2016-08-12	2130	1650	7020	2270	-141	-1.7	--
32	2016-08-12	1270	674	6290	1250	21.3	0.466	--
33	2016-08-12	1170	553	6510	1150	17.4	0.317	--
34	2016-08-12	1130	413	6780	1040	88.1	1.7	--
35	2016-09-23	1900	953	6670	1560	342	2.13	--
36	2016-09-23	1330	545	9250	1410	-82.3	-1.14	--

Definitions

SSC: Suspended sediment concentration (SSC) in mg/l (80154)

TURB: Turbidity in FNU (63680)

Q: Stream flow, mean. daily in ft³/s (00060)

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Appendix 2

Model Statistics, Data, and Plots

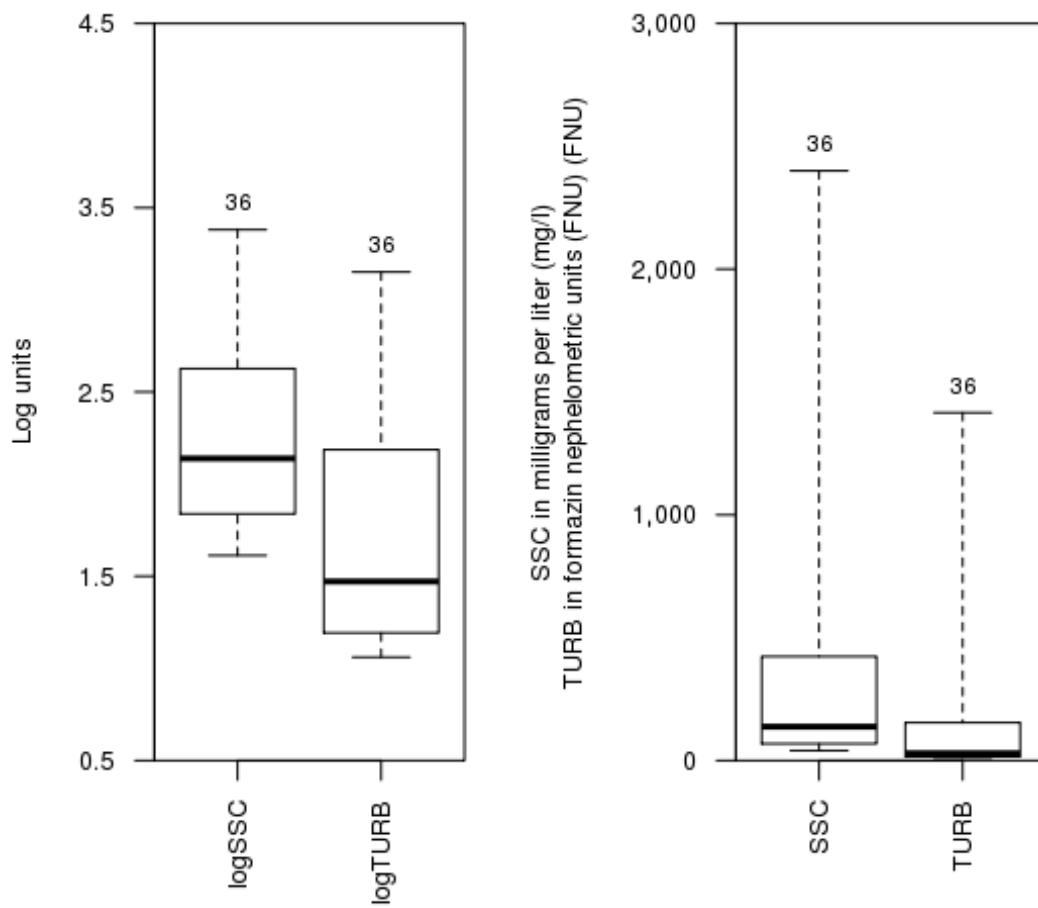
Model

$$\log\text{SSC} = + 0.786 * \log\text{TURB} + 0.902$$

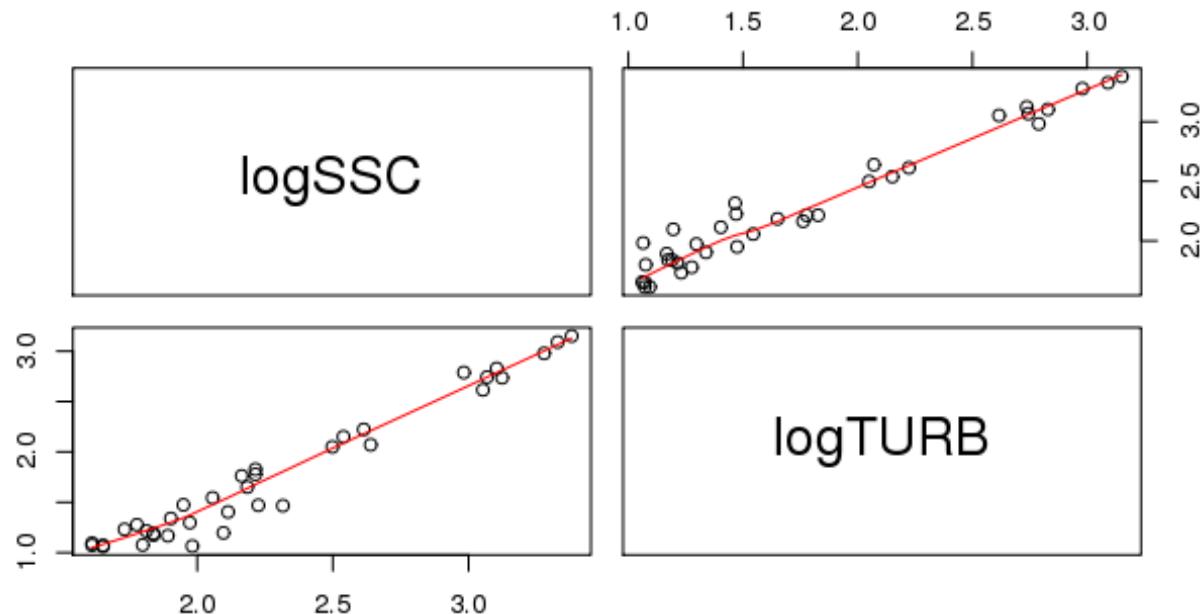
Variable Summary Statistics

	logSSC	SSC	logTURB	TURB
Minimum	1.61	41	1.06	11.5
1st Quartile	1.84	69	1.19	15.6
Median	2.14	138	1.47	29.6
Mean	2.28	449	1.76	210.0
3rd Quartile	2.63	423	2.19	154.0
Maximum	3.38	2400	3.15	1420.0

Box Plots



Exploratory Plots



Basic Model Statistics

Number of Observations	36
Standard error (RMSE)	0.113
Average Model standard percentage error (MSPE)	26.4
Coefficient of determination (R^2)	0.959
Adjusted Coefficient of Determination (Adj. R^2)	0.957
Bias Correction Factor (BCF)	1.03

Explanatory Variables

	Coefficients	Standard Error	t value	Pr(> t)
(Intercept)	0.902	0.0527	17.1	2.71e-18
logTURB	0.786	0.0280	28.1	4.10e-25

