Appendix 4. Calibration Dataset and Model Results for Streamgage 04296280—Barton River Near Coventry—Total Phosphorus Concentration

SITE NUMBER—04296280
SITE NAME—Barton River near Coventry, VT
DATE CREATED—2/4/2014
MODEL DEVELOPMENT DATA PERIOD—8/31/2010 – 5/31/2013
MODEL CALIBRATION DATA SET— Water samples were collected from the upstream side of the bridge over Coventry Station Road using a handheld DH-59 sampler, using USGS protocols and are stored in the NWIS database. The regression model is based on 47 concurrent measurements of total phosphorus concentration (TP), streamflow (Q), and acoustic backscatter for samples collected from 08-31-2010 through 05-31-2013. Sample collection targeted the range of continuously observed hydrologic conditions. Discharge over the sample period ranged from 28 to 6,070 cubic feet per second (ft^3/s) and instantaneous discharge during sample collection ranged from 39 to 4,550 ft^3/s. Summary statistics and complete model-calibration datasets are provided. None of the TP samples were considered outliers.
The acoustic data were collected using a Sontek Argonaut SL 1.5 MHz (serial no. E3132) fixed on the right bank and configured with a blanking distance of 0.5 m and 5 cells of 1.22 m each.
MODEL DEVELOPMENT—Regression analysis was done using the USGS SAID (the Surrogate Analysis and Index Developer Tool, v. 20131101) computer program, which applied various OLS linear regression models to estimate TP concentration from several different independent variables. Output from SAID included a variety of statistical and graphical tools that enabled the user to determine model validity and to make comparisons among regression models. Different combinations of untransformed and log_{10}-transformed data were evaluated. The regression model to estimate the log_{10} TP concentration from two predictor variables, discharge and a binary marker for discharge hysteresis, was selected based on residual plots, RMSE, and R^2.
MODEL SUMMARY—Summary of the final regression analysis for TP concentration at site number 04296280.
Total phosphorus concentration-based model:

$$\log_{10}TP = 0.84 + (0.44 \times log_{10}Q) - (0.45 - HystQ), \quad (4–1)$$

where

TP = total phosphorus concentration, in mg/L;
Q = discharge, in cubic feet per second; and
HystQ = marker to indicate position of sample on the hydrograph (0=rising limb and 1=falling limb or flat) for potential hysteresis effect

The use of discharge and HystQ as explanatory variables makes sense both physically and statistically. Physically because a predominant mechanism for phosphorus transport in streamwater is via attachment to suspended sediment, which has a strong positive relation to discharge. Accounting for the hysteretic effect makes sense because suspended-sediment concentration (and thus, TP) frequently is higher for a given discharge within a storm near the beginning when discharge is rising, compared to after the storm peak when discharge is falling as the sediment supply is diminished. Discharge and hysteresis make statistical sense as explanatory variables because they resulted in a model with low RMSE and relatively high R^2 values.
TOTAL PHOSPHORUS CONCENTRATION RECORD The record was computed using the Surrogate Analysis and Index Developer Tool (SAID; version 20131101). The ADP functioned well and collected continuous acoustic data during the study period except for the following. From 1/19/2011 to 2/8/2011 the ADP was influenced by the presence of shore ice at the sensor. From 12/26/2012 to 1/15/2013 and 4/11/2013 to 4/14/2013 there was a communication issue between the ADP and data logger. On April 15, 2013 a second solar panel was installed and is believed to be introducing a voltage spike during peak sunlight hours from approximately 9 to 11 am. The increase in voltage is believed to be causing a momentary spike in the water temperature being reported by the ADP. Water temperature spikes were within the maximum allowable limits for continuous water-quality monitoring sensors and were not removed.
Computed: Laura Medalie
Reviewed: Richard Kiah

