BUREAU OF CLEAN WATER

Continuous Instream Monitoring Report (CIMR)

Most recent revision: 03/10/2017
Revised by: Lookenbill, Hoger, Wertz & Bendick

BASIN NAME: Loyalsock Creek Basin
HUC: 02050206
COUNTY: Sullivan and Lycoming

BACKGROUND AND HISTORY: Loyalsock Creek is a freestone tributary to the West Branch Susquehanna River that originates in the very western fringes of Wyoming County and flows through Sullivan and Lycoming Counties before emptying into the West Branch Susquehanna River at Montoursville (Figure 1). The basin is characterized by relatively steep topography with gentler rolling terrain found surrounding the farthest downstream reaches. The current land use consists of forested land (85.3%), agriculture (14.23%), and urban/developed (0.47%).

Continuous instream monitoring (CIM) was initially implemented in 2008 and 2009 at Loyalsock Creek sites including: Lopez, Rt. 220 Ringdale, Sandy Bottom, and Montoursville; as well as Mill Creek East and Mill Creek West in response to a Stream Redesignation Petition to redesignate the lower mainstem of Loyalsock Creek from Trout Stocking, Migratory Fishes (TSF, MF) to Exceptional Value, Migratory Fishes (EV, MF) (Table 1, Figure 1). The Loyalsockville site was added and maintained beginning in 2010 through 2013 as part of the ongoing study to determine the cause of reduced recruitment of smallmouth bass in the Susquehanna River basin as well as to characterize instream baseline conditions prior to natural gas development activities. In addition, the data collected at Loyalsockville was incorporated as part of a larger assessment methodology development effort. Additional CIM was implemented on Wallis Run and on tributaries to Lake Mokoma, a man-made lake located on Mill Creek. Wallis Run is a tributary to Loyalsock Creek in Lycoming County, and was targeted in 2011 through 2012 to characterize instream baseline conditions prior to natural gas development activities. Tributaries to Lake Mokoma, Sullivan County, were targeted in response to a request from the Lake Mokoma Homeowners Association to document baseline conditions prior to natural gas development activities.

The CIM data contained in this report includes data collected from 2008 through 2013 and is intended to, in part; supplement the Department's Stream Redesignation Evaluation Report developed in response to the Petition to Redesignate. Additional chemical and biological data collected prior to 2010 can be found in the Loyalsock Creek Basin Stream Redesignation Evaluation Report subsequent to its inclusion into a Final Rulemaking. Chemical and biological data collected at Loyalsockville from 2010 through 2013 is included in this CIM report. Additional CIM reports were completed for Wallis Run and tributaries to Lake Mokoma. CIM reports can be found on the Department's website.

The primary objectives of the assessment were to:

1. Characterize baseline water temperature, specific conductance, pH, and dissolved oxygen (DO) using 24-hour monitoring.
2. Characterize water chemistry.
3. Characterize baseline biological communities.

Table 1. Loyalsock Creek basin continuous instream monitoring (CIM) site locations 2008 – 2013.

SITE CODE	STREAM NAME – SITE NAME & DESCRIPTIONS
66907061-001	Loyalsock Creek (19804) – Lopez, 175 meters upstream of Pigeon Creek, Sullivan County. **DRAINAGE AREA:** 27.0 sq. miles **LATITUDE:** 41.45999 **LONGITUDE:** -75.32500 **PERIOD OF RECORD:** June 26, 2008 to June 23, 2009
66907929-001	Loyalsock Creek (19804) – Rt. 220 Ringdale, at Rt. 220, Sullivan County. **DRAINAGE AREA:** 71.0 sq. miles **LATITUDE:** 41.45600 **LONGITUDE:** -76.44399 **PERIOD OF RECORD:** May 22, 2008 to June 23, 2009
66910339-001	Loyalsock Creek (19804) – Sandy Bottom, adjacent to Sandy Bottom Access, Sullivan County. **DRAINAGE AREA:** 328.0 sq. miles **LATITUDE:** 41.40527 **LONGITUDE:** -76.74887 **PERIOD OF RECORD:** April 23, 2008 to June 23, 2009
66912395-001	Loyalsock Creek (19804) – Loyalsockville, 1000 meters upstream of Rt. 973, and just upstream from power line crossing, Lycoming County **DRAINAGE AREA:** 436.5 sq. miles **LATITUDE:** 41.333402 **LONGITUDE:** -76.916114 **PERIOD OF RECORD:** May 17, 2010 to November 21, 2013
66914175-001	Loyalsock Creek (19804) – Montoursville, just upstream of Mill Creek East (19806), Lycoming County **DRAINAGE AREA:** 447.0 sq. miles **LATITUDE:** 41.26799 **LONGITUDE:** -76.92199 **PERIOD OF RECORD:** April 22, 2008 to April 24, 2009
66914321-001	Mill Creek West (19836) – Warrensville Road, just upstream of Warrensville Road, Lycoming County. **DRAINAGE AREA:** 27.0 sq. miles **LATITUDE:** 41.45999 **LONGITUDE:** -75.32500 **PERIOD OF RECORD:** April 22, 2009 to November 2, 2010
66913863-001	Mill Creek East (19806) – Quaker State Road, just upstream of Quaker State Road, Lycoming County **DRAINAGE AREA:** 21.5 sq. miles **LATITUDE:** 41.27834 **LONGITUDE:** -76.90739 **PERIOD OF RECORD:** April 22, 2009 to November 11, 2010

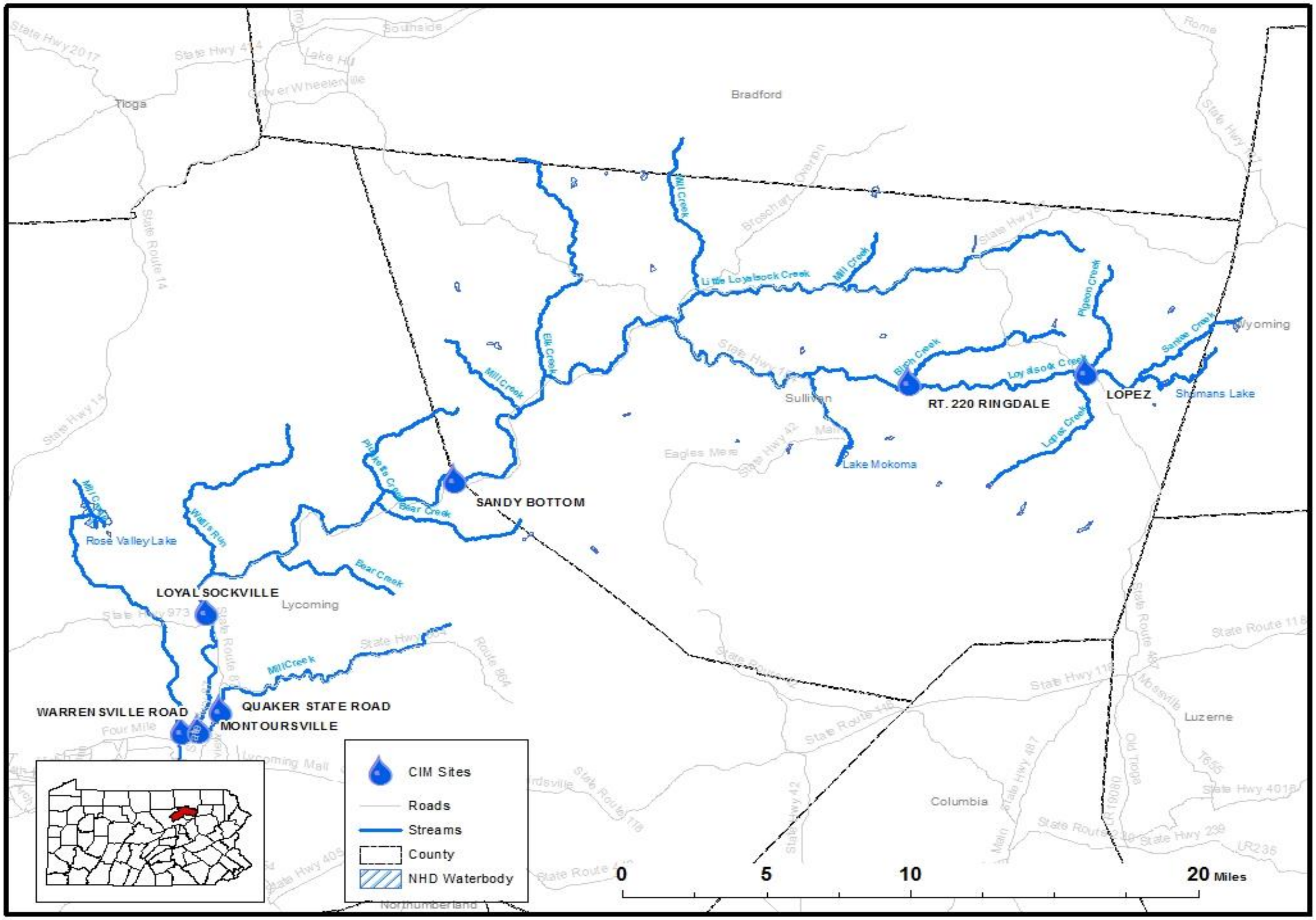

Figure 1. Map of the Loyalsock Creek continuous instream monitoring (CIM) sites.

EQUIPMENT: Initial deployments beginning April and May 2008 on Loyalsock Creek at Rt. 220 Ringdale, Sandy Bottom, and Montoursville utilized multiple OnSet Water Temperature v2 Data Loggers targeting temperature only. In June 2008 a Yellow Springs Instruments (YSI) 600XL water-quality sonde was deployed on Loyalsock Creek at Lopez and an additional YSI 600XL replaced the OnSet Water Temperature v2 Data Logger at Montoursville. In April 2009 additional OnSet Water Temperature v2 Loggers were deployed on Mill Creek East and Mill Creek West.

Over the course of four years (May 17, 2010 to November 21, 2013), four different water-quality sondes were used at the Loyalsock Creek – Loyalsockville site. A YSI 600XLM sonde (Serial #000150CB) was deployed from May 17, 2010 to September 9, 2010. Manta2 sondes from Measurement Specialties were deployed from June 14, 2011 to August 26, 2011 (Serial #MM12100603) and from May 24, 2012 to August 31, 2012 (Serial #MM12100602). Finally, a YSI 600XLM (Serial #00013F64) was utilized from June, 11, 2013 to November 21, 2013. A YSI 6920v2 was used as a field meter during revisits.

WATER QUALITY PARAMETERS:

Parameter	Units
Water Temperature	°C
Specific Conductance (@25°C)	µS/cm[c]
pH	standard units
Dissolved Oxygen	mg/L

DATA:

Each site was visited multiple times over the course of each deployment for the purpose of downloading data, checking calibration and cleaning. Water chemistry grabs were collected at over 22 sites throughout the Loyalsock Creek basin, primarily in response to the Stream Redesignation Petition to redesignate Loyalsock Creek. Water chemistry was collected monthly at many sites and at less frequent intervals at other sites, ranging from single collections to eleven collections throughout the period April 2008 to April 2009. Water chemistry grabs were collected 19 times at the Loyalsockville site throughout the May 17, 2010 to November 21, 2013 deployment. In addition, the Loyalsockville site is co-located with the Department's Water Quality Network (WQN) Station # 408 (WQN0408). The Water Quality Network (WQN) is a statewide, fixed station water quality sampling system operated by the Department that is designed to assess both the quality of Pennsylvania's surface waters and the effectiveness of the water quality management program. One objective of the WQN is to monitor temporal trends in select waters. WQN0408 on Loyalsock Creek has been sampled at least six times per year from 2000 to present. Historical WQN0408 records are as early as 1962.