Correlation Matrix

	Intercept	E.vars
Intercept	1.000	-0.934
E.vars	-0.934	1.000

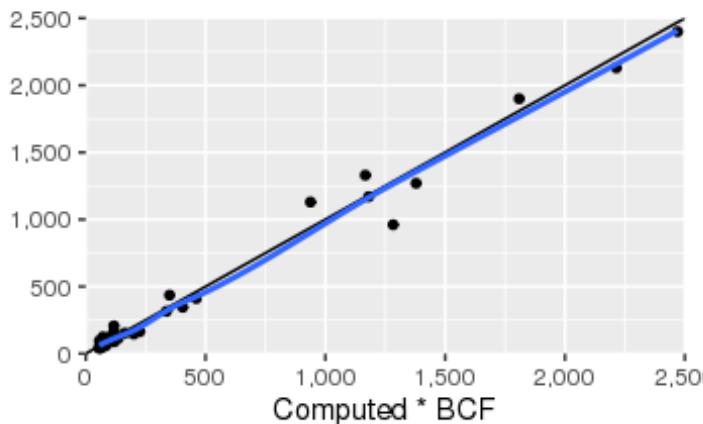
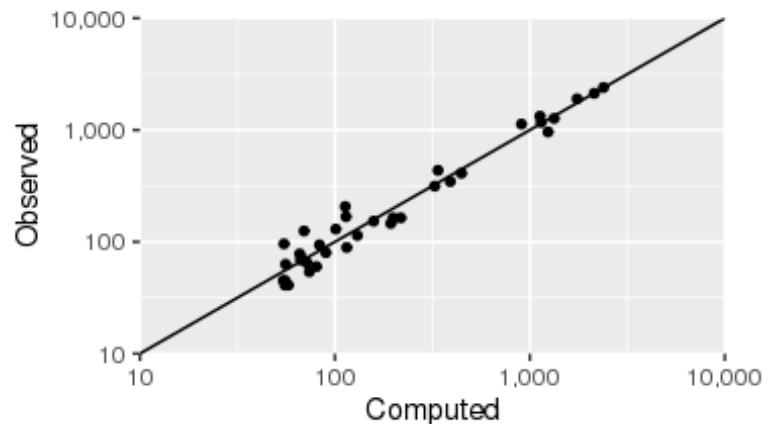
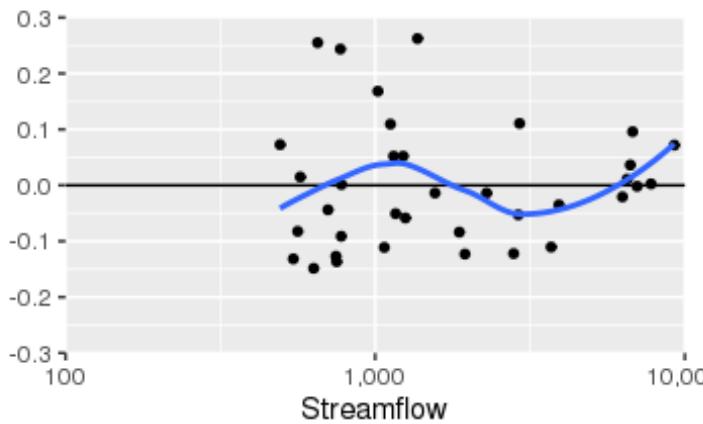
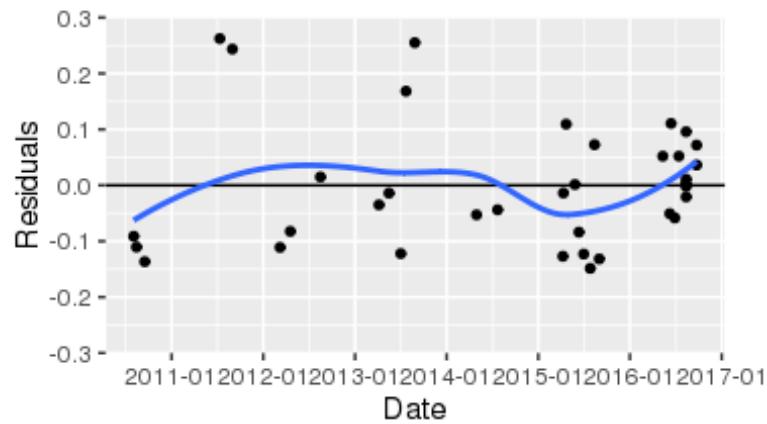
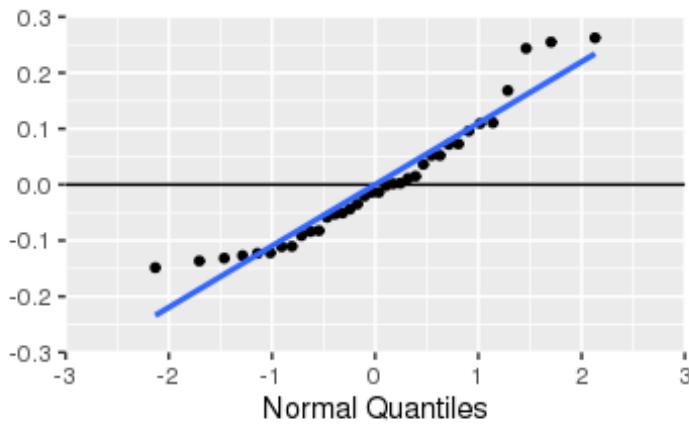
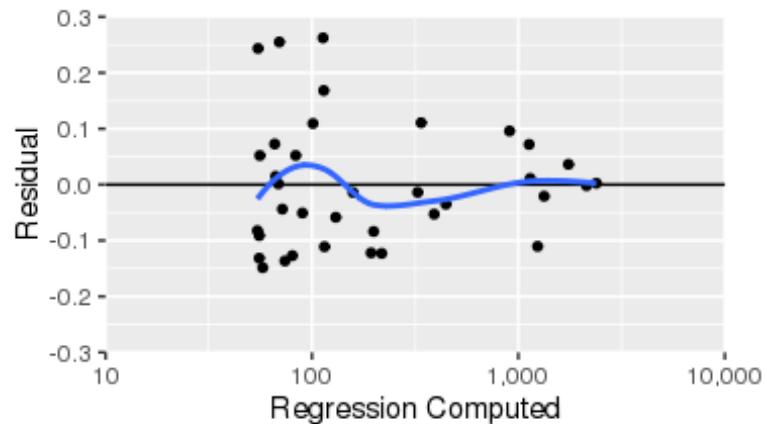
Outlier Test Criteria