Model Form: $\log_{10}TP = 0.84 + (0.44 \times log_{10}Q) - (0.45 \times HystQ)$

Model Calibration

Basic Data

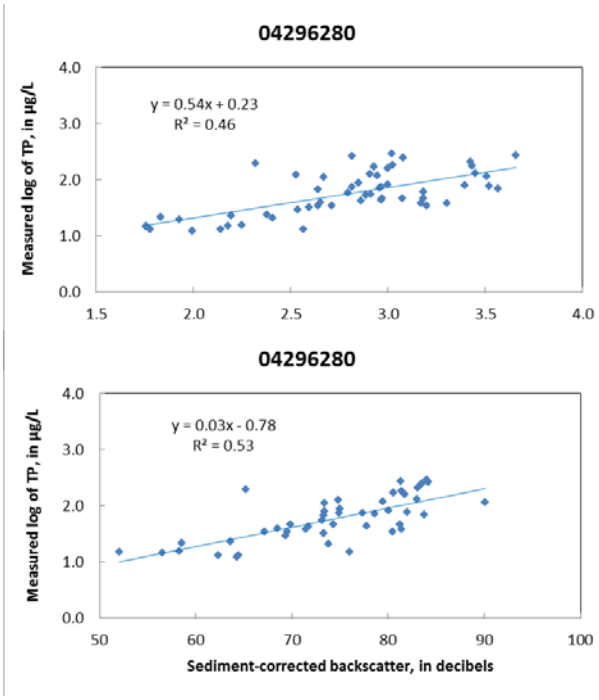
Number of Measurements:	55
RMSE:	0.219
R^2:	0.704
Adj R^2:	0.693
Duan's BCF:	1.169
PPCC:	0.953

Explanatory Variables

Variable	Value	Standard Error
Intercept	0.843	0.194
$Log_{10}Q$	0.441	0.062
HystQ	-0.446	0.068

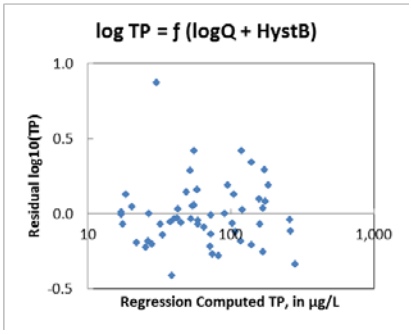
Test Criteria

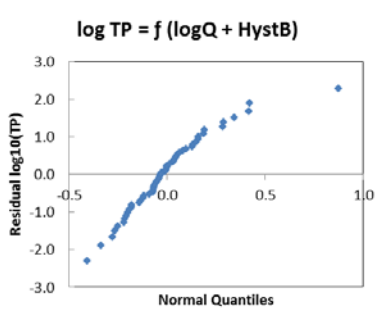
Leverage	Cook's D	DFFITS
0.164	2.044	0.467



Observations exceeding at least one test criterion

Observation	Observed log(TP)	Predicted log(TP)	Residuals	Leverage	Cook's D	DFFITS
14	2.05	2.39	-0.34	0.088	0.084	-0.508
27	2.43	2.01	0.42	0.098	0.149	0.689
46	2.29	1.42	0.87	0.037	0.214	0.961





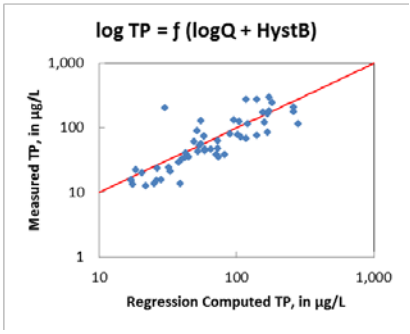


Table 4–1. Calibration dataset and computed values for total phosphorus concentration at streamgage 04296280 in the Barton River near Coventry, Vermont, from July 2010 through May 2013.

[TP, total phosphorus concentration; µg/L, micrograms per liter; Q, discharge; ft3/s, cubic feet per second; MB, measured backscatter; dB, decibels; WCB, water-corrected backscatter; HystQ, marker to indicate position of sample on the hydrograph; dB/m, decibels per meter; °F, degrees Fahrenheit; SCB, sediment-corrected backscatter; AlphaS, sediment-driven attenuation coefficient; --, no data]