Continuous data are graded based on a combination of fouling and calibration error (PA DEP, 2013a). Data collected at all sites throughout 2008 and 2009 were collected prior to PA DEP CIM protocol development, did not have the appropriate, accompanying maintenance record and were graded 'Unverified'. Data collected at Loyalsockville after May 17, 2010 had the appropriate, accompanying maintenance data and was graded based on a combination of fouling and calibration error (PA DEP, 2013a). No data for the Loyalsockville site for this period were graded unusable, so all are included in the final report.

Benthic macroinvertebrates were collected throughout the basin at over 50 stations during the 2008 to 2013 period. Fishes were collected at four stations in 2008. Benthic macroinvertebrates and fishes were collected three times each using the Department's ICE protocol (PA DEP, 2013b) and Wadable Semi-Quantitative Fish Sampling Protocol (PA DEP, 2013c) at the Loyalsockville site 2008 to 2013.

Discrete Water Quality Transect Characterization: A transect across the width of the stream was established to characterize water quality at the Loyalsockville site (Figure 2). Other sites were developed prior to PA DEP CIM protocol development and transects were not established and routinely monitored. The purpose of the transect was to determine if data collected by the sonde was representative of the surface water as a whole. Discrete water quality measurements were taken at three points across the stream. Transects were conducted four times throughout the 2013 sampling period. Temperature and specific conductance measurements indicated a relatively homogenous system; however, some variation was observed in pH and dissolved oxygen (Figure 3).

Discharge: Discharge data contained in this report is from USGS station number 01552000 at Loyalsockville, PA. This USGS station is located approximately ½ mile downstream from the Loyalsockville site.

Figure 2. Loyalsock Creek – Loyalsockville Site

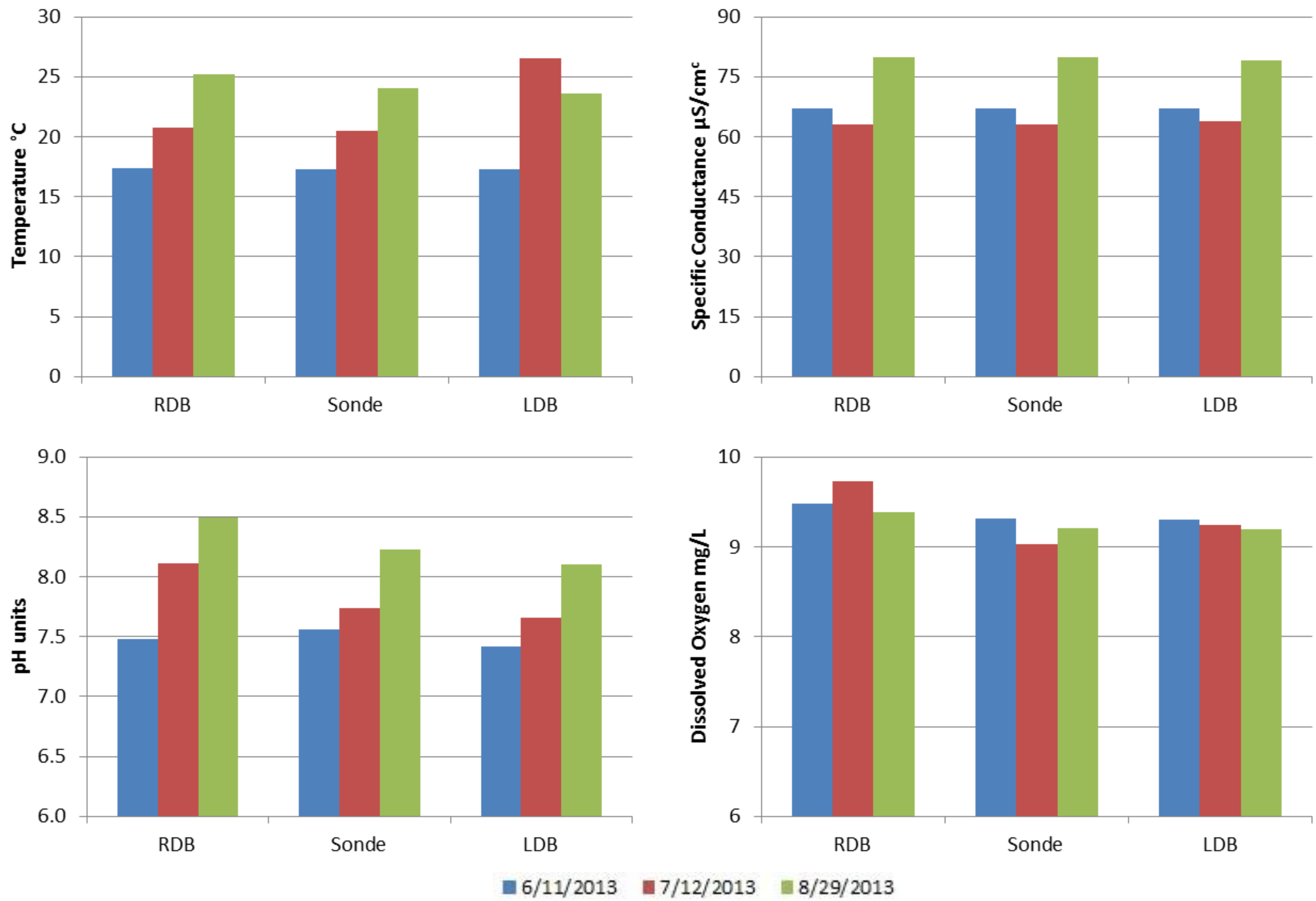

Figure 3. 2013 Loyalsockville discrete water quality transect data collected at the right descending bank (RDB), thalweg (sonde) and left decending bank (LDB).

Water Temperature:

Lopez Statistics (6/26 – 9/15/2008) – Average: 18.4°C; Maximum: 25.5°C; Minimum: 12.1°C.
Rt. 220 Ringdale Statistics (6/26 – 9/15/2008) – Average: 19.6°C; Maximum: 27.6°C; Minimum: 13.3°C.
Sandy Bottom Statistics (6/26 – 9/15/2008) – Average: 21.2°C; Maximum: 26.3°C; Minimum: 16.8°C.
Montoursville Statistics (6/26 – 9/15/2008) – Average: 21.6°C; Maximum: 26.9°C; Minimum: 17.1°C.

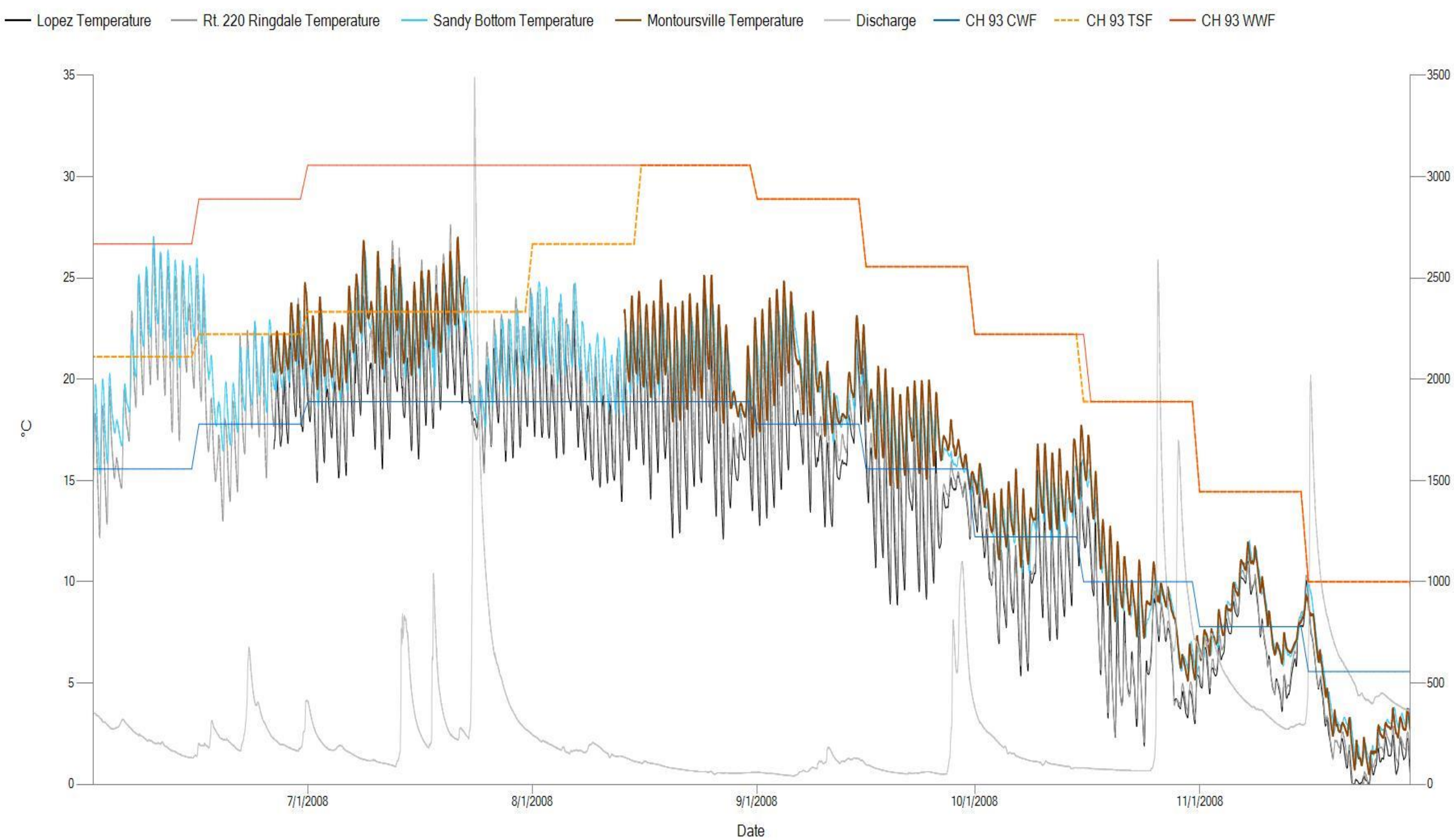

Figure 4. Lopez, Rt. 220 Ringdale, Sandy Bottom, and Montoursville continuous water temperature, continuous discharge, and CH 93 temperature criteria from June 1, 2008 to November 30, 2008.