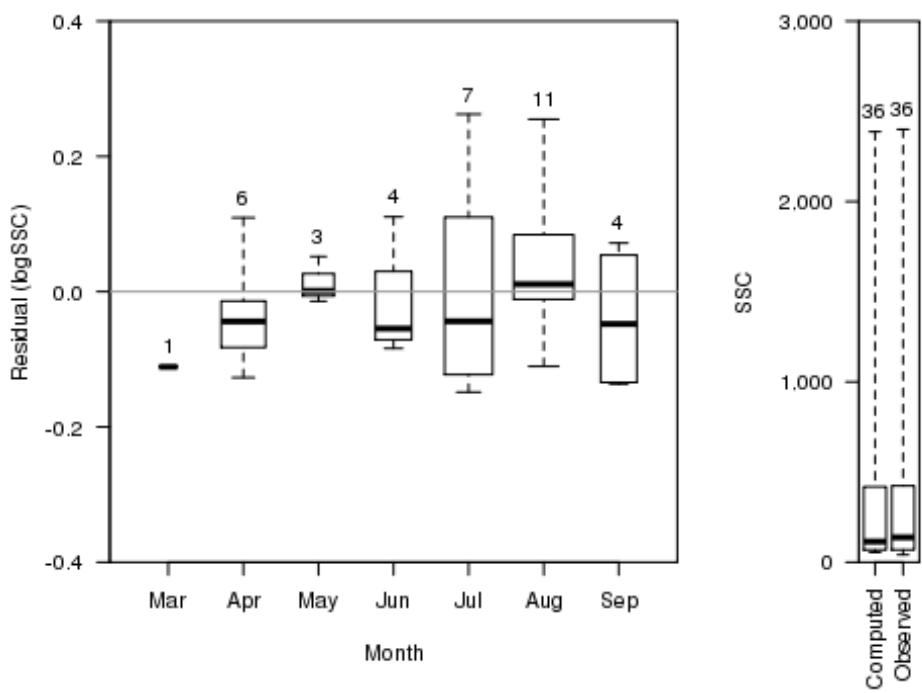
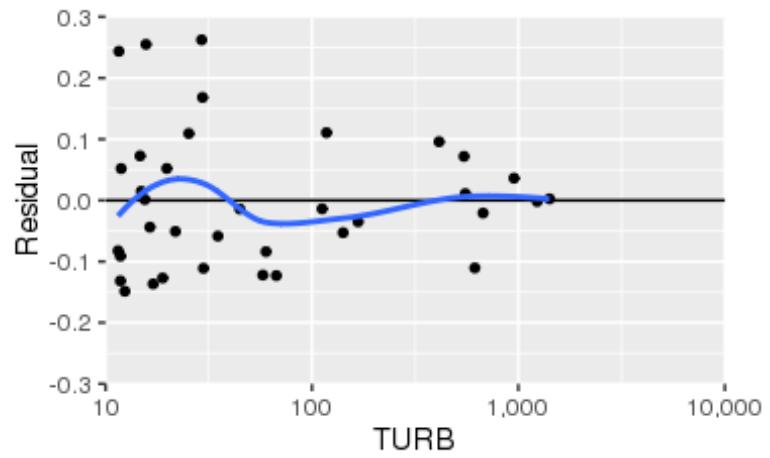
Leverage	Cook's D	DFFITS
0.0833	0.1057	0.3333