Date and time	Calibration dataset									Computed values				
	TP, in µg/L	Q, in ft^3/s	MB, in dB	WCB, in dB	HystQ	AlphaF, in dB/m	Water temperature, in °F	log10TP, in µg/L	log10Q, in ft^3/s	SCB, in dB	AlphaS, in dB/m	Regression computed TP, in µg/L	Residual log(TP), in µg/L	Normal quantiles
7/29/2010 14:30	13	60	41.3	54.46	1	0.39	--	1.11	1.78	--	--	18	-0.07	-0.32
8/3/2010 14:00	122	337	63.9	77.82	0	0.48	--	2.09	2.53	--	--	106	0.13	0.74
8/4/2010 11:45	174	2,710	69.7	83.54	0	0.48	--	2.24	3.43	--	--	266	-0.12	-0.58
8/5/2010 12:15	62	1,520	61.7	75.40	1	0.45	--	1.79	3.18	--	--	74	-0.01	0.09
8/6/2010 14:30	52	766	57.6	71.27	1	0.45	--	1.72	2.88	--	--	55	0.05	0.52
8/11/2010 13:06	24	238	49.5	63.02	1	0.46	--	1.37	2.38	--	--	33	-0.07	-0.47
8/31/2010 12:31	15	57	41.1	54.51	1	0.42	72	1.17	1.76	56.52	0.53	17	0.00	0.14
10/1/2010 11:45	244	1,190	65.4	79.74	0	0.55	60.3	2.39	3.08	83.53	0.89	185	0.19	1.09
10/5/2010 13:25	34	512	52.4	67.03	1	0.62	55.52	1.53	2.71	67.17	0.29	46	-0.06	-0.23
12/2/2010 13:00	160	993	61.1	78.65	0	0.96	37.8	2.20	3.00	81.69	1.06	171	0.04	0.42
3/21/2011 18:40	46	932	51.6	70.69	1	1.12	32	1.66	2.97	69.86	0.60	59	-0.04	-0.14
4/5/2011 14:55	118	881	58.7	77.43	0	1.05	34.2	2.07	2.94	79.49	0.90	162	-0.07	-0.42
4/6/2011 13:20	73	904	59.3	77.93	1	1.07	33.7	1.86	2.96	78.65	0.82	59	0.16	1.01
4/11/2011 13:30	113	3,210	64.3	83.59	0	1.06	34	2.05	3.51	90.03	1.42	287	-0.34	-1.90
4/12/2011 15:45	70	3,690	60.8	77.60	1	0.95	38.4	1.85	3.57	83.79	1.34	109	-0.12	-0.63
4/14/2011 13:30	38	2,000	51.8	69.69	1	1.00	36.5	1.57	3.30	71.42	0.66	83	-0.28	-1.67
4/18/2011 14:05	38	1,470	61.1	79.09	1	0.97	37.6	1.58	3.17	81.43	0.91	73	-0.22	-1.18
4/21/2011 16:15	35	1,580	58.3	76.64	1	0.95	38.7	1.54	3.20	80.49	1.07	75	-0.27	-1.51
4/28/2011 13:00	78	2,470	54.4	69.50	1	0.71	49.8	1.89	3.39	73.38	0.77	91	0.00	0.18
5/2/2011 13:50	43	925	60.4	76.38	1	0.74	48.1	1.64	2.97	77.76	0.70	59	-0.07	-0.37
5/17/2011 17:10	46	1,520	57.4	72.84	1	0.67	52.6	1.66	3.18	74.31	0.54	74	-0.14	-0.69
6/15/2011 13:45	21	256	59.1	73.82	1	0.56	59.9	1.32	2.41	73.77	0.31	34	-0.14	-0.74
6/30/2011 13:10	23	156	49.0	62.92	1	0.50	64.8	1.36	2.19	63.64	0.31	27	0.00	0.23
7/27/2011 15:30	20	85	--	--	1	0.41	--	1.30	1.93	--	--	21	0.05	0.47
8/5/2011 15:15	15	57	36.3	49.77	1	0.40	75	1.18	1.76	52.05	0.43	17	0.01	0.28
8/24/2011 13:20	22	68	43.2	57.24	1	0.48	66.4	1.34	1.83	58.57	0.44	19	0.13	0.81