Mill Creek West Statistics (6/26 – 9/15/2009) – Average: 19.7°C; Maximum: 23.5°C; Minimum: 12.9°C.
Mill Creek East Statistics (6/26 – 9/15/2009) – Average: 18.1°C; Maximum: 23.4°C; Minimum: 12.9°C.
Mill Creek West Statistics (6/26 – 9/15/2010) – Average: 21.0°C; Maximum: 27.4°C; Minimum: 12.6°C.
Mill Creek East Statistics (6/26 – 9/15/2010) – Average: 20.8°C; Maximum: 26.5°C; Minimum: 13.7°C.

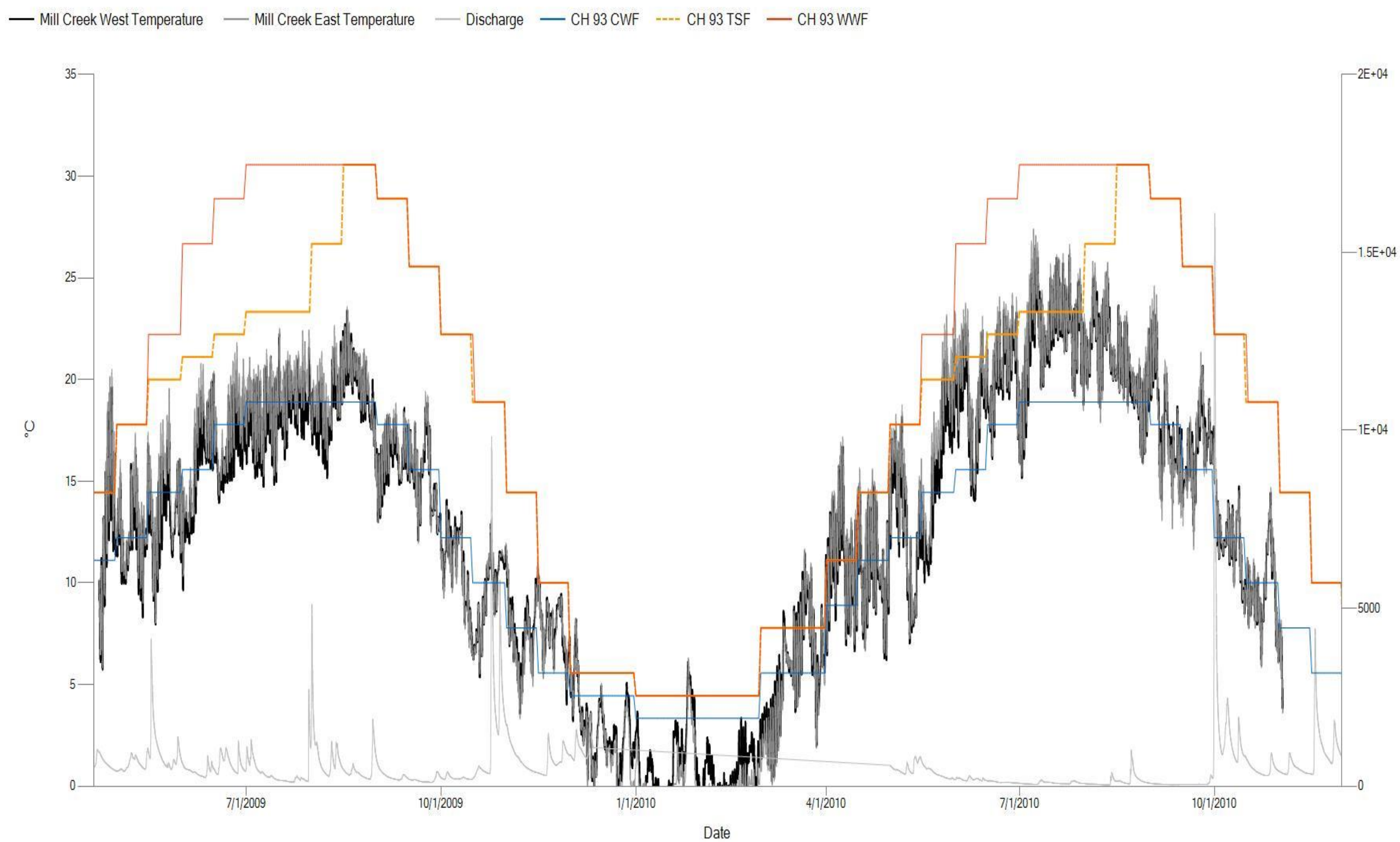

Figure 5. Mill Creek West and Mill Creek East continuous water temperature, continuous discharge, and CH 93 temperature criteria from April 20, 2009 to November 30, 2010.

Mill Creek West Statistics (6/26 – 9/15/2010) – Average: 21.0°C; Maximum: 27.4°C; Minimum: 12.6°C.
Mill Creek East Statistics (6/26 – 9/15/2010) – Average: 20.8°C; Maximum: 26.5°C; Minimum: 13.7°C.
Loyalsockville Statistics (6/26 – 9/15/2010) – Average: 23.8°C; Maximum: 31.7°C; Minimum: 15.4°C.

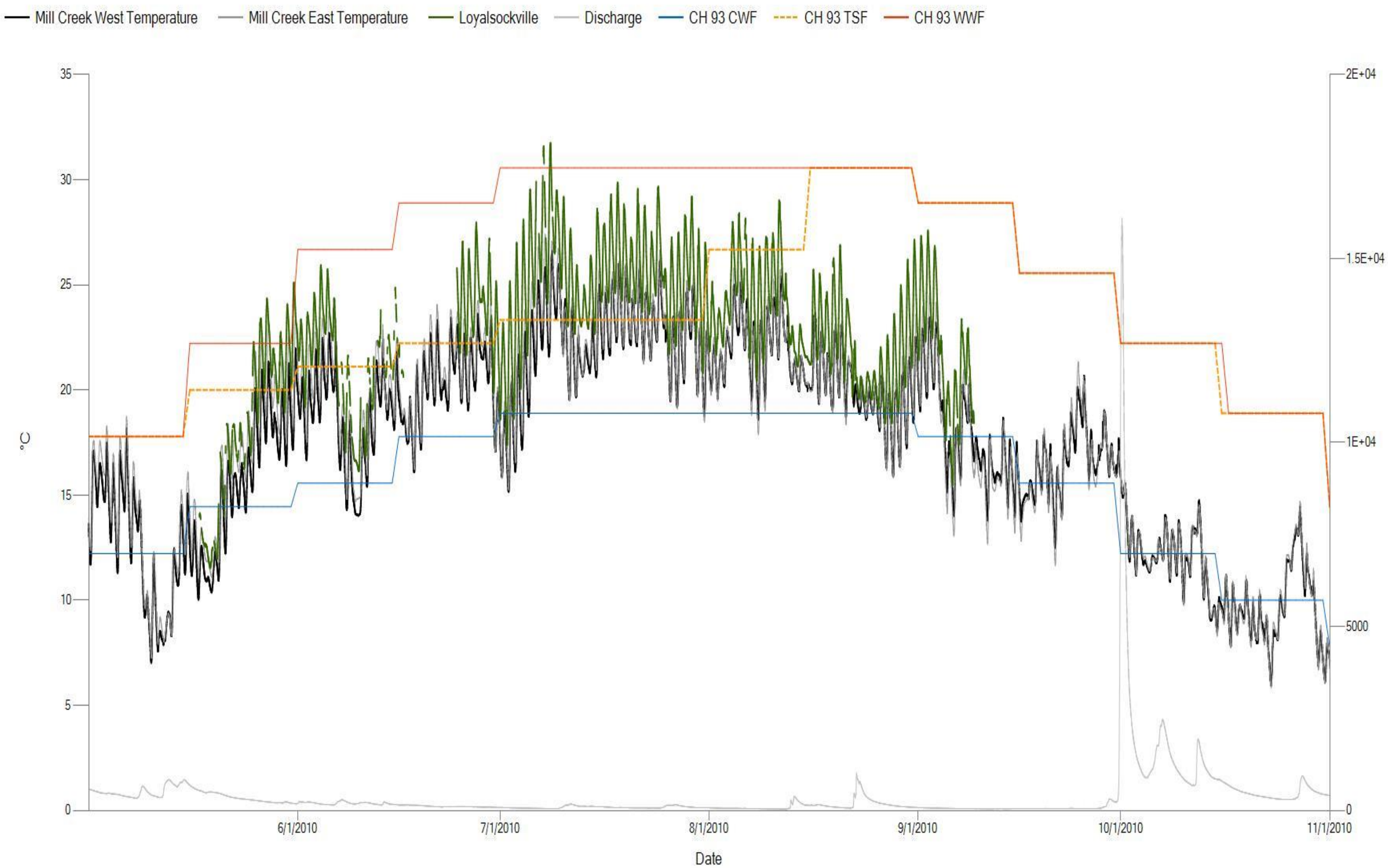

Figure 6. Mill Creek West, Mill Creek East, and Loyalsockville continuous water temperature, continuous discharge, and CH 93 temperature criteria from May 1, 2010 to November 1, 2010.

Loyalsockville Statistics (6/14 – 8/3/2010) – Average: 24.8°C; Maximum: 31.7°C; Minimum: 17.3°C.
(6/14 – 8/3/2011) – Average: 23.8°C; Maximum: 32.9°C; Minimum: 15.4°C.
(6/14 – 8/3/2012) – Average: 23.9°C; Maximum: 29.9°C; Minimum: 17.8°C.
(6/14 – 8/3/2013) – Average: 21.5°C; Maximum: 28.0°C; Minimum: 15.8°C.