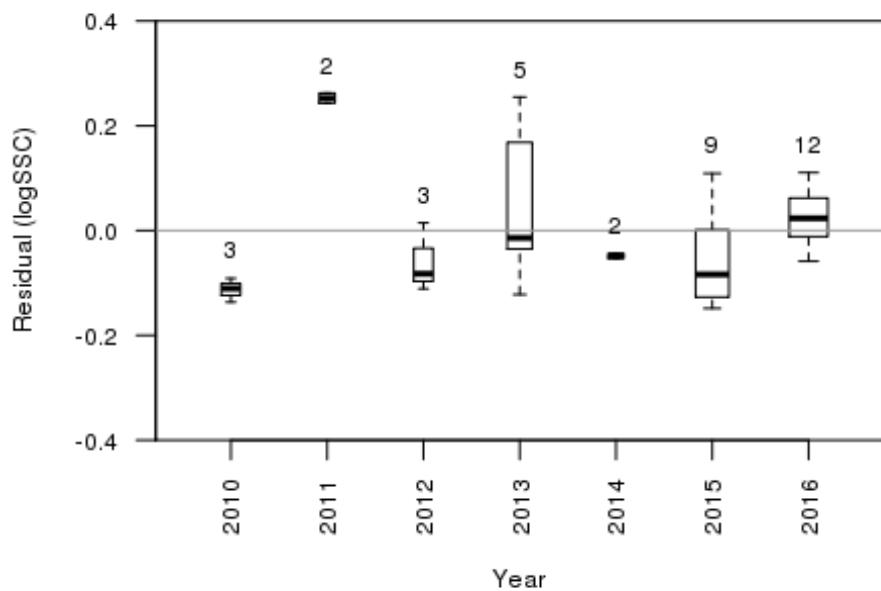
Flagged Observations

		logSSC	Estimate	Residual	Standard Residual	Studentized Residual	Residual	Leverage	Cook's D	DFFITS
8/14/2010	12:15	2.98	3.09	-0.11000		-1.0200		-1.0200	0.0924	5.34e-02
7/12/2011	14:00	2.32	2.05	0.26200		2.3600		2.5400	0.0330	9.48e-02
8/31/2011	12:00	1.98	1.74	0.24400		2.2200		2.3600	0.0572	1.49e-01
8/27/2013	13:30	2.10	1.84	0.25500		2.3100		2.4700	0.0471	1.31e-01
8/11/2016	18:45	3.38	3.38	0.00249		0.0238		0.0234	0.1460	4.83e-05
8/11/2016	20:30	3.33	3.33	-0.00191		-0.0181		-0.0179	0.1360	2.59e-05
8/12/2016	7:00	3.10	3.12	-0.02080		-0.1930		-0.1900	0.0975	2.01e-03
8/12/2016	9:15	3.07	3.06	0.01100		0.1010		0.1000	0.0868	4.89e-04
9/22/2016	20:15	3.28	3.24	0.03630		0.3410		0.3370	0.1180	7.81e-03
9/23/2016	12:00	3.12	3.05	0.07190		0.6640		0.6580	0.0860	2.07e-02