8/29/2011 10:45	270	4,550	64.3	78.67	1	0.53	62.1	2.43	3.66	81.30	0.58	120	0.42	1.90
9/21/2011 15:00	15	177	41.9	56.53	1	0.58	58.6	1.19	2.25	58.27	0.58	29	-0.20	-1.01
9/30/2011 14:30	181	1,060	63.6	78.13	0	0.57	59.2	2.26	3.03	81.40	0.87	176	0.08	0.63
10/25/2011 13:25	13	366	46.0	61.03	1	0.71	50	1.12	2.56	62.33	0.58	39	-0.41	-2.29
3/13/2012 11:10	112	467	54.3	72.01	0	1.05	34.3	2.05	2.67	73.36	0.75	122	0.03	0.32
3/15/2012 14:40	87	708	55.9	73.52	1	1.03	35	1.94	2.85	74.99	0.79	53	0.29	1.27
3/20/2012 16:10	82	996	61.4	77.95	0	0.89	40.7	1.91	3.00	80.08	0.88	171	-0.25	-1.38
3/27/2012 16:15	29	344	50.8	68.58	1	1.02	35.5	1.46	2.54	69.33	0.63	38	-0.05	-0.18
4/10/2012 16:00	67	437	56.3	73.03	0	0.91	40	1.83	2.64	73.33	0.52	119	-0.18	-0.87
4/25/2012 10:45	34	435	53.4	69.40	1	0.81	44.5	1.53	2.64	69.49	0.42	43	-0.03	0.05
5/17/2012 12:20	32	394	58.8	73.32	1	0.62	55.8	1.51	2.60	73.29	0.33	41	-0.04	-0.05
5/31/2012 13:15	73	920	62.0	75.75	1	0.50	64.5	1.86	2.96	77.31	0.57	59	0.16	0.94
6/11/2012 15:30	15	150	61.8	75.34	1	0.47	67.3	1.18	2.18	75.98	0.41	27	-0.18	-0.81
4/11/2013 10:25	60	621	--	--	1	--	--	1.78	2.79	--	--	50	0.15	0.87
4/15/2013 10:15	75	652	56.2	73.33	0	0.97	37.6	1.87	2.81	74.87	0.76	142	-0.21	-1.09
4/17/2013 13:40	170	844	60.8	77.68	0	0.93	39.1	2.23	2.93	80.51	1.00	159	0.10	0.69
4/18/2013 12:30	125	807	57.3	74.29	1	0.95	38.4	2.10	2.91	74.83	0.64	56	0.42	1.67
4/22/2013 17:15	55	813	56.8	73.00	1	0.84	42.9	1.74	2.91	73.14	0.51	56	0.06	0.58
4/26/2013 10:45	40	450	52.7	69.05	1	0.86	42.1	1.60	2.65	68.54	0.37	43	0.03	0.37
5/2/2013 11:05	197	209	49.7	64.50	1	0.64	54	2.29	2.32	65.21	0.40	31	0.87	2.29
5/17/2013 16:45	12	96	49.8	64.17	1	0.60	57.2	1.09	2.00	64.30	0.30	22	-0.19	-0.94
5/21/2013 15:10	13	133	49.6	64.02	1	0.60	56.9	1.12	2.14	64.43	0.34	26	-0.22	-1.27
5/22/2013 13:12	268	643	64.8	79.45	0	0.63	54.6	2.43	2.82	84.15	1.07	142	0.34	1.51
5/23/2013 11:40	292	1,030	65.8	80.16	0	0.59	57.9	2.47	3.02	83.98	0.93	175	0.29	1.38
5/24/2013 10:30	206	2,519	63.7	78.07	0	0.59	58	2.31	3.42	83.12	1.07	263	-0.04	-0.09
5/24/2013 15:45	129	2,792	63.9	78.39	1	0.60	56.8	2.11	3.45	83.01	0.93	97	0.19	1.18
5/26/2013 10:40	77	3,198	62.6	78.30	1	0.77	46.5	1.88	3.52	81.95	0.88	104	-0.06	-0.28
5/28/2013 8:55	46	1,477	63.9	78.92	1	0.68	51.9	1.66	3.07	81.21	0.80	66	-0.09	-0.52
5/31/2013 10:50	42	715	57.2	71.52	1	0.58	58.3	1.63	2.86	71.73	0.34	53	-0.03	0.00