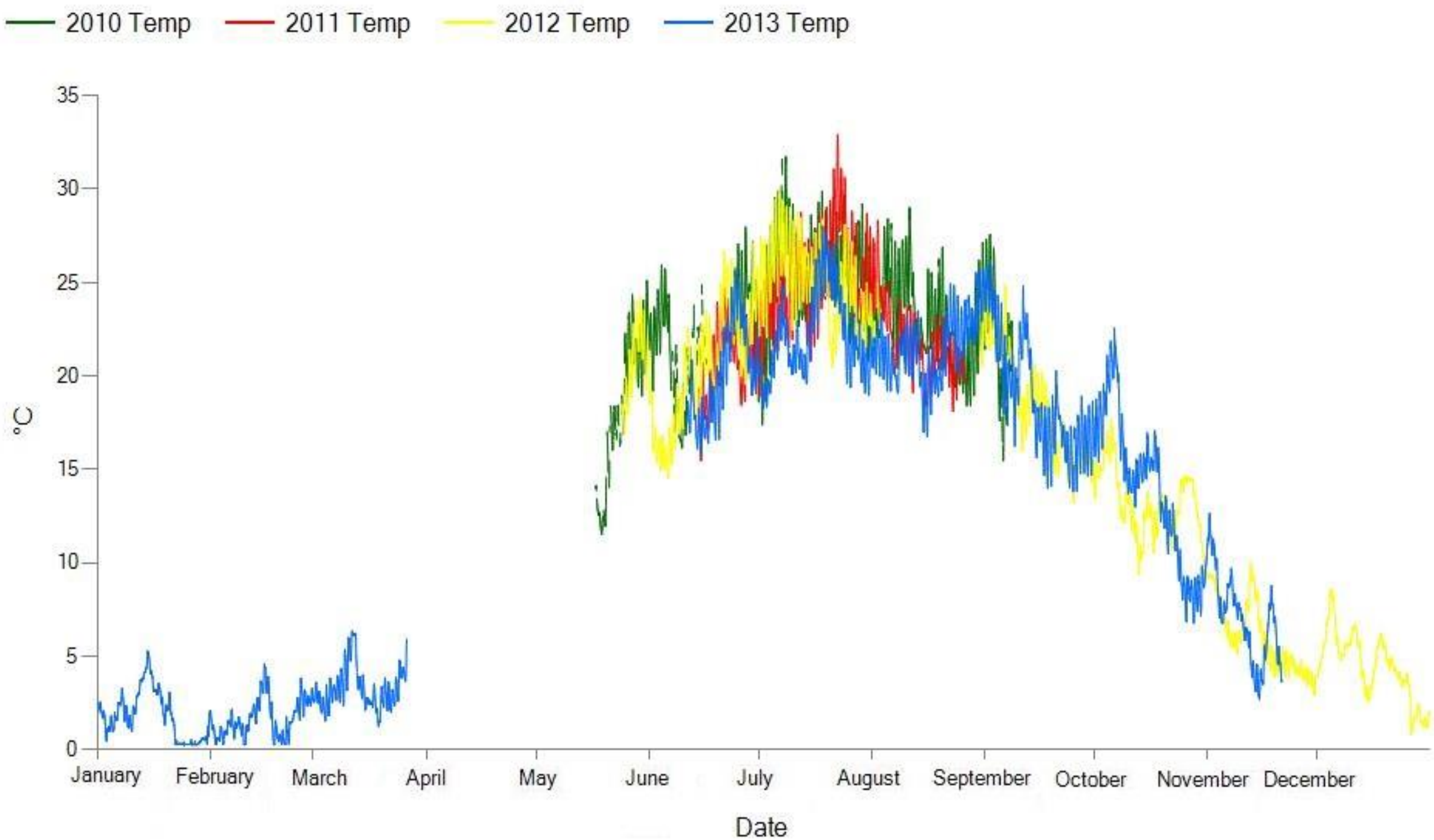

Figure 7. Loyalsockville continuous water temperature yearly report 2010 to 2013. Data are overlapped for year-to-year comparison.

Specific Conductance:
Lopez Statistics (6/26/2008 – 06/23/2009) – Average: 23 µS/cm; Maximum: 42 µS/cm; Minimum: 11 µS/cm.
Montoursville Statistics (6/26/2008 – 06/23/2009) – Average: 63 µS/cm; Maximum: 88 µS/cm; Minimum: 42 µS/cm.

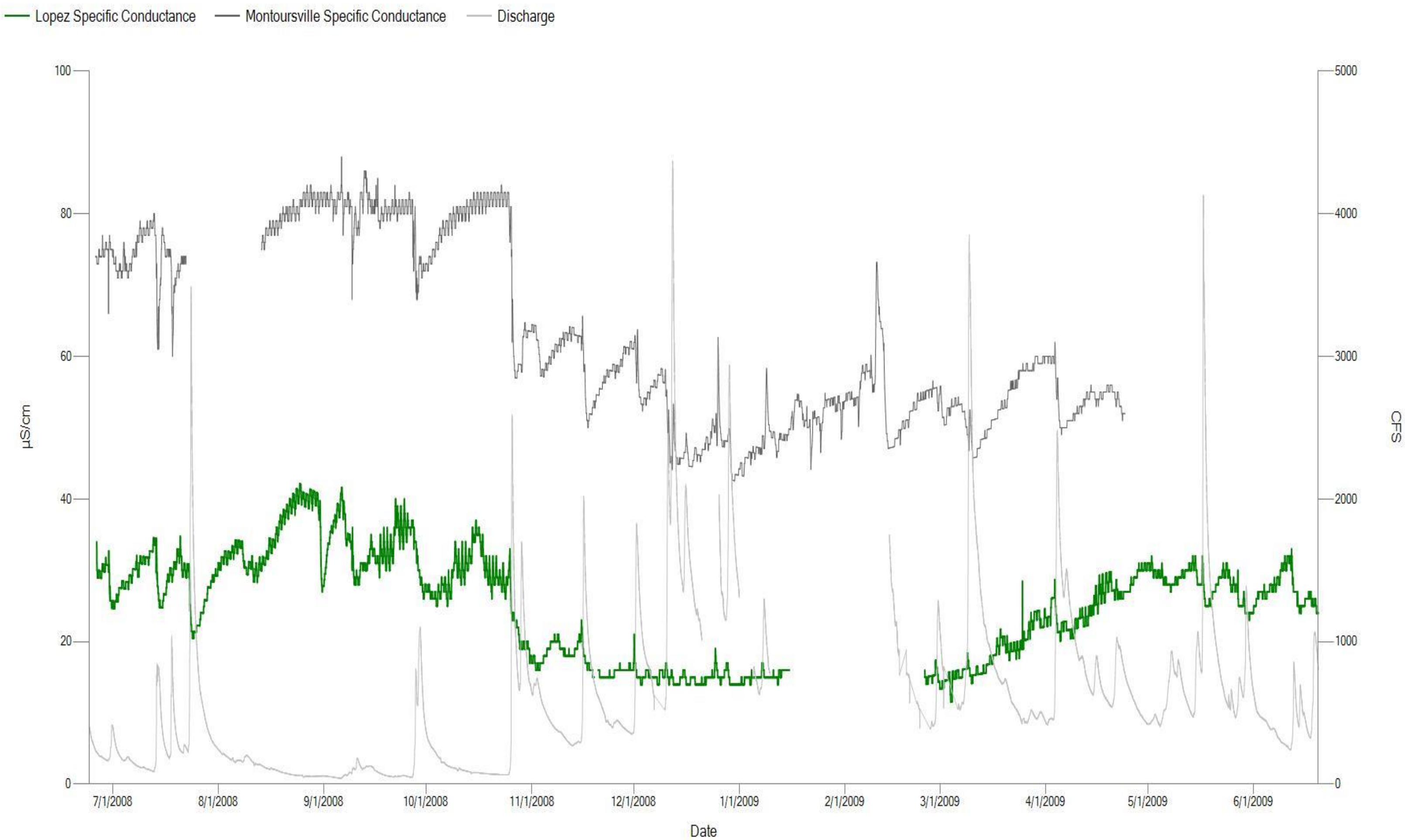

Figure 8. Lopez and Montoursville continuous specific conductance and continuous discharge from June 24, 2008 to June 20, 2009.

Loyalsockville Statistics (6/14 – 8/3/2010) – Average: 73 µS/cm; Maximum: 80 µS/cm; Minimum: 58 µS/cm.
(6/14 – 8/3/2011) – Average: 67 µS/cm; Maximum: 80 µS/cm; Minimum: 53 µS/cm.
(6/14 – 8/3/2012) – Average: 77 µS/cm; Maximum: 87 µS/cm; Minimum: 49 µS/cm.
(6/14 – 8/3/2013) – Average: 65 µS/cm; Maximum: 80 µS/cm; Minimum: 49 µS/cm.

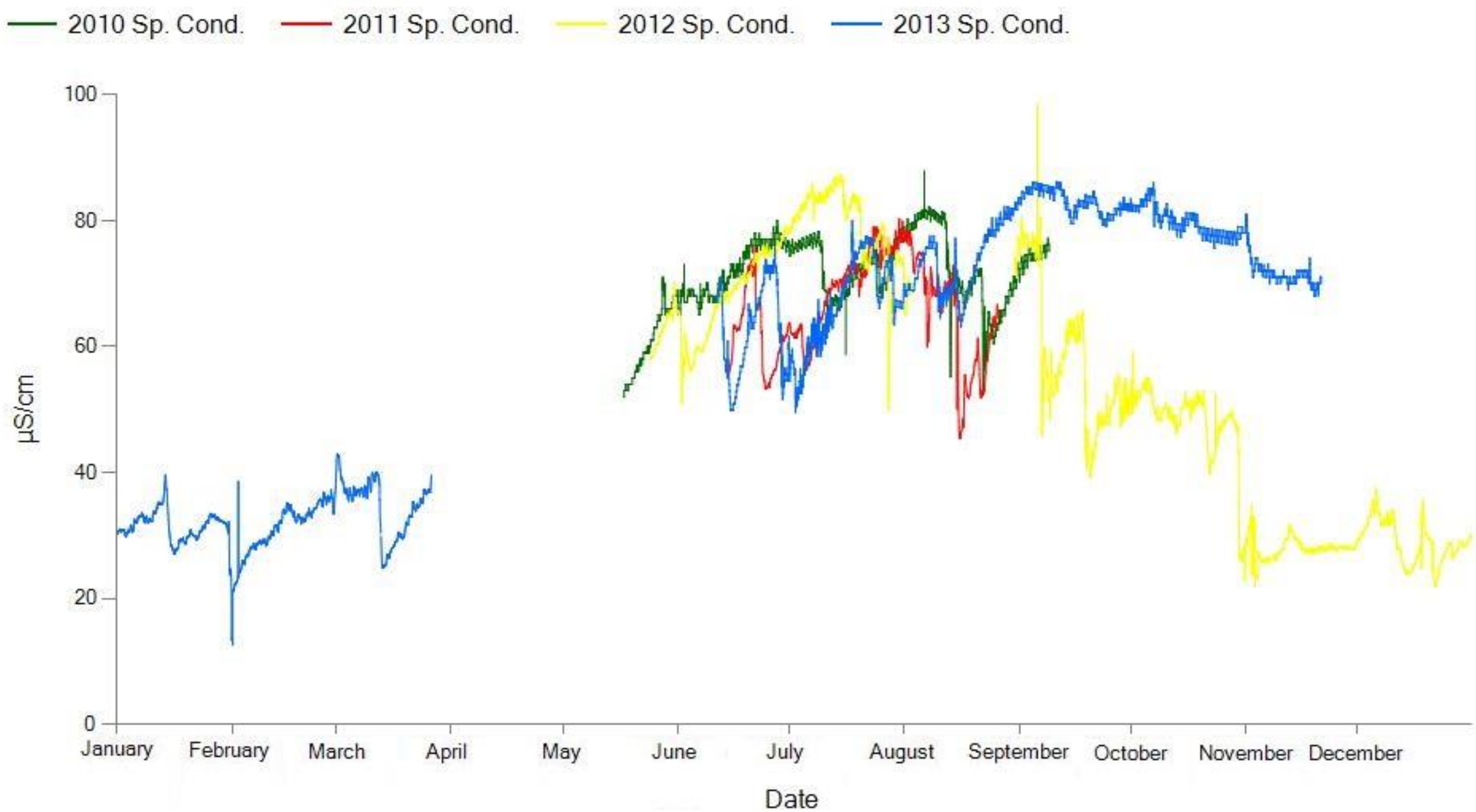

Figure 9. Loyalsockville continuous specific conductance yearly report from 2010 to 2013. Data are overlapped for year-to-year comparison.

pH:

Lopez Statistics (6/26 – 12/31/2008) – Average: 6.4 units; Maximum: 7.1 units; Minimum: 5.7 units.
Montoursville Statistics (6/26 – 9/15/2008) – Average: 7.1 units; Maximum: 8.8 units; Minimum: 6.3 units.