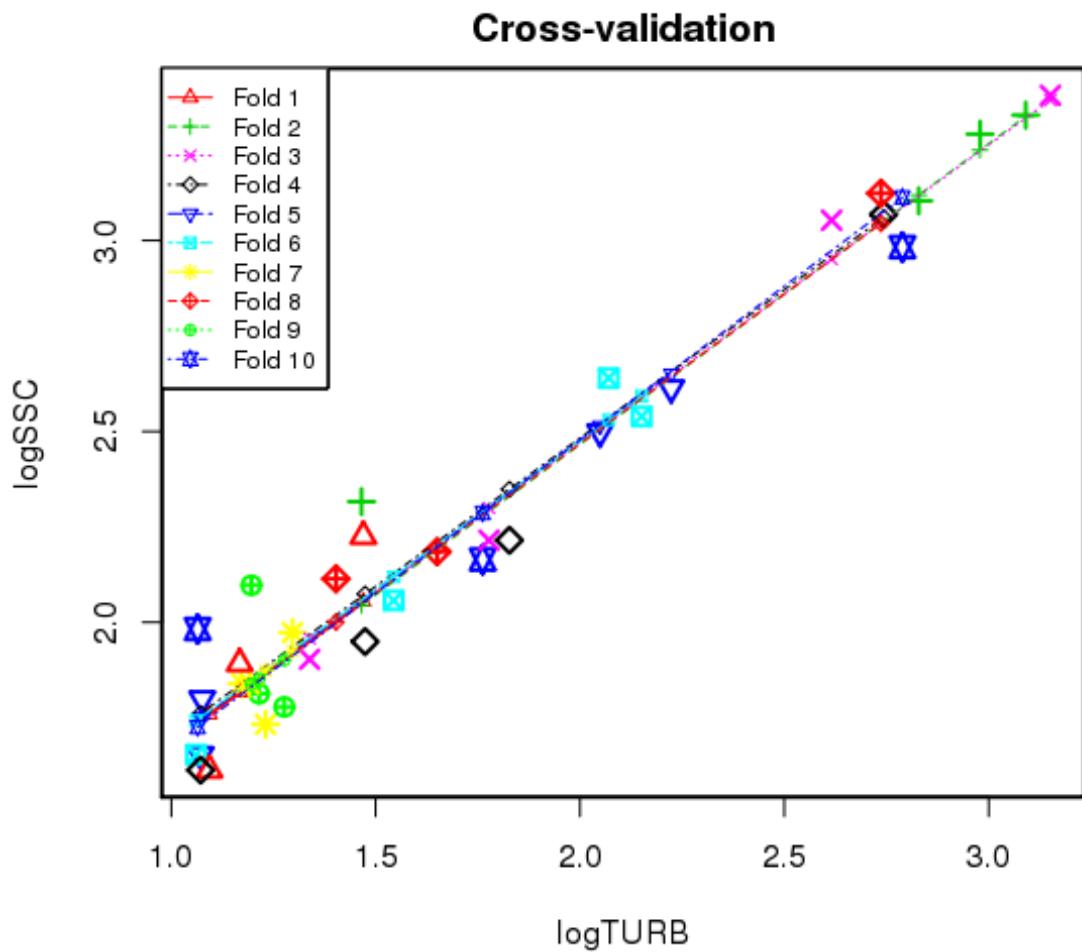
Statistical Plots







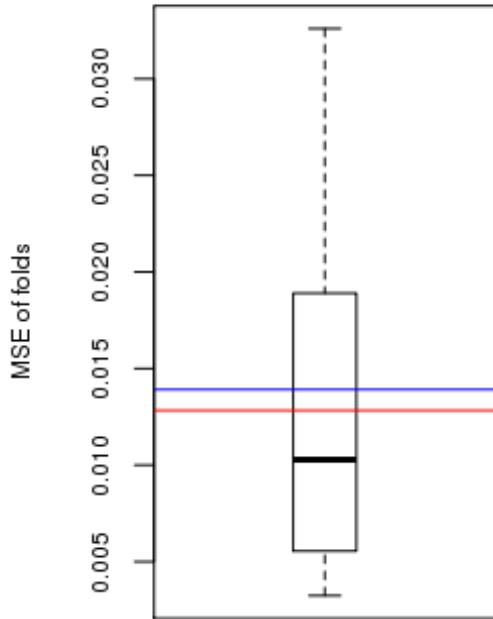
Cross-Validation



```

Minimum MSE of folds: 0.00324
Mean MSE of folds: 0.01390
Median MSE of folds: 0.01030
Maximum MSE of folds: 0.03260
(Mean MSE of folds) / (Model MSE): 1.08000