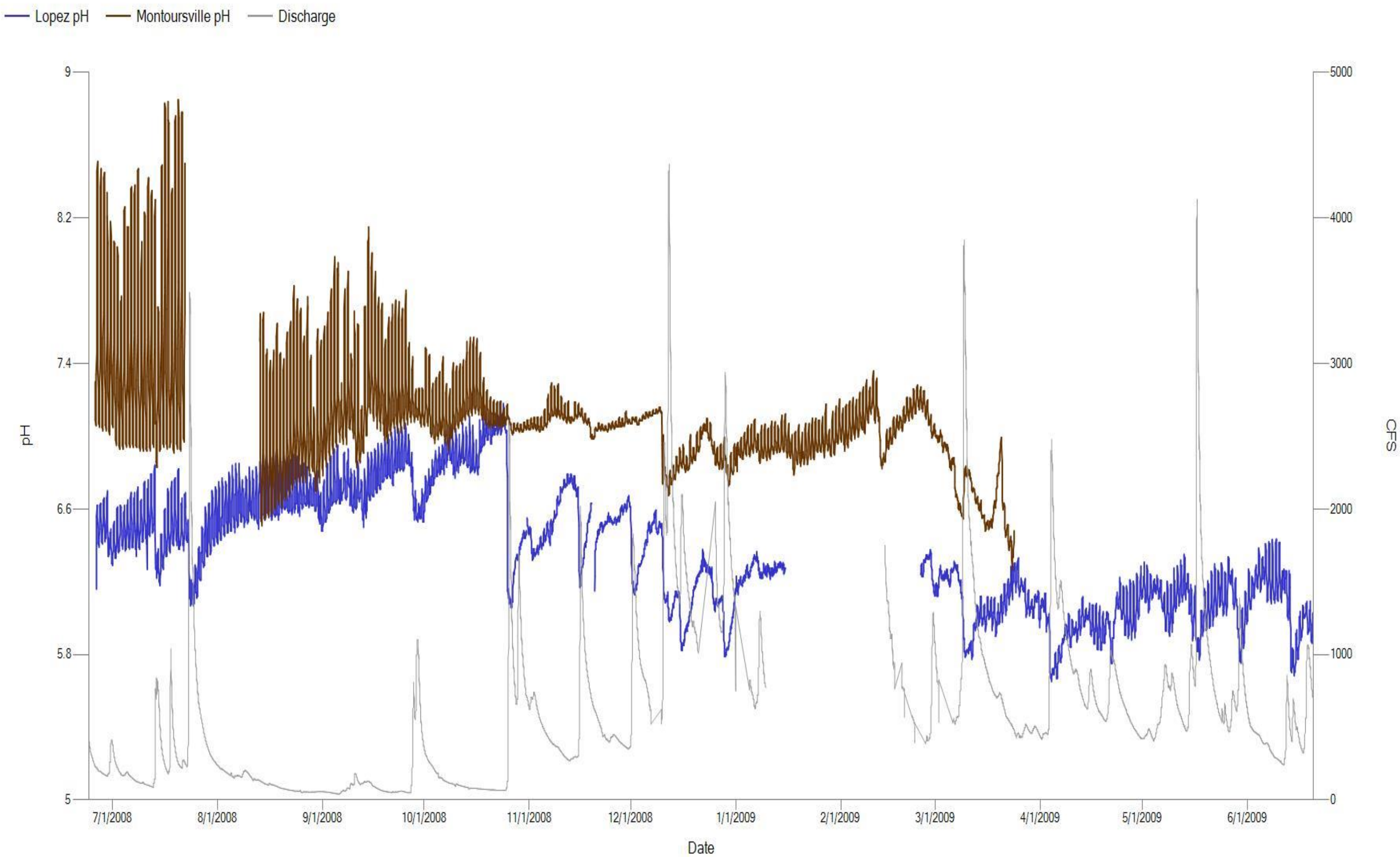

Figure 10. Lopez and Montoursville continuous pH and continuous discharge from June 24, 2008 to June 20, 2009.

Loyalsockville Statistics (6/14 – 8/3/2010) – Average: 7.9 units; Maximum: 9.0 units; Minimum: 7.1 units.
(6/14 – 8/3/2011) – Average: 7.4 units; Maximum: 9.4 units; Minimum: 6.8 units.
(6/14 – 8/3/2012) – Average: 7.8 units; Maximum: 8.7 units; Minimum: 7.3 units.
(6/14 – 8/3/2013) – Average: 7.4 units; Maximum: 8.6 units; Minimum: 6.6 units.

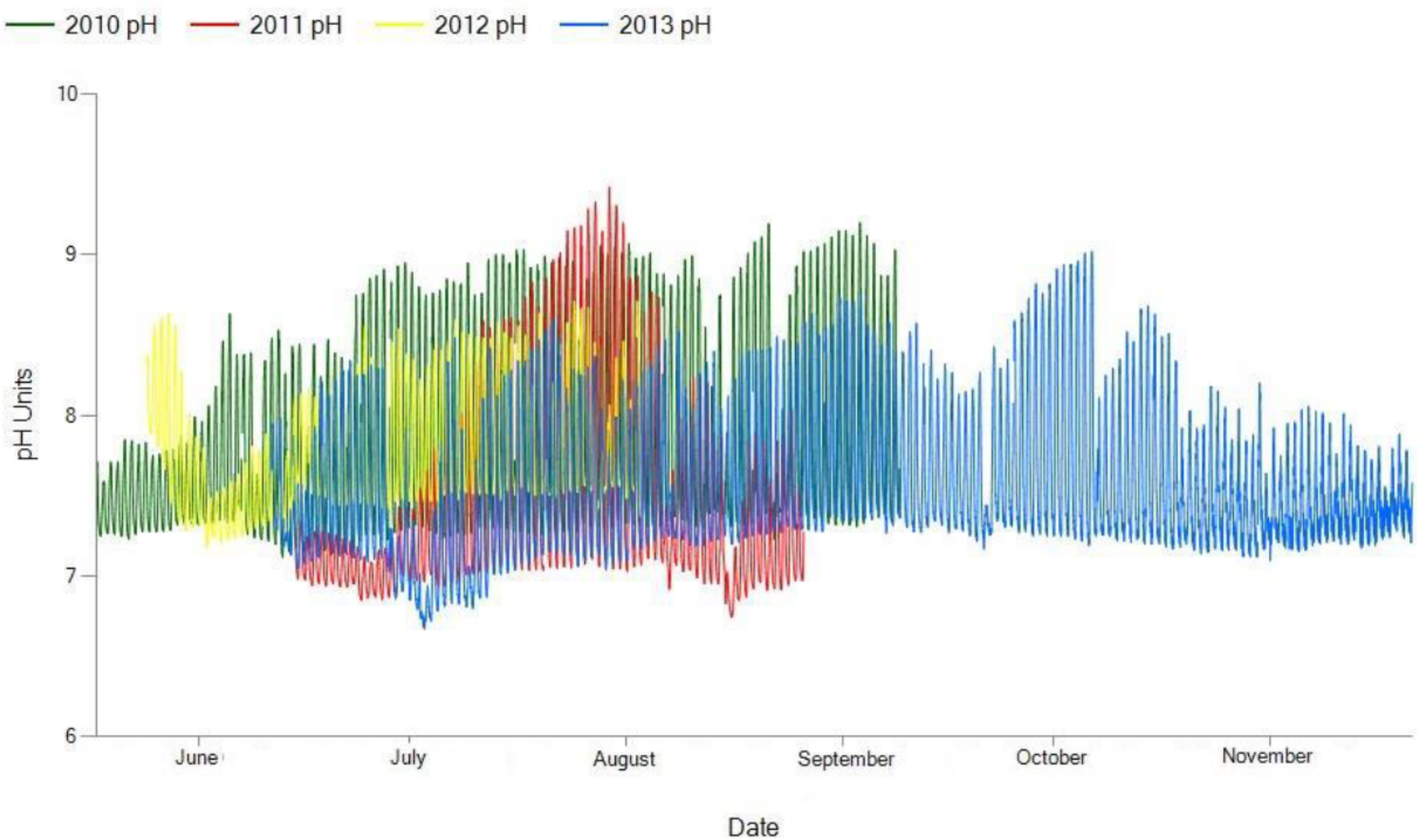

Figure 11. Loyalsockville continuous pH yearly report from 2010 to 2013. Data are overlapped for year-to-year comparison.

Dissolved Oxygen:

Loyalsockville Statistics (6/14 – 8/3/2010) – Average: 8.4 mg/l; Maximum: 10.3 mg/l; Minimum: 6.6 mg/l.
(6/14 – 8/3/2011) – Average: 8.1 mg/l; Maximum: 9.8 mg/l; Minimum: 5.9 mg/l.
(6/14 – 8/3/2012) – Average: 8.2 mg/l; Maximum: 9.8 mg/l; Minimum: 6.6 mg/l.
(6/14 – 8/3/2013) – Average: 8.7 mg/l; Maximum: 10.1 mg/l; Minimum: 7.2 mg/l.

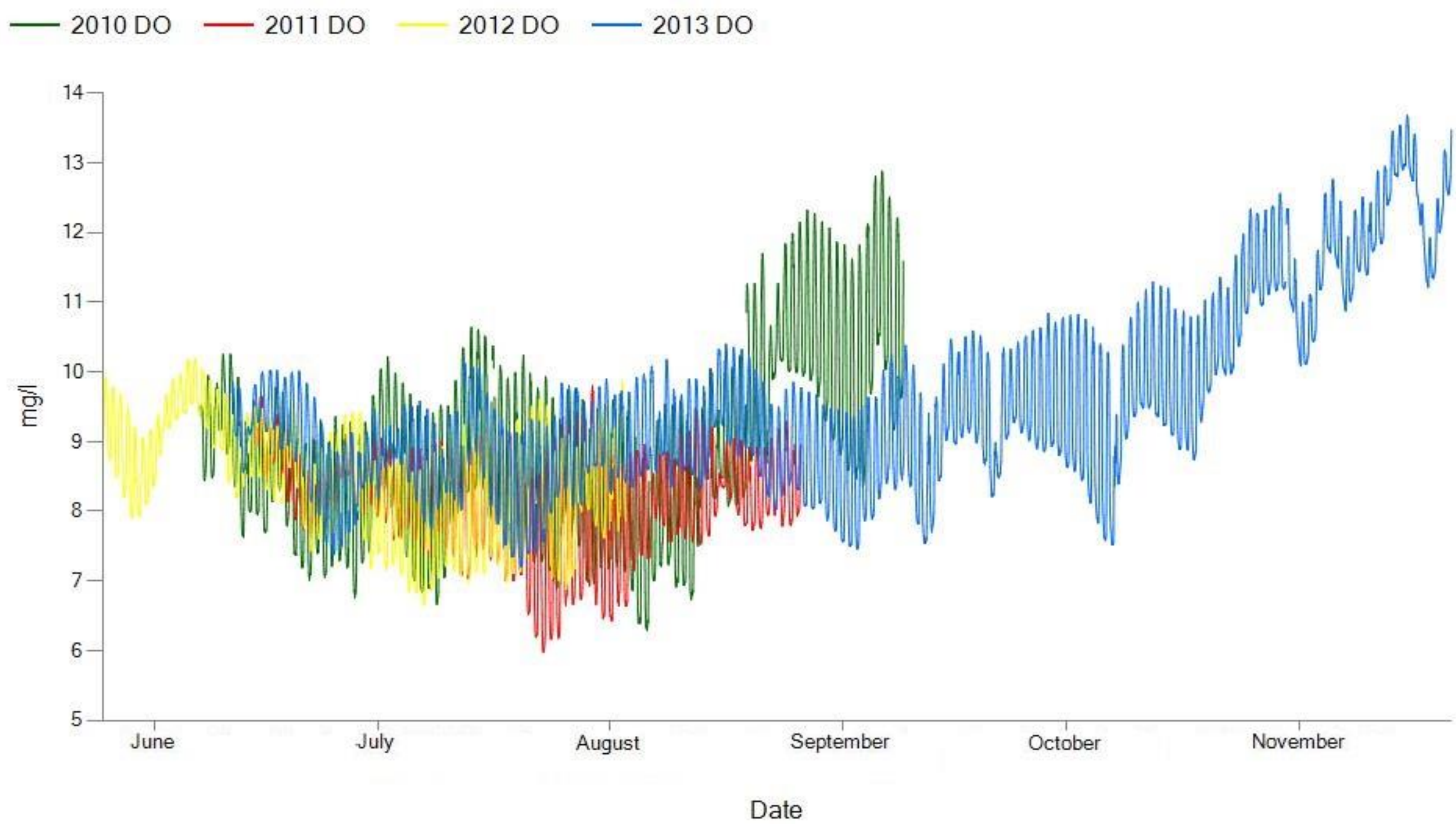

Figure 12. Loyalsockville continuous dissolved oxygen yearly report from 2010 to 2013. Data are overlapped for year-to-year comparison.

In-situ Water Chemistry Loyalsockville: Samples were collected five times in 2010 (Table 2), four times in both 2011 and 2012 (Tables 3 & 4), and six times in 2013 (Table 5). Standard analysis code (SAC) 046 was used in 2010 and SAC 612 in all other years. Measurements with "<" indicate concentrations below the reporting limit.

Table 2. 2010 Loyalsockville chemical grab sample results.

PARAMETER	UNITS	06/07/2010	06/23/2010	06/28/2010	08/19/2010	09/09/2010
		08:30	16:45	14:15	16:45	09:30
DISCHARGE	CFS	266	102	89	89	42
ALUMINUM T	UG/L	<200	<200	<200	<200	<200
ARSENIC T	UG/L	<3.0	<3.0	<3.0	<3.0	<3.0
BARIUM T	UG/L	26.000	23.000	27.000	22.000	29.000
BORON T	UG/L	<200	<200	<200	<200	<200
BROMIDE	MG/L	<0.2	<0.2	<0.2	<0.05	<0.05
CALCIUM T	MG/L	7.887	8.283	8.664	8.508	9.290
CHLORIDE T	MG/L	3.35	4.02	4.21	4.82	4.77
IRON T	UG/L	27.000	22.000	24.000	<20.0	<20.0
MAGNESIUM T	MG/L	1.245	1.226	1.303	1.244	1.461
MANGANESE T	UG/L	10.000	<10.00	11.000	<10.00	10.000
SELENIUM T	UG/L	<7	<7	<7	<7	<7
SODIUM T	MG/L	2.427	2.488	2.600	2.888	2.936
STRONTIUM T	UG/L	39.000	38.000	41.000	41.000	47.000
SULFATE T	MG/L	6.84	7.56	7.92	7.90	7.66
ZINC T	UG/L	<10.0	<10.0	<10.0	<10.0	<10.0
BOD	MG/L		1.70	0.80	0.60	0.90
HARDNESS T	MG/L	25	26	27	26	29
OSMOTIC PRESSURE	MOSM	<1	<1	<1	<1	1
TDS @ 180C	MG/L	58		56		
TSS	MG/L	<5	<5	<5	<5	<5
ALKALINITY	MG/L	16.4	20.2	21.0	22.2	24.2
AMMONIA T	MG/L		<.02	<.02	<.02	<.02
NITRATE & NITRITE T	MG/L		0.11	0.11	0.05	0.08
PHOSPHORUS T	MG/L		<.01	0.015	<.01	<.01

Table 3. 2011 Loyalsockville chemical grab sample results.

PARAMETER	UNITS	06/07/2011	06/14/2011	07/14/2011	08/03/2011
		15:30	10:45	10:30	13:00
DISCHARGE	CFS	448	313	93	101
ALUMINUM T	UG/L	<200	<200	<200	<200
BARIUM T	UG/L	24.000	23.000	25.000	23.000
BORON T	UG/L	<200	<200	<200	<200
BROMIDE	UG/L	<50.00	<50.00	<50.00	<50.00
CALCIUM T	MG/L	6.159	6.115	7.912	8.126
CHLORIDE T	MG/L	2.79	2.60	3.42	3.93
COPPER T	UG/L	<4	<4	<4	<4
IRON T	UG/L	59.000	60.000	35.000	28.000
LEAD T	UG/L	<1.0	<1.0	<1.0	<1.0
MAGNESIUM T	MG/L	1.009	0.991	1.203	1.221
MANGANESE T	UG/L	<10.00	10.000	12.000	14.000
NICKEL T	UG/L	<50	<50	<50	<50
SELENIUM T	UG/L	<7	<7	<7	<7
SODIUM T	MG/L	2.074	1.962	2.436	2.379
STRONTIUM T	UG/L	29.000	29.000	36.000	37.000
SULFATE T	MG/L	7.38	6.42	7.50	7.15
ZINC T	UG/L	<10.0	<10.0	<10.0	<10.0
HARDNESS T	MG/L	20	19	25	25
OSMOTIC PRESSURE	MOSM	1	<1	<1	1
TDS @ 180C	MG/L	58	82	62	36
TSS	MG/L	<5	<5	<5	<5
TOC	MG/L	2.20	2.76	1.44	1.60
ALKALINITY	MG/L	13.0	13.2	21.4	20.2
AMMONIA D	MG/L			0.03	0.02
AMMONIA T	MG/L				<.02
NITRATE & NITRITE T	MG/L	<0.04	0.11	0.07	0.07
NITROGEN T	MG/L	0.10	0.31	<0.25	<0.25
ORTHO PHOSPHORUS T	MG/L	<0.01	<0.010	<0.01	<0.01
PHOSPHORUS D	MG/L			<0.01	<0.01
PHOSPHORUS T	MG/L				<.01

Table 4. 2012 Loyalsockville chemical grab sample results.

PARAMETER	UNITS	05/24/2012	06/14/2012	08/02/2012	08/30/2012
		14:15	12:15	11:15	11:30
DISCHARGE	CFS	560	363	251	147
ALUMINUM D	UG/L		<200.0	<200.0	<200.0
ALUMINUM T	UG/L	<200	14.300	48.500	15.300
ARSENIC D	UG/L		<3.0	<3.0	<3.0
ARSENIC T	UG/L	<3.0	<3.0	<3.0	<3.0
BARIUM T	UG/L	22.000	25.000	24.000	26.000
BORON T	UG/L	<200			
BROMIDE	MG/L	<0.05	<0.2	<0.2	<0.2
CADMIUM D	UG/L		0.275	<.20	<.20
CADMIUM T	UG/L		<0.2	<0.2	<0.2
CALCIUM T	MG/L	6.585	7.940	8.301	9.260
CHLORIDE T	MG/L	2.39	3.5	2.9	3.2
CHROMIUM T	UG/L		<50	<50	<50
COPPER D	UG/L		<4	<4	<4
COPPER T	UG/L		<4	<4	<4
IRON D	UG/L		<20	<20	<20
IRON T	UG/L	27.000	36.000	62.000	32.000
LEAD D	UG/L		<1.0	<1.0	<1.0
LEAD T	UG/L		<1.0	<1.0	<1.0
LITHIUM T	UG/L	<25			
MAGNESIUM T	MG/L	1.001	1.134	1.207	1.274
MANGANESE T	UG/L	<10.00	<10.00	16.000	11.000
NICKEL D	UG/L		<4.0	<4.0	<4.0
NICKEL T	UG/L		<4.0	<4.0	<4.0
SELENIUM T	UG/L	<7			
SODIUM T	MG/L	1.869			
STRONTIUM T	UG/L	31.000	37.000	37.000	39.000
SULFATE T	MG/L	7.36	<15.0	<15.0	<15.0
ZINC D	UG/L		<5.0	<5.0	<5.0
ZINC T	UG/L	<10.0	<5.0	<5.0	5.000
BOD	MG/L	0.40			
HARDNESS T	MG/L	21	25	26	28
OSMOTIC PRESSURE	MOSM	<1			
TDS @ 180C	MG/L	54	62	60	52
TSS	MG/L	<5	<5	<5	<5
ACIDITY T	MG/L		-25.00	-23.20	-16.60
ALKALINITY	MG/L	14.2	20.0	21.2	26.2
AMMONIA T	MG/L	<.02	<.02	<.02	<.02
NITRATE & NITRITE T	MG/L	0.18			
NITRATE T	MG/L		0.22	0.15	0.13
NITRITE T	MG/L		<.01	<.01	<.01
PHOSPHORUS T	MG/L	<.01	<.01	<.01	<.01

Table 5. 2013 Loyalsockville chemical grab sample results.

PARAMETER	UNITS	06/11/2013	08/01/2013	08/29/2013	09/25/2013	10/30/2013	11/21/2013
		10:57	08:30	12:16	11:30	06:59	09:54
DISCHARGE	CFS	343	281	133	120	101	247
ALUMINUM T	UG/L	19.000	27.000	17.000	<13.7514	27.000	<13.7514
BARIUM T	UG/L	27.000	29.000	29.000	26.000	28.000	22.000
BORON T	UG/L	<19.1058	<19.1058	<19.1058	20.00	<19.1058	<19.1058
BROMIDE	UG/L	<7.03284	12.3190	11.6340	13.6430	12.8640	7.1540
CALCIUM T	MG/L	7.230	8.100	8.880	9.580	8.710	7.865
CHLORIDE T	MG/L	3.4250	3.3990	3.9500	4.1750	4.4410	3.9690
COPPER T	UG/L	0.602	0.620	0.449	0.491	0.928	0.473
IRON T	UG/L	37.000	73.000	28.000	20.000	23.000	23.000
LEAD T	UG/L	0.114	0.081	<0.07258	<0.07258	<0.07258	<0.07258
MAGNESIUM T	MG/L	1.071	1.202	1.329	1.432	1.498	1.153
MANGANESE T	UG/L	9.000	13.000	11.000	6.000	4.000	3.000
NICKEL T	UG/L	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856	<13.7856
SELENIUM T	UG/L	<0.32605	<0.32605	0.656	<0.32605	<0.32605	0.354
SODIUM T	MG/L	2.137	2.504	2.731	2.779	2.741	2.444
STRONTIUM T	UG/L	36.000	43.000	44.000	49.000	47.000	40.000
SULFATE T	MG/L	6.5950	6.0610	7.0700	7.5470	7.4040	7.1460
ZINC T	UG/L	<5.1325	<5.1325	<5.1325	<5.1325	<5.1325	<5.1325
HARDNESS T	MG/L	22	25	28	30	28	24
OSMOTIC PRESSURE	MOSM	<1	2	1	2	1	2
TDS @ 180C	MG/L	52	54	58	48	64	60
TSS	MG/L	6	<5	<5	<5	<5	<5
TOC	MG/L	1.3070	2.3010	1.1900	0.8750	0.8520	1.6080
ALKALINITY	MG/L	17.6	17.6	24.0	24.0	23.2	17.0
AMMONIA D	MG/L	0.007	0.011	0.016	<0.007	<0.00672	<0.008
AMMONIA T	MG/L	0.010	0.010	0.015	<0.00672	<0.00672	<0.008
NITRATE & NITRITE D	MG/L	0.266	0.162	0.190	0.193	0.154	0.241
NITRATE & NITRITE T	MG/L	0.270	0.186	0.170	0.198	0.115	0.236
NITROGEN D	MG/L	0.269	0.187	0.281	0.280	0.167	0.345
NITROGEN T	MG/L	0.353	0.253	0.296	0.263	0.200	0.419
ORTHO PHOSPHORUS D	MG/L	0.005	0.006	0.004	0.003	0.003	0.005
ORTHO PHOSPHORUS T	MG/L	0.008	0.005	0.005	0.004	0.003	0.003
PHOSPHORUS D	MG/L	0.005	0.004	<0.00305	<0.00305	0.005	0.003
PHOSPHORUS T	MG/L	0.004	0.006	0.005	0.005	0.007	0.004