```



Red line - Model MSE

Blue line - Mean MSE of folds

Model-Calibration Data Set

	Date	logSSC	logTURB	SSC	TURB	Computed logSSC	Computed SSC	Residual	Normal Quantiles	Censored Values
0										
1	2010-08-03	1.65	1.07	45	11.8	1.74	57.5	-0.0912	-0.714	--
2	2010-08-14	2.98	2.79	961	615	3.09	1280	-0.11	-0.807	--
3	2010-09-16	1.73	1.23	54	17	1.87	76.5	-0.137	-1.7	--
4	2011-07-12	2.32	1.47	207	29.2	2.05	117	0.262	2.13	--
5	2011-08-31	1.98	1.06	96	11.6	1.74	56.7	0.244	1.46	--
6	2012-03-08	1.95	1.47	89	29.8	2.06	119	-0.111	-0.907	--
7	2012-04-18	1.65	1.06	45	11.5	1.74	56.3	-0.0824	-0.545	--
8	2012-08-16	1.84	1.17	69	14.9	1.82	69	0.0148	0.391	--
9	2013-04-06	2.61	2.22	411	167	2.65	461	-0.035	-0.174	--

10	2013-05-16	2.18	1.65	153	44.7	2.2	164	-0.0141	-0.0346	--
11	2013-07-02	2.16	1.76	146	57.8	2.29	200	-0.122	-1.02	--
12	2013-07-23	2.23	1.47	168	29.5	2.06	118	0.168	1.28	--
13	2013-08-27	2.1	1.2	125	15.7	1.84	71.9	0.255	1.7	--
14	2014-04-30	2.54	2.15	346	142	2.59	404	-0.0529	-0.391	--
15	2014-07-23	1.81	1.21	65	16.4	1.86	74.4	-0.0438	-0.245	--
16	2015-04-09	1.78	1.28	60	18.9	1.91	83.2	-0.127	-1.28	--
17	2015-04-11	2.5	2.05	315	112	2.51	337	-0.0139	0.0346	--
18	2015-04-22	2.11	1.4	130	25.3	2	105	0.109	1.02	--
19	2015-05-27	1.84	1.19	69	15.5	1.84	71.2	0.00136	0.174	--
20	2015-06-12	2.21	1.78	164	59.9	2.3	206	-0.0838	-0.627	--
21	2015-07-01	2.21	1.83	164	67.2	2.34	225	-0.123	-1.14	--
22	2015-07-27	1.61	1.09	41	12.4	1.76	59.7	-0.149	-2.13	--
23	2015-08-13	1.89	1.17	78	14.7	1.82	68.3	0.0727	0.807	--
24	2015-09-01	1.61	1.07	41	11.8	1.74	57.5	-0.132	-1.46	--
25	2016-05-11	1.8	1.08	63	11.9	1.75	57.8	0.052	0.545	--
26	2016-06-08	1.9	1.34	80	21.8	1.95	93.1	-0.0508	-0.317	--
27	2016-06-13	2.64	2.07	436	118	2.53	350	0.111	1.14	--
28	2016-06-28	2.06	1.54	114	35	2.12	135	-0.0585	-0.466	--
29	2016-07-14	1.97	1.3	94	19.8	1.92	86.3	0.0521	0.627	--
30	2016-08-11	3.38	3.15	2400	1420	3.38	2470	0.00249	0.245	--
31	2016-08-12	3.33	3.09	2130	1230	3.33	2210	-0.00191	0.104	--
32	2016-08-12	3.1	2.83	1270	674	3.12	1380	-0.0208	-0.104	--
33	2016-08-12	3.07	2.74	1170	553	3.06	1180	0.011	0.317	--
34	2016-08-12	3.05	2.62	1130	413	2.96	938	0.0959	0.907	--
35	2016-09-23	3.28	2.98	1900	953	3.24	1810	0.0363	0.466	--
36	2016-09-23	3.12	2.74	1330	545	3.05	1170	0.0719	0.714	--

Definitions

SSC: Suspended sediment concentration (SSC) in mg/l (80154)

TURB: Turbidity in FNU (63680)

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