Biology: The indigenous aquatic community is an excellent indicator of long-term conditions and is used as a measure of water quality. Benthic macroinvertebrates were collected from the Loyalsockville site on August 3, 2011, December 1, 2011, and November 6, 2013 (Table 6). Additional macroinvertebrate samples were collected throughout the Loyalsock Creek basin that were not included in this report. Fishes were collected from the Loyalsockville site on August 3, 2011, December 1, 2011, and August 29, 2013 (Table 7). Additional fish samples were collected throughout the Loyalsock Creek basin that were not included in this report.

Table 6. Taxa list for benthic macroinvertebrate surveys at Loyalsockville (yyyymmdd).

Family	Genus	20110803	20111201	20131106
Baetidae	*Acentrella*	1		3
	Baetis	2		
	Heterocloeon	3		
Isonychiidae	*Isonychia*	53	1	49
Heptageniidae	*Epeorus*	3	1	4
	Leucrocuta	4		2
	Maccaffertium	10		24
Ephemerellidae	*Ephemerella*			2
	Eurylophella			5
	Serratella	3		
Leptophlebiidae	*Leptophlebiidae*		1	
Taeniopterygidae	*Taeniopteryx*		17	31
	Oemopteryx		7	1
	Strophopteryx		4	1
	Taenionema		9	
Nemouridae	*Prostoia*		8	1
Capniidae	*Allocapnia*		174	
Perlidae	*Paragnetina*	3		
Perlodidae	*Isoperla*		1	
Corydalidae	*Corydalus*	1		
Philopotamidae	*Chimarra*	23		3
Polycentropodidae	*Polycentropus*		1	
Hydropsychidae	*Ceratopsyche*	14		
	Cheumatopsyche	30		7
	Hydropsyche			14
Rhyacophilidae	*Rhyacophila*			1
Glossosomatidae	*Glossosoma*			4
Lepidostomatidae	*Lepidostoma*		1	
Uenoidae	*Neophylax*			1
Psephenidae	*Psephenus*	3		
Elmidae	*Optioservus*	8		36
	Stenelmis	21		
Athericidae	*Atherix*	1		
Empididae	*Hemerodromia*			3
Simuliidae	*Prosimulium*		7	
	Simulium			1
	Chironomidae (family)	2	1	
	Ancylidae (family)			1
	Hydracarina (unranked)			1
	Oligochaeta (subclass)		1	

Table 7. Taxa list for fish surveys at Loyalsockville (yyyymmdd).

Family	Scientific Name	Common Name	20080710	20120712	20130829
Catostomidae	*Catostomus commersonii*	White Sucker	6	11	52
	Hypentelium nigricans	Northern Hogsucker	2	9	50
Centrarchidae	*Micropterus dolomieu*	Smallmouth Bass	10	108	57
	Ambloplites rupestris	Rock Bass	3	6	12
	Lepomis gibbosus	Pumpkinseed			8
	Lepomis cyanellus	Green Sunfish			1
	Micropterus salmoides	Largemouth Bass			1
Cottidae	*Cottus bairdii*	Mottled Sculpin	85		15
Cyprinidae	*Notropis volucellus*	Mimic Shiner	16		1067
	Semotilus corporalis	Fallfish	3		186
	Nocomis micropogon	River Chub	30	1	168
	Notropis rubellus	Rosyface Shiner			93
	Notropis amoenus	Comely Shiner	2		
	Campostoma anomalum	Central Stoneroller	7	1	78
	Exoglossum maxillingua	Cutlip Minnow	11	21	71
	Rhinichthys atratululus	Blacknose Dace		2	
	Rhinichthys cataractae	Longnose Dace	53	8	57
	Pimephales notatus	Bluntnose Minnow		6	46
	Cyprinella spiloptera	Spotfin Shiner			6
	Notropis hudsonius	Spottail Shiner			1
Ictaluridae	*Noturus insignis*	Margined Madtom	28	3	95
	Ameiurus nebulosus	Brown Bullhead			1
Percidae	*Etheostoma blennioides*	Greenside Darter	24	178	196
	Etheostoma zonale	Banded Darter	40	7	166
	Percina peltata	Shield Darter	3	42	158
	Etheostoma flabellare	Fantail Darter	40	72	127
	Etheostoma olmstedi	Tessellated Darter		11	13
Salmonidae	*Salmo trutta*	Brown Trout	2		1
	Salvelinus fontinalis	Brook Trout		1	

ASSESSMENT:

Continuous: Continuous instream monitors (CIMs) record instream parameters that have defined water quality standards (WQS) in 25 Pa Code §93.7 (temperature, pH and DO). Certain conditions must be met in order to properly assess data from CIMs. Any readings that do not comply with the applicable numeric WQS criteria are considered exceedances and are reviewed to determine if representative of the stream segment and if representative of natural quality as stated in 25 Pa Code §93.7(d). All data reviews are consistent with requirements as described in 25 Pa Code §96.3 which includes the 99 percent frequency measurement rule.

Defining Criteria Exceedance

The WQS criteria for pH and DO are expressed as either a discrete minimum, discrete maximum, or as a daily average (continuous 24-hour period, §93.1) concentration. The individual recordings exceeding the listed criteria are summed and the percent of the year (%Y) that those readings represent is calculated using the following equation:

$$\%Y = 100 * [n / (525{,}600 / i)]$$

Where

n = number of exceedances
i = recording interval in minutes
The constant (525,600) is the number of minutes in a year (365 days * 24 hrs/day * 60 min/hr)

If %Y > 1, then the criterion is not achieved 99% of the time as required by §96.3(c), and the waterbody is considered in violation of water quality standards. A period of one year is applied as a rolling year to avoid arbitrary divides as with a calendar year or water year. The 99 percent frequency measurement calculation is based on one continuous 365-day period.

Sampling Critical Time Periods

Temperature, pH and DO are all affected by seasonal change and can, therefore, be predicted to a certain degree. For example, CIMs may be deployed during the growing season when increases in instream production and respiration occur. The Department's CIM efforts have documented increases in pH values, increases in diel pH fluctuation, corresponding decreases in DO values, and increases in diel DO fluctuation beginning in early spring and persisting through the fall. This correlates with increased photoperiod and increased air and surface water temperatures. The effect of increased temperature and photoperiod to increased instream production and respiration are well documented (Odum 1956, Strickland et al. 1970, Neori and Holm-Hansen 1982, Raven and Geider 1988). Diel fluctuation is the difference of minimum and maximum values over a 24-hour period. This is caused by both plant photosynthetic activity and respiration throughout the day and community respiration at night (Odum 1956, White et al. 1991, Wurts 2003). An increased photoperiod with adequate nutrition will increase the standing biomass of photosynthetic organisms (Valenti et al. 2011). Phosphorus has been documented to be the limiting factor of standing biomass in freshwater systems (Stevenson 2006), however other studies indicate increased nitrogen and phosphorus can produce higher biomass than nitrogen or phosphorus alone, suggesting co-limitation (Carrick and Price 2011). During the growing season, pH is most likely to exceed maximum criteria (9.0) and DO to fall below the minimum criteria or 7-day average as described in §93.7, for each critical use. Sampling during critical periods may give sufficient information to make an assessment decision and greatly reduce the amount of resources needed to conduct the survey.

The Department must also recognize that critical or limiting conditions may not be consistent year-to-year, and a single year of data may not accurately represent conditions that water quality standards were developed to protect. Typically, this is driven by the amount and timing of precipitation for a given period or year. Elevated precipitation will result in increased surface water discharge, which moderates limiting conditions characterized by temperature, pH and DO. The Department has documented in past surveys that elevated discharge can reduce daily DO, pH, and temperature fluctuations and increase daily minimum DO values and decrease maximum pH and temperature values. It is imperative to characterize conditions that drive critical or limiting conditions, and reference those conditions as part of the protected use assessment and subsequent reassessments.

CIM, Temperature

Temperature criteria in §93.7 are applied to heated waste sources regulated under 25 Pa Code Chapters 92a and 96. Temperature limits apply to other sources when they are needed to protect designated and existing uses. An appropriate thermal evaluation includes a biological assessment based on instream flora and fauna to determine whether the biological community is affected by the thermal regime. Typically, fish community evaluations have the best resolution in characterizing a waterbody's thermal regime due to the effects to physiology and distribution patterns (Shuter et al. 1980, Ridgeway and Shuter 1991, Azevedo et al. 1998, Wehrly and Wiley 2003, Lyons et al. 2009). CIM temperature data is not typically used to assess critical uses. However, High Quality criterion in § 93.4b (a)(1)(i), "The water has long-term water quality, based on at least one year of data which exceeds levels….at least 99% of the time…" for a list of parameters including temperature may be applied to qualify as a High Quality Water.

CIM temperature data was compared to temperature criteria found in Table 3 of §93.7. CIM data collected 2008 through 2013 do not meet Cold Water Fishes (CWF) temperature criteria in §93.7 99% of the time. TSF criteria is met 99% of the time at Lopez 2008 through 2009 and at Montoursville 2008 through 2009, however the Montoursville evaluation is based on less than one continuous year of data (Table 8). Generally, temperatures are more elevated in downstream reaches. In 2011 the Loyalsockville site had maximum temperature of 32.9°C, but the maximum average of 24.8°C was documented from Loyalsockville in 2010 (Figure 7).

Table 8. CIM temperature data when compared to temperature criteria found at §93.7.

Site - Period	Meets CWF	Meets TSF	Meets WWF
Lopez – 6/2008-6/2009[1]	95%	99%	99%
Rt. 220 Ringdale – 6/2008-6/2009[1]	71%	97%	99%
Sandy Bottom – 6/2008-6/2009[1]	55%	96%	99%
Montoursville – 6/2008-4/2009[1]	92%[2]	99%[2]	99%[2]
Mill Creek West – 4/2009-4/2010[1]	63%	94%	94%
Mill Creek East – 4/2009-4/2010[1]	58%	94%	94%
Mill Creek West – 11/2009-11/2010[1]	47%	91%	95%
Mill Creek East – 11/2009-11/2010[1]	47%	88%	94%
Loyalsockville – 2010	73%	88%	99%
Loyalsockville – 2011	81%	92%	100%
Loyalsockville – 2012	60%	87%	97%
Loyalsockville – 2013	60%	96%	100%

[1] Based on data graded 'Unverified' (PA DEP, 2013a)

[2] Calculated based on less than one year of data that may not have been critical period

CIM, pH

CIM pH data collected from Lopez, Loyalsockville, and Montoursville sites was below the criteria maximum (9.0) found at §93.7 at least 99% of the time for each targeted year (Figures 10 & 11). There were however exceedances of 9.0 at Loyalsockville that occurred during the afternoon hours for 10 consecutive days July 22 through July 31, 2011 that represent 0.28% of a year (Figure 11). Data collected from Lopez in 2008 was above the criteria minimum (6.0) found at §93.7 87.3% of the time. The pH data from the Lopez site indicates the criterion is not achieved 99% of the time as required by §96.3(c). Nearly all of the low pH values are accompanied by increases in discharge, which is often a result of impacts from acid deposition (Figure 10).

CIM, DO

CIM DO data collected at the Loyalsockville site 2010 through 2013 met the criteria minimum (5.0 mg/l) found at §93.7 at least 99% of the time for each targeted year. Maximum daily fluctuation (3.1 mg/l) occurred in 2011 and the minimum DO (5.9 mg/L) occurred during two consecutive one-hour readings on July 23, 2011, which represents approximately 0.02% of the year (Figure 12, Table 8).

Biological: Two benthic macroinvertebrate samples were collected in 2011 and a single sample was collected in the fall of 2013. The first sample collected in August 2011 indicates attainment of the aquatic life use. The second sample collected in November 2011 also indicates attainment, but is lower than expected. Benthic macroinvertebrate communities in Pennsylvania surface waters are seasonally different. Samples collected throughout the summer, before October, will usually have lower diversity and abundance resulting in lower Index of Biotic Integrity (IBI) scores. Samples collected after October and through the winter typically will have higher diversity and abundance and higher IBI scores (PA DEP 2013d, PA DEP 2015). The sample collected in the fall of 2013 had an IBI score 18-points higher than the fall 2011 score (Table 9). This difference is greater than precision estimates for IBI scores and would be interpreted as a change in water quality (PA DEP, 2015). In late-August through early-September 2011 Loyalsock Creek basin was impacted by Hurricane Irene and Tropical Storm Lee. The affects are evident from the fall 2011 macroinvertebrate sample, and by the fall of 2013 it appears that the macroinvertebrate community at the Loyalsockville site had improved (Tables 6 & 9).

Table 9. Macroinvertebrate metric calculations.

Date (yyyymmdd)	IBI	Richness	Mod EPT	HBI	% Dom	% Mod May	Beck3	Shannon Div
20110803	65.0	18	9	3.96	28.6	41.6	10	2.25
20111201	66.2	15	11	2.90	74.4	1.3	9	1.12
20131106	83.0	22	15	3.26	25.1	45.6	14	2.27

The Loyalsock Creek fish assemblage is atypical of many streams in Pennsylvania of similar size. For its size, Loyalsock creek does very well at maintaining a relatively cool-water fish assemblage. Fish assemblages can be categorized along a gradient according to the thermal preferences of species within the assemblage (Eaton 1996, Lyons 2009). Since 2008 the trend seems to be a gradual shift towards a warmer fish assemblage. This trend is evident in the structure of the fish assemblage data collected in 2008, 2012, and 2013 at the Route 973 bridge near Loyalsockville being comprised of 24% cold-water individuals in 2008 and declining to 1% in 2013. This overall "warming trend" does not appear to be caused by anthropogenic activities as much as by the colonization of introduced (invasive) warm-water fishes, most notably the Mimic shiner (Notropis volucellus). The Mimic shiner's relative abundance in Loyalsock Creek has increased from 26% (to the insectivore guild) in 2008 to a maximum of 61% in 2012. The metrics, percent benthic individuals (minus tolerant species) increasing, and percent tolerant species decreasing, are typical metrics that show response to anthropogenic stress (Karr 1990). Loyalsock Creek has ranked fairly high on both of these metrics, and has even made the top tenth percentile among wadable Pennsylvania streams for each of these metrics on multiple occasions.

SUMMARY:

Parameters collected by the CIMs indicate that there are at least two distinct water quality signatures characterized within the Loyalsock Creek basin (Figures 4 – 11). The farthest upstream site at Lopez is colder, pH is lower, and specific conductance is extremely low. At the two downstream sites (Loyalsockville and Montoursville) specific conductance, temperatures, and pH are all comparatively higher, but still relatively low when compared to a majority of the Commonwealth's surface waters.

From 2008 through 2009 CIM specific conductance measurements at Lopez are extremely low, ranging 11-42 µS/cm (Figure 8). Low specific conductance suggests low anthropogenic impact, but can also be indicative of reduced alkalinity and hence minimal buffering capacity. Lower pH with less daily fluctuation and with significant seasonal depressions beginning as early as late November and persisting through early spring is also an indication of limited buffering. Most pH depressions for the Lopez site are accompanied by high-water storm and snowmelt events characteristic of acid deposition impacts. pH criteria violations did occur on at least two separate occasions December - January, 2009 and again on multiple occasions March – April, 2009 (Figure 10). At the lower mainstem sites pH levels are comparatively higher with greater daily fluctuations during summer months, and minor seasonal depressions through the colder months (Figures 10 & 11).

Specific conductance measurements at Loyalsockville were relatively consistent and low over the four years (2010-2013) with yearly averages ranging 65-77 µS/cm (Table 10). CIM measurements of pH were more variable year-to-year. Daily swings of pH measurements in 2012 were much reduced compared to other years (Figure 11). Fluctuations were higher in July and August of 2010 and July 2011 with swings of over two units. The maximum pH of 9.42 units (July 2011) exceeds the water quality criterion (Table 3 of §93.7(a)), however, does not violate the 99% requirement (§96.3(c)). There were no violations of DO criteria (5.0 mg/l), but daily fluctuations were different across 2010 – 2013 data. Daily DO fluctuations were lowest in 2013 and highest in 2010. Daily DO fluctuations correlate with average discharge with 2013 having the highest (691 CFS) and 2010 the lowest (94 CFS) (Table 10 & Figure 13). Yearly and seasonal characteristics, like discharge, must be considered when evaluating CIM data.

Biological samples indicate that the lower mainstem of Loyalsock Creek is attaining the aquatic life use of TSF, MF as well as the existing use of EV, MF. The Department conducted an evaluation of Loyalsock Creek in response to a petition to redesignate Loyalsock Creek. Based on surveys conducted in 2008 the Department determined that the existing use of Loyalsock Creek to be EV, MF. The existing use of Loyalsock Creek mainstem was signed on July 2, 2008. An additional evaluation was completed subsequent to the 2008 evaluation, and an additional existing use determination was made for the remainder of the Loyalsock Creek basin. Existing use documentation can be found on the Department's website subsequent to final stream redesignation rulemaking.

Table 10. Loyalsockville comparison of year-to-year CIM data from June 14 to August 3.

		2010	**2011**	**2012**	**2013**
Water Temperature	Min	17.3	15.4	17.8	15.8
	Avg	24.8	23.8	23.9	21.5
	Max	31.7	32.9	29.9	28.0
Specific Conductance	Min	58	53	50	49
	Avg	73	67	77	65
	Max	80	80	87	80
pH	Min	7.1	6.8	7.3	6.6
	Avg	7.9	7.4	7.8	7.4
	Max	9.0	9.4	8.7	8.6
Dissolved Oxygen	Min	6.6	5.9	6.6	7.2
	Avg	8.4	8.1	8.2	8.7
	Max	10.3	9.8	9.8	10.1
Daily DO Fluctuation	Avg	2.2	1.6	1.7	1.3
	Max 7-day Avg	2.6	2.8	2.2	1.8
	Max	2.8	3.1	2.3	2.1
Discharge	Avg	94	178	182	691

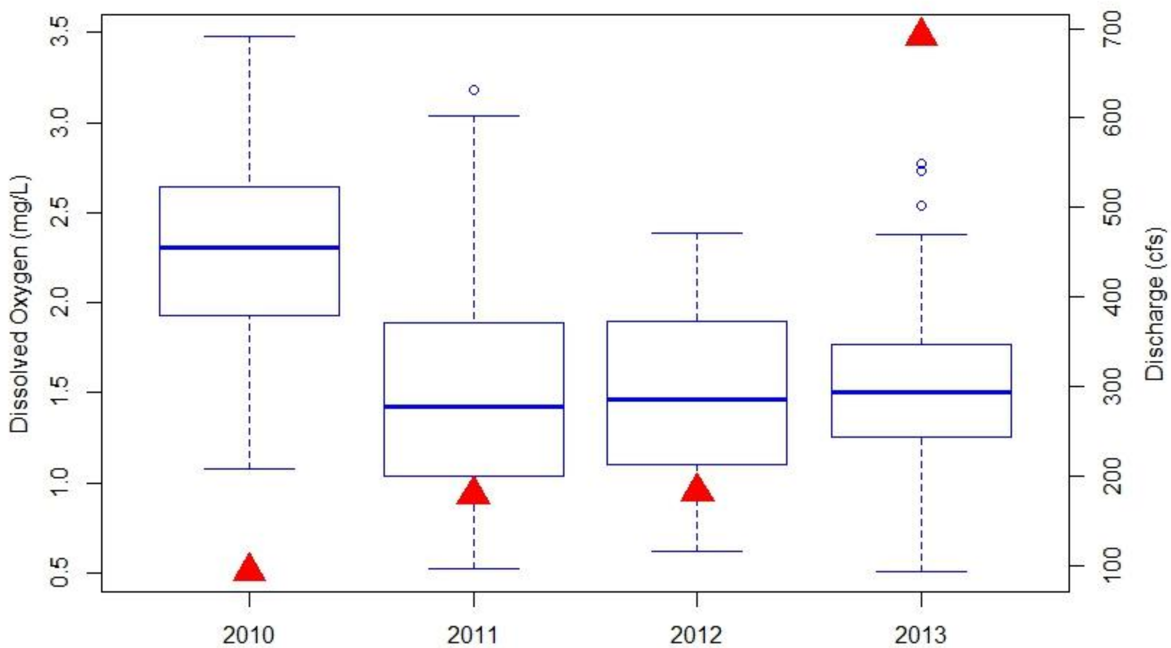

Figure 13. Loyalsockville comparison of average daily dissolved oxygen range (boxplots) from June 14 to August 3 each year. Average discharge for the period (red triangles) is included to demonstrate the effect of flow on production-based fluctuations in dissolved oxygen.

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